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To meet the need for a high quality scientific publishing in its research fields of interest, the International Association of Research Organizations for the Information, Media and Graphic Arts Industries (iarigai) publishes the peer reviewed quarterly Journal of Print and Media Technology Research.

The Journal is fostering multidisciplinary research and scholarly discussion on scientific and technical issues in the field of graphic arts and media communication, thereby advancing scientific research, knowledge creation and industry development. Its aim is to be the leading international scientific periodical in the field, offering publishing opportunities and serving as a forum for knowledge exchange between all those scientist and researchers interested in contributing to or benefiting from research in the related fields.

By regularly publishing peer-reviewed high quality research articles, position papers, survey and case studies, the Journal will consistenly promote original research, networking, international collaboration and the exchange of ideas and know how. Editors will also consider for publication review articles, topical and professional communications, as well as opinions and reflections of interest to the readers. The Journal will also provide multidisciplinary discussion on research issues within the field and on the effects of new scientific and technical development on society, industry and the individual. Thus, it will serve the entire research community, as well as the global graphic arts and media industry.

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Premedia technology and processes

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Contents

A letter from the Editor

Gorazd Golob
Editor-in-Chief
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In the present, second issue of Vol. 4 of the Journal we remain faithful to the tradition and the editorial policies of our Journal. With six published papers we have covered various research areas including printed electronics and functional printing, management of print processes, protection against forgery of printed matter, investigation of halftoning processes and search for optimal typographic design of the packaging in a multilingual environment, respectively. With this, our publication remains interdisciplinary, international, and open to new ideas with the intention to further develop our broad research area.

Even Topicalities, edited again by Markéta Držková (marketa.drzkova@jpmtr.org) from Pardubice, reflects this orientation of our colleagues and partners. In a review of current news, events, published books and defended theses it is clear that we are reaching the edges of our really wide research fields, so the question arises whether we should somehow limit our future activities. Border areas of our research work range from studies of the composition and functionality of materials, spectroscopy and colorimetry, advanced statistical methods, design and cognitive science. Our core areas remain the printing technology and media, however without involvement in the above mentioned and other new fields we can't be successful in the future. As an editor, I can only conclude that I am really pleased with the authors, reviewers and editorial board, which together ensure the high quality of published papers.

The quality of a scientific journal is primarily manifested in the satisfaction of readers, along with authors, reviewers and editors contributing to the publication. However, ranking in the international systems for indexing, providing international recognition and visibility is also very important. In addition to the three databases of indexed journals where we are already present, we have renewed the already started processes and began with the procedures for inclusion in the bibliographic databases at Thompson Reuters (SCI impact factor), INSPEC, Scopus, Compendex as well as Directory of Open Access Journals (DOAJ and International Bibliography of the Social Sciences (IBBS). Procedures of the evaluation and inclusion of new Journal are relatively long, and maybe we are not even eligible for all of them. In any case, you can reasonably hope that by the end of this year we will have at least partially succeeded. Our activities are supported by the Board of iarigai, which decided that the Journal should be more open to the public with an open access option for papers published at least six months ago, which corresponds to the status of green open access journals., recognized by European Commission.

Unfortunately, we have had some delays with the new website and open access options mentioned above. One of the reasons is a change in my professional life. Due to the legislation I have been forced to retire, earlier than I would have liked, and just in the days of the editing and publishing of this issue I also have to fulfill my last obligations to the students at my home institution. The good side of this change is that I will now be fully dedicated to the Journal and achievement of its objectives. The goals remain the same, but our expectations of reaching them soon are more realistic now. All contacts and e-mail address of the editor will remain unchanged in the future, however you can now also reach me on gorazd.golob@jpmtr.org.

Once again I would like to invite you all to participate by submitting papers for publication, to promote and spread our Journal in the professional, research and scientific circles where you are active. The current situation is not critical, but we are far from satisfaction. In the present as well as in the next issue of the Journal you will be able

to access the articles that were submitted in the last year. The entire editorial process is still very long and should be shortened. The number of contributing authors has been expanding and will require an extended circle of reviewers, especially for specific border areas. We also expect your proposals and suggestions for further improvements of the Journal of Print and Media Technology Research.

Ljubljana, June 2015

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Cold foil transfer technology for functional printing

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Abstract

Since some years, several research institutes, institutions and companies are working on the realization of electronic components by innovative methods, which can lead to cost-effective, simplified and flexible production of such products. Among other low-cost technologies such as coating and vapor deposition, printing as an additive structuring process is one focus of research. Another interesting additive printing-related method is cold foil transfer technology or also so-called cold foil stamping. The cold foil transfer technology is conventionally used in the finishing step for various, mostly decorative, printing products. For a real metal effect to be obtained in graphic arts printing so-called cold foils are used, which in most cases have an aluminium layer. The metal is applied by vapor deposition with high demands on the polyester foil properties, so that the metal particles are close together and thus set up a thin homogeneous conductive aluminium layer in the nanometer range. The fact that the cold foils have a metal layer has led to the idea of using this printing method for electronic applications using its conductivity. The following criteria are important for using cold foil transfer processes for printed electronics: electrical conductivity, reproducibility and reliability of such metal layers, especially depending on different printing process settings. In this research, the cold foil is transferred to a substrate in a sheet-fed offset printing press. The samples are measured by using a contactless measurement method. The experiments show a medium to low sheet resistances of the transferred aluminium layer. Furthermore, the conductivity of the aluminium areas on the substrate depend on their location on the much larger substrate sheet. The objective of this research – application of the cold foil transfer technology and determination of its process boundaries for the use in the electronics field – could be confirmed.

Keywords: hot stamping, sheet-to-sheet process, mass production, electric conductivity, printed electronics

1. Introduction

Functional printing has shown a rapid development in the last years. Optimized functional fluids enable the production of the various functional layers and this even with instruments and devices beyond the laboratory scale. Functional fluids that have the suitable electrical properties can be processed with established industrial mass manufacturing processes, amongst others, with printing processes, investigated by Organic and Printed Electronic Association (OE-A, 2013).

In flexographic printing, the printing plate is compressible. Therefore, it is suitable for rigid substrates such as glass and also for surfaces, which are sensitive to mechanical stress (Kipphan, 2001). Gravure printing offers benefits in the production of very thin functional layers down to the nanometer range. Screen printing provides advantages for high laydown of ink material (Rausch et al., 2011). The latter is useful, for example, in the production of electroluminescent devices. With the development in chemical industry, the functional fluids are also optimized to be printed by inkjet printing. Inkjet in graphic arts industry is mainly used for short-run and personalized print production. Further specific advantages of inkjet arise due to its modularity and flexibility allowing integration into various architectures ranging from desktop printers to print production systems and even into existing printing presses as imprinting solutions (Leenders, 2005).

In addition to conventional printing methods, it has been tried to produce functional layers using the hot stamping technology. The Paper "Hot Stamping Technology for Functional Printing" (Lyashenko, Salun and Doersam, 2012) investigates hot stamping processes for the production of electrical components. It was confirmed that hot stamped metal layers exhibit reasonably

good conductivity. Furthermore, it was shown that the electrical conductivity of these metal layers depends on the properties of hot stamping foils (Lyashenko, 2014).

Based on these findings, an investigation of the production of the electricaly conductive layers using cold foil transfer technology was conducted as well. With cold foil transfer technology, the functional layer can be manufactured on highly productive presses with some advantages for mass production at lower cost. The cold foil transfer is a well-established process in graphic arts industry mainly used for inline decorative refinement. The differences between the cold foil basic material composition and the hot stamping foil are shown in Figure 1 and Figure 2.

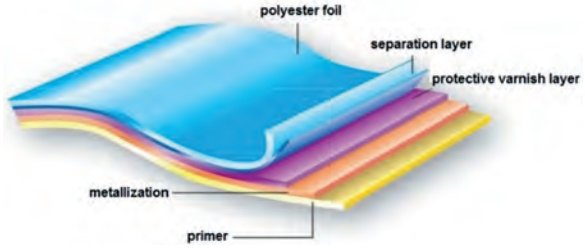


Figure 1: The layer composition of a cold foil (Kurz, 2011)

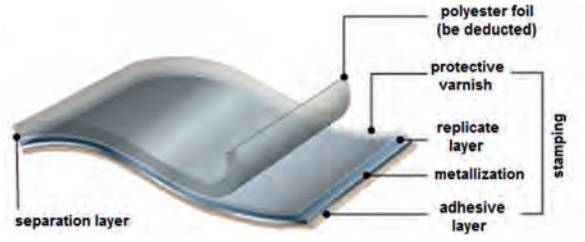


Figure 2: The layer composition of a hot stamping foil (Kurz, 2011)

The main difference is the primer layer in cold foils (Figure 1) and the adhesive layer in hot stamping foils (Figure 2) as these layers have to be adapted to the substrate. In case of cold foil, the primer layer has to meet the requirements of the preprinted glue and, in case of hot stamping foil, the adhesive layer will be activated by heat and has to stick to the surface of the substrate.

The external glue in case of cold foil is applied by printing methods such as offset and flexographic printing like a conventional printing ink. In the next step, the cold foil is pressed onto the substrate in a special cold foil transfer unit. In those areas where the glue is located, the metal cold foil is transferred as shown in Figure 3. The other layers of both foils are similar and play almost the same role. There are a polyester foil, a separation layer, a protective varnish layer and a metallization (usually aluminium) by vacuum-deposition (Figure 1 and Figure 2). Replicate layer is typically used in hologram stamping foils only.

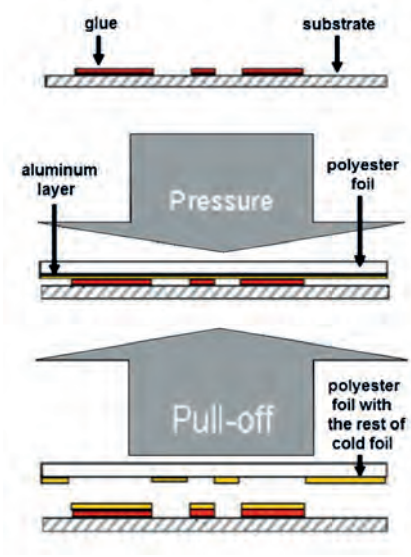


Figure 3: Working principle of cold foil transfer process (Heidelberg, 2012)

Besides the advantage of a high-speed mass production, the cold foil transfer technology has substantially lower manufacturing costs and flexibility in the layout as opposed to the hot stamping. (Remark: cold foil can be applied not only for the full areas, but also for screened areas. In the graphic arts industry, cold foil is transferable for areas with screen ruling lower than 40 l/cm and halftone areas between 20 % and 90 % (Heidelberg, 2012).) Visual and tactile effects, however, are not mentioned here since they are not aimed for in electrical applications.

2. Printing experiments

The printing experiments were carried out on an offset printing press Heidelberg Speedmaster XL 105-5+L. Printing units 1 and 2 were used for cold foil transfer. In the first offset printing unit, the glue was printed as usual in standard graphic arts applications. The second unit was equipped with a cold foil transfer unit, in which the cold foil is pressed onto the printing sheet. All other subsequent printing units were off (no pressing). For the experiments, a standard gloss paper BVS (manufactured by Scheufelen GmbH) in format 1050 × 750 mm with the grammage of 135 g/m² was used. As cold foil material, two similar types of foils were applied, for short named Type 1 and Type 2. The regular thickness of the aluminium layer for the cold foil process, which is usually used in the graphic industry, is between 10 and 20 nm. As this is a very thin layer, the sheet resistance is not expected to be very low. Both types of cold foil materials are without a coloring above the metallization (aluminium). The glue material GLUE FoilStar 100 (Heidelberg Saphira®) similar to a conventional oil-

Table 1: Settings of the printing experiments on Heidelberg Speedmaster XL 105-5+L

Test run	Type of cold foil material	Color density of glue	Dampening [%]	Speed [sheets/h]	Tension of foil web (out and up side) [N/cm]	Engagement [mm]
1	2	0.3	25	8000	1.0/1.5	0.15
2	2	0.3	25	8000	1.0/1.5	0.25
3	2	0.3	25	10000	1.0/1.5	0.25
4	2	0.3	25	12000	1.0/1.5	0.25
5	2	0.3	25	14000	1.0/1.5	0.25
6	2	0.3	25	10000	0.4/1.5	0.25
7	2	0.3	25	10000	2.0/1.5	0.25
8	2	0.22	25	10000	1.0/1.5	0.25
9	2	0.35	25	10000	1.0/1.5	0.25
10	2	0.3	40	10000	1.0/1.5	0.25
11	2	0.25-0.3	15	10000	1.0/1.5	0.25
12	1	0.25-0.3	15	10000	1.0/1.5	0.25
13	1	0.3	40	10000	1.0/1.5	0.25
14	1	0.35	25	10000	1.0/1.5	0.25
15	1	0.22	25	10000	1.0/1.5	0.25
16	1	0.3	25	10000	2.0/1.5	0.25
17	1	0.3	25	10000	0.4/1.5	0.25
18	1	0.3	25	14000	1.0/1.5	0.25
19	1	0.3	25	12000	1.0/1.5	0.25
20	1	0.3	25	10000	1.0/1.5	0.25
21	1	0.3	25	8000	1.0/1.5	0.25
22	1	0.3	25	8000	1.0/1.5	0.15

For each test run, 100 sheets were printed (after initial set-up running), which were dried at room temperature 2 days in the pressroom.

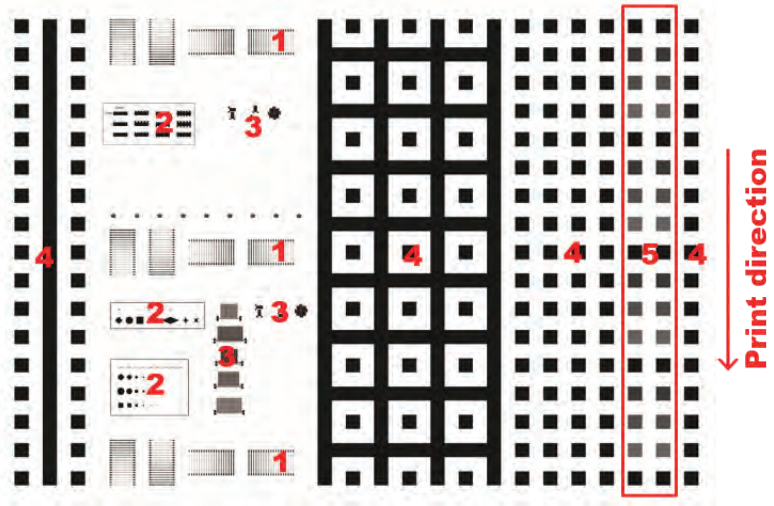


Figure 4: Sheet layout in format 1050 × 750 mm for printing experiments: 1 – circuit paths; 2 – visual control elements; 3 – sensor elements; 4 – full tone fields; 5 – half tone fields (10–100 %); print direction shows direction of sheet running in the offset printing press, in other words, the leading edge of the print sheet is shown in the lower edge of the image

based ink for offset printing (including dampening) was used. The printing layout is shown in Figure 4.

To proof the different visual and functional properties, different printed elements were included into the layout: sensor elements, circuit paths, full tone fields and lines, half tone fields (10–100 % in 10 % step) and some elements for visual control of the print quality (Figure 4).

Four speeds were applied on the printing press: from 8000 to 14000 sheets/h in steps of 2000 sheets/h. To avoid any additional stress effect on the metal layer, the dryer was off. To analyze the influence of glue amount and dampening on the conductivity of cold foil areas, the supply of glue and dampening was varied. The tension of the cold foil web was defined between 0.4 N/cm and 2.0 N/cm. The engagement between the pressure cylinders in the cold foil transfer unit were chosen between 0.15 mm and 0.25 mm (line width of engagement). The value of powder was constant at 5 % as well as the draw-off angle of the cold foil roll during the manufacturing process. The exact settings of the printing experiments are listed in Table 1.

3. Measurements of electrical sheet resistance

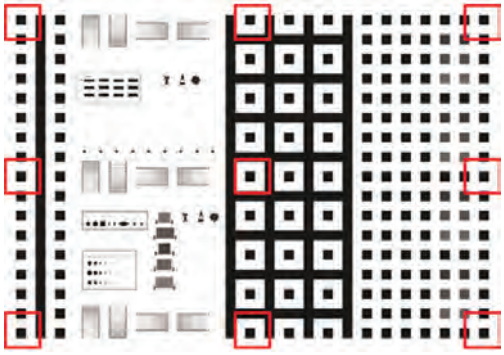


Figure 5: Layout of the printed sheets; fields selected for the measurements are marked with red frame

Figure 6: Designation of position selected fields on the printed sheets

To investigate the electrical conductivity of the printed cold foil samples, each 10th printed sheet was taken from each test run (in total 10 printed sheets/test run). On each printed sheet nine areas were defined: three on the leading edge of the printed sheet (gripper side, C-positions), three in the middle (B-positions) and three on the outside edge (A-positions) (see Figure 5 and Figure 6). In total, 1980 samples 2 × 2 cm in size were taken for the analysis.

As the printed cold foil elements are provided on the upper side with a protective insulating layer, the challenge was to measure the electrical resistance of the aluminium layer in spite of this protective layer. Etching of the protective layer of the cold foils (Egitto, 1990) similar to the hot stamping foils in a plasma system (Lyashenko, Salun and Doersam, 2012) proved to be less practical because of long etching times needed (more than 120 minutes) and also because of the large number of samples. In addition, there is a problem with the electrical sheet resistance measurements based on a 4-point measurement method (Van der Pauw, 1958) that were not plausible by reason of the sharpness of sensory needles of the measurement station and because of the very thin metal layers of the cold foils (Figure 7) that were frequently destroyed by the sensory needles (Lyashenko, Salun and Doersam, 2012).

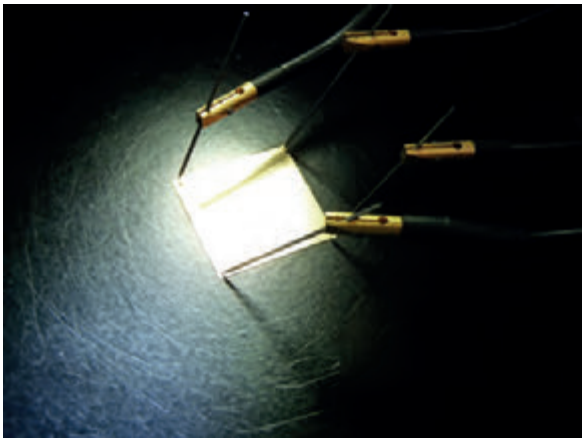


Figure 7: Sheet resistance measurement of a printed cold foil sample on the 4-point measurement station

As an alternative to the 4-point measurement method, the eddy current measurement method was selected, which is often used in semiconductors industry (Claeys et al., 2006; Schroder, 2006). The contactless sheet resistance measurement system SRM-14TSS of company NAGY Messsysteme GmbH (Figure 8) works on the eddy current principle, in which the test object is placed in the magnetic field of the coil of a high-frequency circuit. As a result, both the specific electrical resistance and the sheet resistance of the measured

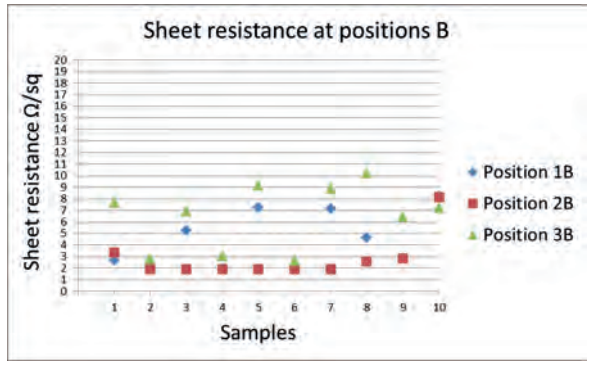
object can be determined. In addition, the special manufactured NAGY system SRM-14TSS allows a visual inspection of the homogeneity of the samples and the metal layer of the cold foils through a built-uniformly illuminated field.

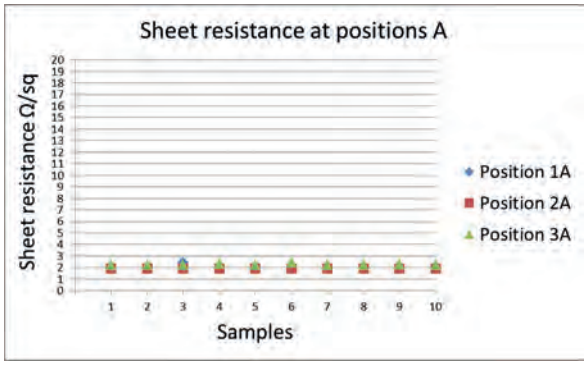
With the NAGY system SRM-14TSS the printed cold foil samples were measured without contact and without removing the protective layer. The sheet resistance was determined for each sample using a circle measurement area with a diameter of 15 mm. The measurements of the sheet resistance were performed once for each sample.

Figure 8: The contactless sheet resistance measurement system SRM-14TSS of company NAGY Messsysteme GmbH (NAGY, 2014)

4. Statistical analysis

For the evaluation, 1980 printed cold foil samples with eight input variables (settings of the printing experiments) were measured. This is a high amount of data, which is most useful to judge by a statistical method of analysis. The analysis was performed using the software Cornerstone version 5.1. Using such an analysis it is possible to determine the influence of individual input variables, the square of the input variables and the influence of the combination of the input variables on the conductivity of the cold foil metal layers (output variable). In the investigated case, the conductivity was measured indirectly by measuring the sheet resistance values (Figure 9).





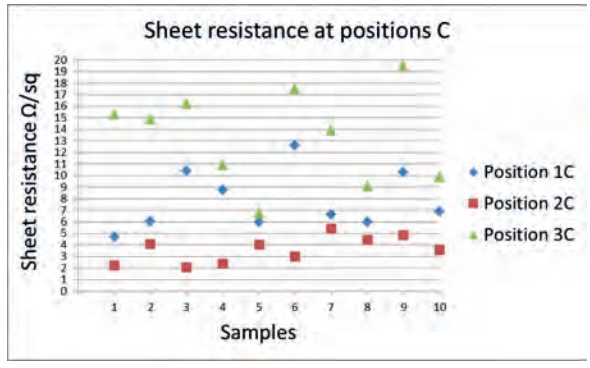


Figure 9: Sheet resistance values of cold foil samples for test run number 14 at positions A, B and C (Type 1 cold foil material); for the positions 1A to 3C see Figure 5 and Figure 6

5. Results

The sheet resistance values of 1980 printed cold foil samples were distributed between 1.76 and 38.15 Ω/sq with a mean value of 4.52 Ω/sq. In Figure 9 the measurement results of the sheet resistance for test run number 14 (see Table 1) at positions A, B and C of printed cold foil samples of the Type 1 cold foil material are shown.

Ten different samples for every position were measured. By regression analysis using Cornerstone 5.1, a coefficient of determination (Jann, 2005) of 0.7380 was obtained after data transformation. This value shows that 73.8 % of the sheet resistance values can be explained with the help of the achieved regression model. In other words, the coefficient of determination of 0.738 is the ratio between the variation of the regression model and the variation of measured values of the sheet resistance; 26.2 % of the variation of sheet resistance values cannot be explained by the regression model.

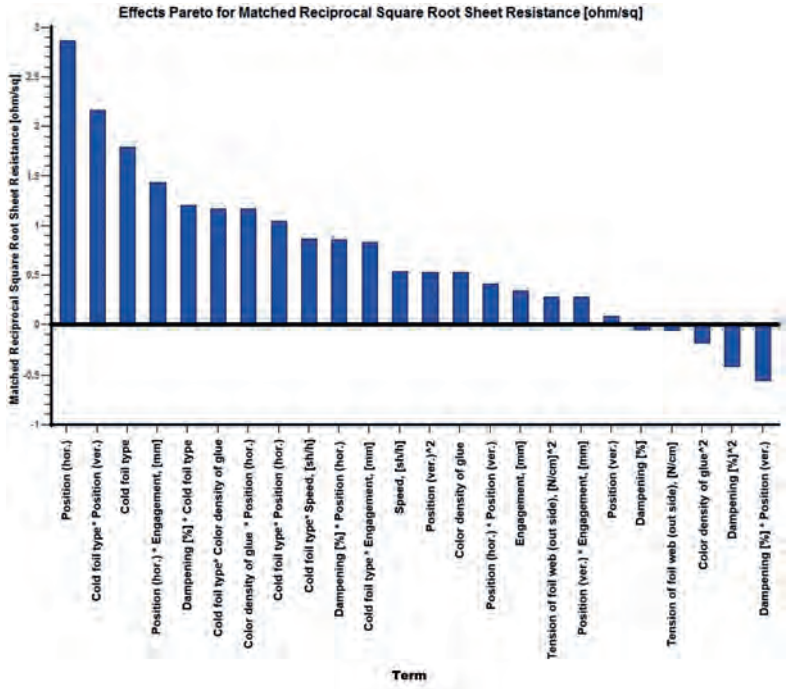


Figure 10: Chart Effects Pareto for the influence of input variables (printing setting) on the examined output variable (electrical sheet resistance of printed cold foil samples)

To examine the influence of input variables on the examined output variable the chart "Pareto Effects" (SAS, 2012) was created (Figure 10). The highest positive values indicate the greatest influence among the input variables measured on the sheet resistance values. From left to right, the influences of the input variables drop. The lower the absolute height, the lower the influence on the output variable. Negative values mean an inverse influence on the output variable. From the regression analysis a total of 53 terms were created; 29 terms in the regression model were not taken into account because the probability of error exceeded 10 %, as described is SAS (2012).

Following the rules of statistical analysis, terms in the model with an error probability of over around 10 % were eliminated. Amongst those were linear, quadratic and interaction terms, e.g. the tension of the foil web (upper side i.e. incoming web) and other inputs.

The diagram in Figure 10 shows the following results. The terms such as horizontal position of the printed cold foil samples on the printed sheet and cold foil material itself, have the highest influence on the sheet resistance values. If the cold foil material is changed, the sheet resistance is strongly affected. The term "vertical position" has a minor influence on the sheet resistance values. The variation of this term results in a small change in the sheet resistance. Similarly, the sheet resistance can be reduced only slightly when the dampening or the tension of foil web (outer side) are slightly increased. This means a small increase in the conductivity.

The statistics histogram was used to check the normal distribution of the measured values (Figure 11).

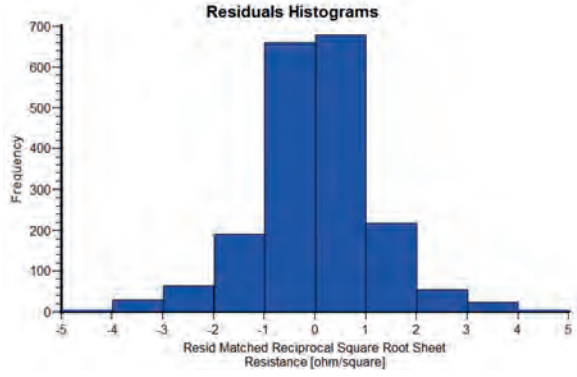


Figure 11: Residuals Histogram for distribution of the measured sheet resistance values of printed cold foil samples

In addition, a so-called Residuals Probability Plot was created (Figure 12). This plot resolves the weak spots of the histogram. It shows the distance between the measured values and the standard normal probability distribution. By performing this evaluation, the measurement data were transformed in order to reduce the outliers of the measurement values and to produce a meaningful Residuals Probability Plot.

The central range of the regress values fit very well to the normal probability distribution. The values at the beginning and end of the curve, however, depart from normal distribution. In this case there is the so-called

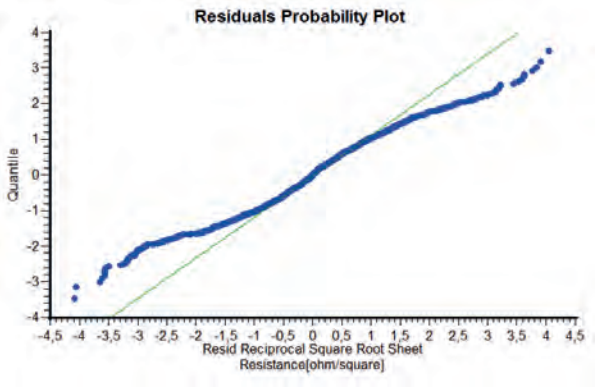


Figure 12: Residuals Probability Plot for distribution of the measured and then transformed sheet resistance values of printed cold foil samples

"heavy tails" (poor fit), since the extreme residuals are higher than expected in the case of the normal distribution. The extreme residuals can be explained by the measurement error, which could arise from various causes. One of them is the layer homogeneity of the printed cold foil samples that was checked on the additional illuminated field of the NAGY system SRM-14TSS. In some samples some cracks in the metal layer could be seen (Figure 13), which strongly depended on the position of the samples on the printed sheet. The horizontal positions A, at the gripper edge, provided stable and smaller sheet resistance values, while in the horizontal positions B and C they were up to 23-fold higher.

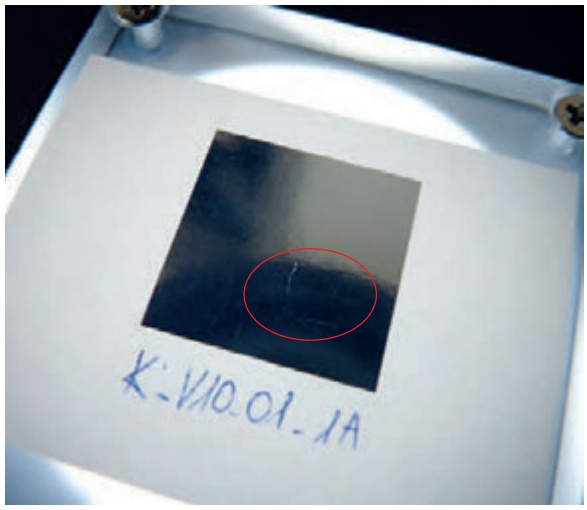


Figure 13: A printed cold foil sample on the illuminated field of the NAGY system SRM-14TSS with a marked position of a crack in the metal layer

6. Discussion

The following criteria are considered to be important for using cold foil transfer processes for printed electronics: first, the electrical conductivity (in the investigated case, sheet resistance values in Ω/sq) and second, the reproducibility and reliability of such metal layers, especially depending on different printing process settings.

The experiments and the statistical analysis have shown several interesting points that should be considered in future research and applications:

- The sheet resistance values were distributed inhomogeneously over the printed sheets depending on the horizontal position of the samples. The samples on the trailing edge (A-positions) of the printed sheet had low and homogeneous sheet resistance values (around 2 Ω/sq). On the contrary to this, high and varying sheet resistance values were recognized in the middle and on the leading edge of the printed sheet (B- and C-positions). It should be noted that this was depending on the printing process. Probably, the engagement was distributed inhomogeneously over the sheet. This influenced the distribution of the adhesive layer as well as the quality of the transferred cold foil material. The visual quality of the printed cold foil layer with regard to the homogeneity was to a certain extent influenced by tiny cracks in the metal layer that were observed in almost all cold foil samples mainly located on the leading edge and in the middle of the printed sheet (B- and C-positions). Additionally, influences such as deformation of the printed sheet during the printing process can be a reason for the layer cracks. In contrast to the horizontal position of the cold foil samples, the vertical position on the printed sheet had a small influence on the sheet resistance values.
- Another important parameter in the analysis of the measurement results is the cold foil material itself. The measurement results indicate that the Type 1 cold foil material shows more stable and smaller sheet resistance values and less metal layer defects such as cracks. The basic electrical resistance value was highly dependent on the type of the cold foil material. Parameters such as homogeneity, thickness and density/porosity of the metal layer can be enumerated that might influence conductivity as well as the ease of transfer under the influence of the glue. One has to admit that such transfer materials are made for graphic applications only and are by far not intended to manufacture electronic devices.
- Almost any change in the printing setting has resulted in a change of the measured values. The color density of glue corresponding to the glue layer thickness and the printing speed continue the list of the most influential parameters by cold foil transfer process. An increase of these parameters has led to an increase of sheet resistance.

7. Conclusion

In summary, it can be said that cold foil transfer technology is an additional candidate for applications in functional printing. The printed metal layers exhibit reasonably good conductivity and sheet resistance values in Ω/sq-range at least for applications where electric current is not that crucial (e.g. for capacitive-related systems). Furthermore, a way to optimize the homogeneity of the cold foil printed samples over the printed sheets should be found. Therefore, the investigation of different glue types for the printing process and different cold foil engagements on the out and up side of the printing unit could be helpful. To understand the role of the cold foil materials themselves, a systematic investigation of the cold foils currently available on the market needs to be performed.

At this time, only cold foil materials for graphic arts applications with a thickness in the range of 20 nm and below are available. Therefore, another option for the cold foil manufacturers might be to develop further quality grades (e.g. aluminium layers with higher thickness) optimized for electronic functions to achieve higher values of conductivity for a broader range of electric applications. In parallel one then has to investigate and optimize the transfer process for thicker aluminium layers anew.

A further interesting point is the investigation of various applications of electronic components such as circuit tracks, capacitors or sensor elements manufactured using cold foil transfer technology. Because of the given measuring system, only solid areas could be investigated in this research. In case of circuit tracks, however, one might study the currently achievable resolution of the printed elements with special pattern designs without using the contactless measuring method that is suitable for areas elements only.

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A novel method to determine register variation of a press by a densitometry tool

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Abstract

The print quality of a printing machine highly depends on good register variation values. The measuring of register variation is very important for putting a multicolor press in operation or for its repair and service. The manufacturers of print presses also need the evaluation of register variation to develop new products. The current industry standard method for measuring the register variation is based on image processing, which is a very expensive method. It was a great demand to determine the register variation by an alternative and affordable technique. In the present paper we introduce a new method to determine the register variation based on densitometry. In order to create a new method, a special color test target has been designed. The input of the method is the densitometric measurement values, and its output is the register variation value. The results of the method have been compared with those of an image processing method and the correlation coefficient between the results is almost 0.9. Since in the proposed method only a densitometer is needed, it can be considered as a very inexpensive alternative to the image processing methods. The results were also demonstrated to different specialists of a manufacturer of print press and received very positive feedback.

Keywords: sheet-fed printing, printing press, print quality, Neugebauer equation, Murray-Davies equation

1. Introduction

There are a number of factors that affect the print quality. Different tests and testing forms help to carry out the quality defects and help to control the printing process (Jang et al., 2004). The register variation during printing production is one of the most important print quality criteria. It is important not to confuse the terms register variation with registration and mis-registration. Hence in the following paragraph we give a short introduction to these terms.

In color printing, registration is the method of correcting the superimpositions of colors in halftone print. Mis-registration occurs when one or more colors in a set are not aligned. The mis-registration should be minimized during the make-ready time, and if it is in an acceptable range, then the printing production can begin. According to the standards, developed by International Organization for Standardization (ISO) for offset lithographic printing, the mis-registration should be less than 100 μm (excluding newspaper printing) between two or more colors (ISO 12647-2/13 and ISO 12647-3/13, 2013). There are different forms of register marks designed in order to check the accuracy of the registration. Manufacturers of printing presses offer to install an automated inline registration and register control system for adjusting the mis-registration on the modern offset presses (Otto and Rolf, 2005; Hauck, 2003; Blasius, Korinek and Reithofer, 1991). The register control systems have an accuracy of 30 to 50 μm by building an average value after measuring 10 to 80 printing sheets. Register variation occurs when the transportation of a printing substrate is not accurate from one printing unit (PU) to the next one. In a wet-on-wet printing (e.g. offset) register variation leads to doubling which causes visual color variation from one sheet to the other one. Register variation occurs because of some technical factors such as high printing speed, instability of the substrate, dampening, etc. Although attempts have been made to reduce the register variation (Hauck, 2007a to 2007e and 2008), in practice it is impossible to achieve a register variation value equal to zero. The tolerance and parameters of the register variation are given by German

Print and Media Industries Association (bvdm, 2002). For example, the standard deviation of register variation in the circumferential direction (press direction) from the first printing unit (PU1) to the last one has to be less than 19 µm for a 10-color offset printing press.

Obtaining a logical and acceptable register variation is a big challenge for all printing press manufacturers. Therefore it is very important to attain an acceptable tolerance of register variation in multicolor printing (bvdm, 2002; FOGRA, 2005). The commonly used method for measuring the register variation is based on image processing, which is a very expensive method. For example, the basic version of the register measuring system (LUCHS, 2014; Loh, 1998 and 2006) costs around 35.000 €. Therefore, there is a great demand to evaluate the register variation by an alternative inexpensive and affordable automatic technique. The authors of this paper previously introduced a new method for measuring the register variation (Hauck and Gooran, 2011). This method is based on spectrometry (CIE-XYZ tristimulus values) and gives similar results to the image processing method although it is much less expensive. However, some printing presses and ink inline control system manufacturers, such as manroland, KBA, QuadTech, and Grapho Metronic use a densitometry tool. The densitometry measuring is also faster than spectrometry and the measuring time is very important especially for the high speed running web presses. Therefore, there was a need and we were asked to modify our previous model to a densitometry-based method to be used in the presses that use a densitometry tool. In this paper we don't intend to discuss the pros and cons for densitometry or spectrometry in controlling the press. In the present paper a novel method to determine a metric value for the register variation based on densitometry is proposed and examined.

The aim of this paper is to propose an alternative method for the measuring of register variation of a printing press. Please notice that the measurement of the register variation will happen during the print production and has nothing to do with the registration and its tolerance during the make-ready phase.

First, in the present paper, a short description of the image processing method is given. Then authors' novel method to determine the register variation is described in detail. Finally, the experimental results of the proposed method are compared with those of the image processing method.

2. Image processing method

The image processing method is the industry standard to semi-automatically determine the register variation. LUCHS is the most known image analysis based device. In the following, this method is briefly explained although it is not described in detail by the PIDSID-Institution (the manufacturer of LUCHS) how the LUCHS method works. However, it is known that the device produces a high-resolution image of the measuring element shown in Figure 1 (LUCHS, 2014).

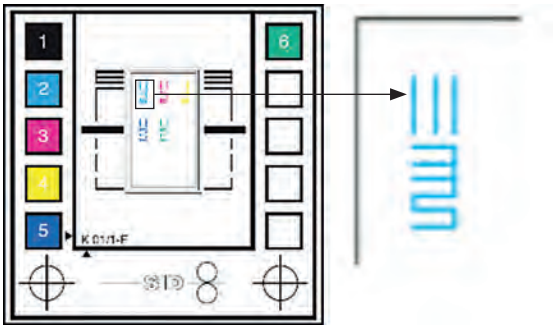

Figure 1: LUCHS measuring element and an enlargement of a part of it

The frame in Figure 1 is printed in the first printing unit (PU, in this example black) and the horizontal and vertical lines (Luchs, 2014) are printed in the following PUs (in this example cyan PU2, magenta PU3 and so on). The pixel positions of the horizontal and vertical lines will be determined and compared to those of the black frame.

Figure 2 illustrates the simplified work principle. The black frame ("F" in Figure 2) is for example about 1 × 1 mm. Line "a" is a horizontal base line printed in PU1 and "b" is a reference line printed in PU2. Now a high-resolution camera system takes an image of the frame and the reference line using for example 1000 × 1000 pixels. That means in this case it automatically gives a metric unit, i.e. 1 pixel/µm. The register value in the circumferential direction is defined as the distance between these two lines (lines "a" and "b"). Now, by measuring this distance in two consecutive printed sheets the register variation can be determined by taking the difference between these two register values.

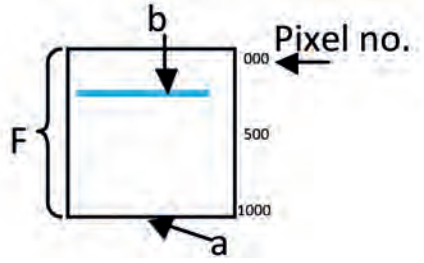

Figure 2: Simplified work principle of the image processing for evaluating the register variation

The register variation in the lateral (sidewise) direction is determined accordingly, decided by the vertical lines. The result of evaluating the register variations is illustrated by a graph and the calculated standard deviation. Notice that the absolute register value in each sheet is not so important for putting the press in operation or repair. The shape of the register variation distribution for a set of evaluated sheets is more important and the most important factor is their standard deviation. For more detail please see (LUCHS, 2014; Loh, 1998 and 2006).

3. Proposed method

3.1 Design, assumptions and restrictions

The goal of the proposed method is to determine the register variation by only using a densitometry tool. In order to do that a special and advantageous color stripe is needed. Figure 3 shows a sample for such a stripe for measuring the register variation between the second and the third PU. This figure illustrates an enlargement of the advantageous color stripe, which consists of solid patches (C_{solid}, M_{solid}, B_{solid}), and patches including single printed (C_{BaseL} and M_{RefL}) and partly overlapped lines and gaps (B_{olapL}). C, M and B stand for cyan, magenta and blue (magenta on cyan), respectively. How the width of these lines is chosen will be discussed later in this section. These patches are printed in two different printing units; in this example cyan is printed in PU2 and magenta in PU3. Generally the register variation is determined between two consecutive PUs (e.g. PU2 and PU3) or between the first and the last PU (e.g. PU1 and PU4 for 4-color printing).

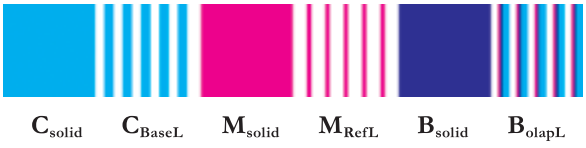

Figure 3: The enlargement of the measuring color stripe for the proposed method

The register deviations occur because of the inaccurate transportation of the printing substrate from PU2 to PU3. When the consecutive printed sheets are compared to each other, a variation of the position of the base lines to the reference lines can be visually observed (by using a 50× magnifying glass). Figure 4a illustrates an enlargement of a part of the partly overlapped lines (B_{olapL}) in Figure 3. Figure 4a shows the overlapped lines as they are designed in the prepress file and Figures 4b and 4c illustrate how they would look like if register variation occurs in two different directions.

So the width of cyan lines, blue lines (overprinted area), magenta lines and unprinted white gaps vary for different sheets related to the amount of the register variation (Figure 4). Of course, the width of these lines also corresponds to their coverage.

In the proposed model, the coverage of the lines (cyan, blue, magenta and the white gap) is determined for each printed sheet. Our focus in this part is on the vertical lines for the lateral register variation but a similar color stripe is designed using horizontal lines for the register variation in the circumferential direction.

Figure 5 shows an enlargement of a part of the single printed and the partly overlapped lines in the designed color stripe in the prepress file. As seen in Figure 5a the width of the basis line (cyan) and unprinted gap (white)

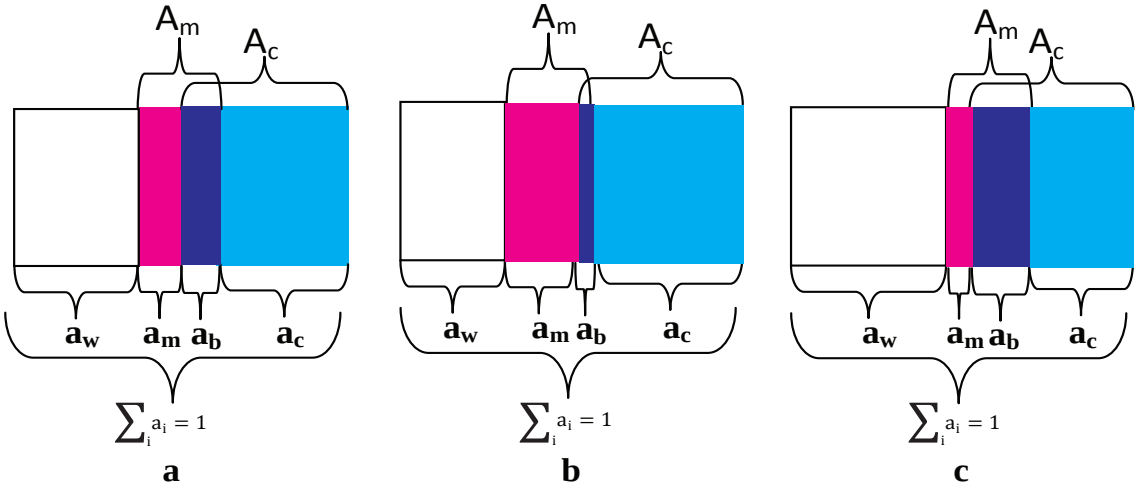

Figure 4: a) The overlapped lines in the prepress file and after make ready in the print; b) and c) the overlapped lines if the register variation occurs in two different directions

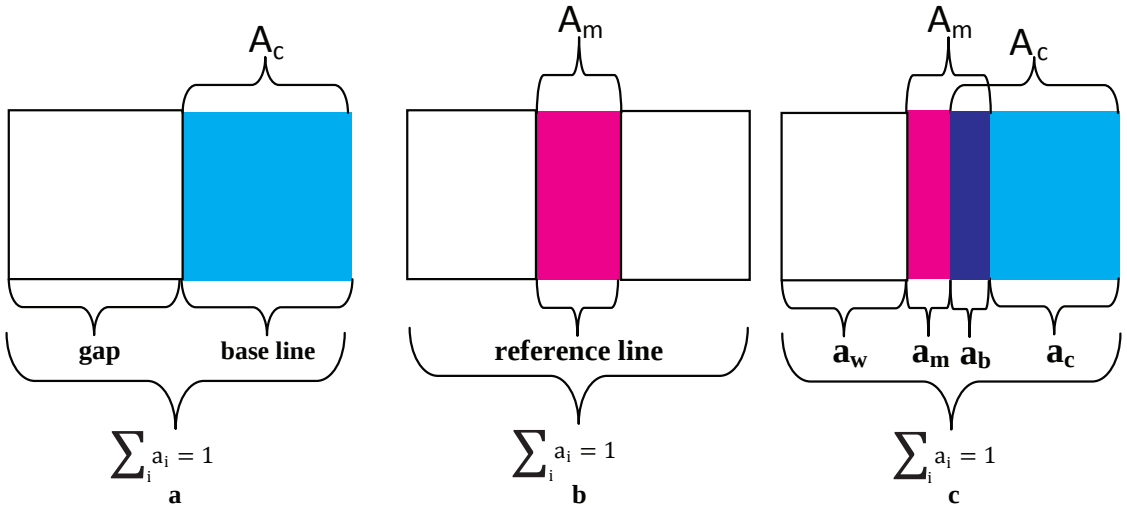

Figure 5: Enlargement of a) base line (C_{BaseL}), b) reference line (M_{RefL}) and c) partly overlapped (B_{olapL})

are equal and correspond to the area coverage 0.5 or 50 %. The width of the reference line (magenta) and the unprinted gap corresponds to 0.25 and 0.75, respectively, see Figure 5b. In Figure 5c, the width of the overlapped area (blue) corresponds to 0.125. The width of pure cyan, pure magenta and the unprinted gap correspond to (0.5 – 0.125 = 0.375) and (0.25 – 0.125 = 0.125), and (0.5 – 0.125 = 0.375), respectively.

The variation in the width of cyan (corresponds to a_c), blue (a_b), magenta (a_m) and paper (a_w) lines in Figure 5c due to register change can be used to determine the amount of the register variation. However, in this study we use the variation of the width of blue line (corresponds to the coverage a_b) to determine the register variation. Notice that a_c, a_b, a_m and a_w denote the coverage of the corresponding color, which are proportionally related to their width. According to Figure 5c, the working range of this system to detect the register variation corresponds to 12.5 % in each direction (left or right). In this design the width of the cyan lines and magenta lines in Figure 5a and 5b are 128 and 64 µm, respectively. This means that this design is able to detect the register variation up to 0.125 × 256 = 32 µm in each direction, which means a total register variation of 64 µm. Normally, this working range is enough to put the press in operation (FOGRA, 2005 and bvdm, 2002). It is possible to expand the width of the lines and the unprinted gaps in the design to increase the working range if demanded. In our experiment a densitometry tool with a measuring spot of 3 mm in diameter was used. If there is a need to increase the width of the lines then we recommend using a measuring spot bigger than 3 mm in diameter.

Here we need to add that the width of magenta lines is chosen to be less than (in this case half) that of the cyan lines to avoid total coverage of the patch B_{olapL} in Figure 3 due to dot gain, which could decrease the dynamic range of the measurement data. We also need to add that the effect of dot gain is included in the equations of the proposed method, see Section 3.2.

3.2 Basic calculations

In Figure 5c, assume that a_c is the coverage of cyan (base line), a_b is the coverage of blue (overprinting area of cyan and magenta), a_m is the coverage of magenta (reference line), and a_w is the coverage of white (unprinted area) after print. A_c is the coverage of the single printed base line, which is determined by measuring C_{BaseL} region in the color stripe, see Figure 3. A_m is the coverage of the printed reference line, which is determined by measuring M_{RefL} region in the color stripe, see Figure 3. Notice that the effect of dot gain is included in the determined values of A_c and A_m because the calculations are based on the measured optical density after print, which also includes the effect of dot gain (Namedanian and Gooran, 2011). It has to be mentioned that the effect of dot gain is taken into account for each printed sheet.

As mentioned before the register variation from sheet to sheet corresponds to the variation of the coverage of the blue lines (a_b).

In Figure 5c it can easily be seen that

$$a_c = A_c - a_b \quad [1]$$
$$a_m = A_m - a_b \quad [2]$$
$$a_w = 1 - A_c - A_m + a_b \quad [3]$$

3.3 Register variation determination based on densitometry

As mentioned before, some printing presses and ink inline control system manufacturers such as manroland,

KBA and QuadTech use a densitometry instead of a spectrometry tool in order to control the press. This method is proposed for these applications.

Let R denote the reflectance value of the densitometer (demonstrated with β in some literatures). The relationship between optical density and reflectance is as follows:

$$R = 10^{-D} \qquad [4]$$

where D is the optical density and is measured with the complementary filter of the overprinted ink (magenta in our experiment). Recall that in this experiment cyan is printed in PU2 and magenta in PU3. We recommend using the densitometer in the absolute optical density mode and for each sheet measuring its own paper's optical density value. This minimizes the additional noise that might occur because of the quality variation of the paper surface.

In the densitometry method the concept of the color stripe in Figure 3 is used. Since it is easier to write the equations using R (reflectance) than D (density) all equations are written using R, which is converted to D at the end. The Neugebauer equation (Neugebauer, 1937) can be written as

$$R_t = \sum_i a_i R_i \qquad \sum_i a_i = 1 \qquad [5]$$

where R_t denotes the total reflectance of the halftone print and R_i denotes the reflectance value of cyan, magenta, blue or paper. For B_{olapL} region in Figure 3, Equation 5 becomes

$$R_t = \left[\left(A_c - a_b\right) R_c\right] + \left[\left(A_m - a_b\right) R_m\right] + \left(a_b\, R_b\right) + \left[\left(1 - A_c - A_m + a_b\right) R_w\right] \qquad [6]$$

where A_c and A_m are calculated by Murray-Davies equation (Murray, 1936)

$$A_i = \frac{R_w - R_i^{Line}}{R_w - R_i^{Solid}} \qquad [7]$$

where the index i is c for cyan and m for magenta and w denotes the unprinted gap (paper). Therefore, R_w denotes the reflectance of the bare paper. The superscript Solid and Line denote the solid and line screened patches for the corresponding color, see Figure 3. For example, R_c^{Solid} and R_c^{Line} are the measured reflectances of C_{solid} and C_{BaseL} in Figure 3, respectively. In our previous work we assumed that the coverage for cyan and magenta lines after print could be different in C_{BaseL} and M_{RefL} compared to their corresponding coverage in B_{olapL}. We observed in all of our experiments that this difference is negligible. Therefore, in the following we don't take that into account.

Equations 6 and 7 give

$$R_t = \left[\left(\frac{R_w - R_c^{Line}}{R_w - R_c^{Solid}} - a_b\right) R_c^{Solid}\right] + \left[\left(\frac{R_w - R_m^{Line}}{R_w - R_m^{Solid}} - a_b\right) R_m^{Solid}\right] + \left(a_b\, R_b^{Solid}\right) + R_w - \left(\frac{R_w - R_c^{Line}}{R_w - R_c^{Solid}}\, R_w\right) - \left(\frac{R_w - R_m^{Line}}{R_w - R_m^{Solid}}\, R_w\right) + \left(a_b\, R_w\right) \qquad [8]$$

Where R_t is the measured reflectance value of the patch B_{olapL} in Figure 3 and R_c^{Solid}, R_m^{Solid}, R_b^{Solid} and R_w denotes the measured reflectance value of the solid cyan, magenta, blue and bare paper. Now, a_b is determined by using Equation 8, which is shown in Equation 9.

$$a_b = \frac{R_t + R_w - R_c^{Line} - R_m^{Line}}{R_b^{Solid} + R_w - R_c^{Solid} - R_m^{Solid}} \qquad [9]$$

Finally, the reflectance values in Equation 9 are replaced by their corresponding optical density values to get

$$a_b = \frac{10^{-D_t} + 10^{-D_w} - 10^{-D_c^{Line}} - 10^{-D_m^{Line}}}{10^{-D_b^{Solid}} + 10^{-D_w} - 10^{-D_c^{Solid}} - 10^{-D_m^{Solid}}} \qquad [10]$$

3.4 Evaluation of the register variation

For the evaluation of the register variation, a number of consecutive printed sheets are needed. Normally, the print machine manufacturers evaluate a series of about 30 to 50 consecutive printed sheets. This number of sheets allows a meaningful evaluation and statistics. Assume that we have a series of measured data of a_b for n printed and measured sheets. The arithmetic average of a_b is determined by

$$\overline{a_b} = \frac{1}{n}\sum_{i=1}^{n} a_b^i \qquad [11]$$

where a_b^i is the coverage of blue (a_b) for printed sheet no. i.

Now the centered and metric transformed value (r_i) of a_b is calculated by Equation 12.

$$r_i = \left(a_b^i - \overline{a_b}\right)\delta \qquad [12]$$

The factor δ is used to transform the centered coverage to a metric amount [μm].

As discussed in Section 3.1, in this experiment the width of a cyan line is 128 μm, which corresponds to the coverage of 0.5. Therefore, a coverage of unity means

$128 \times 2 = 256$ µm and thereby $\delta = 256$ µm. Now the factor δ converts the coverage (i.e. a_b) to a metric unit. For example, if a_b is equal to 0.35 for sheet no. 1 and equal to 0.5 for the consecutive printed sheet (i.e. no. 2) then we will have a shift of 0.15 which corresponds to 0.15×256 µm = 38.4 µm.

4. Experimental results, comparisons and discussions

The graph of the register variation and the standard deviations are the most important data for evaluating and interpreting the register variation of a press. In order to evaluate the proposed method the results are compared with those of the LUCHS method which is the industry standard in the field.

Figure 6 shows the designed test form containing six LUCHS measuring elements and our designed color stripe in the middle. The elliptical marked areas show the needed elements in our experiment. These three marked areas correspond to the three demonstrated patches in Figure 3. This special design of the test form is necessary because of the following reasons. The paper dimension is not absolutely stable. Paper dimension changes during the printing process due to different tensions in different locations of the paper and other parameters, such as the dampening in ratio to the ink. The difference in tensions partly depends on the location of the print subject on the paper sheet. For example, in the locations with high coverage of ink the tension is higher than in the locations with lower coverage. The adhesion power between the ink and the printing blanket and between the ink and the paper cause tension. This tension disturbs the paper dimension, which increases in the high-speed printing. That means this problem should be taken in mind when designing the test form to compare the LUCHS and the authors' method. That is why six LUCHS elements were located in different areas around our color stripe. The comparison of the LUCHS values achieved by these six LUCHS elements is used to determine the paper instability, which is demonstrated in Table 1, column 4.

In the following, the graphic and the numerical results of the LUCHS device and the densitometry methods are demonstrated. For testing and comparing both methods it was necessary to have samples with a high dynamic of register variations. Hence the samples were produced under following printing conditions: The test was carried out using a Roland 700, a sheet-fed offset

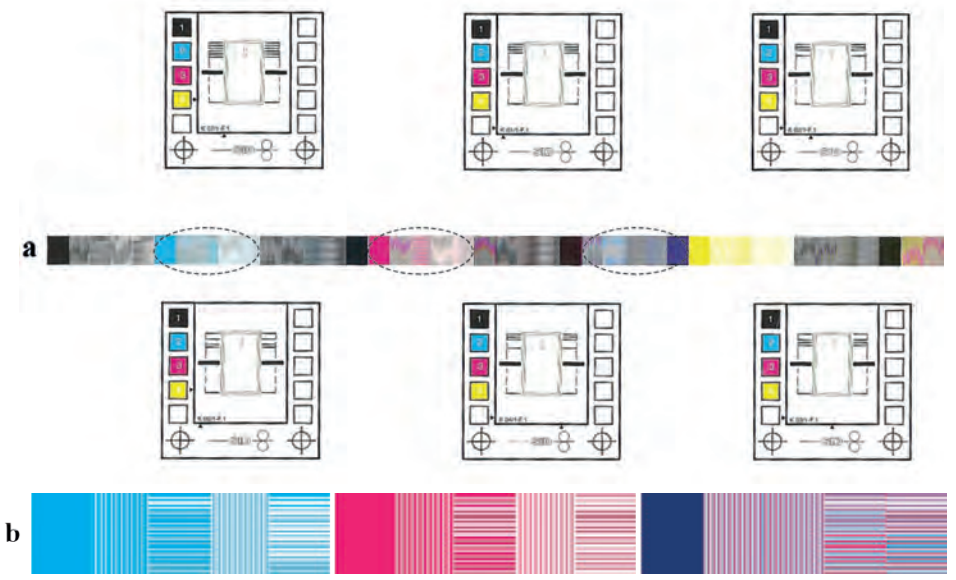

Figure 6: a) The six LUCHS elements are placed around the designed color stripe – the elliptical marked areas show the needed elements; b) the enlargement of the needed elements (these elements correspond to the three demonstrated patches in Figure 3)

Table 1: Up: the comparison of the standard deviation between the LUCHS and the introduced methods; down: correlation coefficients between LUCHS and the proposed methods

	LUCHS method	Densitometry method	Paper instability (LUCHS)
Standard deviation	8.5 µm	8.8 µm	abs [9.2 – 8.5] = 0.7 µm
The linear correlation between LUCHS register values and densitometry register values: 0.87.			

press, installed in manroland Print Technology Center in Offenbach, Germany. The press was accelerated from 8000 to 13000 sheets/hour with open driver shaft. The used paper substrate was a stable both side glossy coated 150 g/m². For the densitometric measurements a Color Pilot from Grapho Metronic (manroland) was used. This experiment was done by experts of a printing press manufacturer. A set of consecutive printed sheets (48 sheets) from this run has been evaluated. Most of the modern sheet fed offset presses have double impression cylinders. Therefore every impression cylinder and every transfer cylinder has two different gripper systems. The register variation value of the consecutive printed sheets will be evaluated separately for the first gripper system using odd and for the second gripper system using even printed sheets. That is necessary for analyzing the register variations of a modern press. Hence the graphics, Figure 7, are drawn using red (odd) and blue (even) curves. Figure 7 shows the graph of the centered registered value in [µm] for LUCHS (S_i) and our proposed method (r_i in Equation 12). For the result of the LUCHS method we used the middle LUCHS element in the upper row. It can be seen that the shape and the characteristic of the curves of the two methods are similar. As discussed in Section 1 the absolute register value of each sheet is not so important. The shape of the register variation for a set of evaluated sheets is more important and the most important factor is their standard deviation (FOGRA, 2005 and bvdm, 2002). In Table 1, the standard deviation and the linear correlation of the two methods are shown. The difference of the standard deviation between the two methods is only 0.3 µm, which is very satisfying in comparison to the range of the register variation (FOGRA, 2005 and bvdm, 2002). The correlation coefficient value between LUCHS and the proposed method is also shown in Table 1. The achieved correlation coefficient values are close to 0.9, which shows a satisfactory correlation between the methods. In order to figure out the instability of the paper surface we even compared the results of the LUCHS method using the six LUCHS elements. We took the arithmetic average value of the LUCHS elements and compared it to the results of the middle LUCHS element in the upper row. As seen in Table 1, this difference is about 0.7 µm.

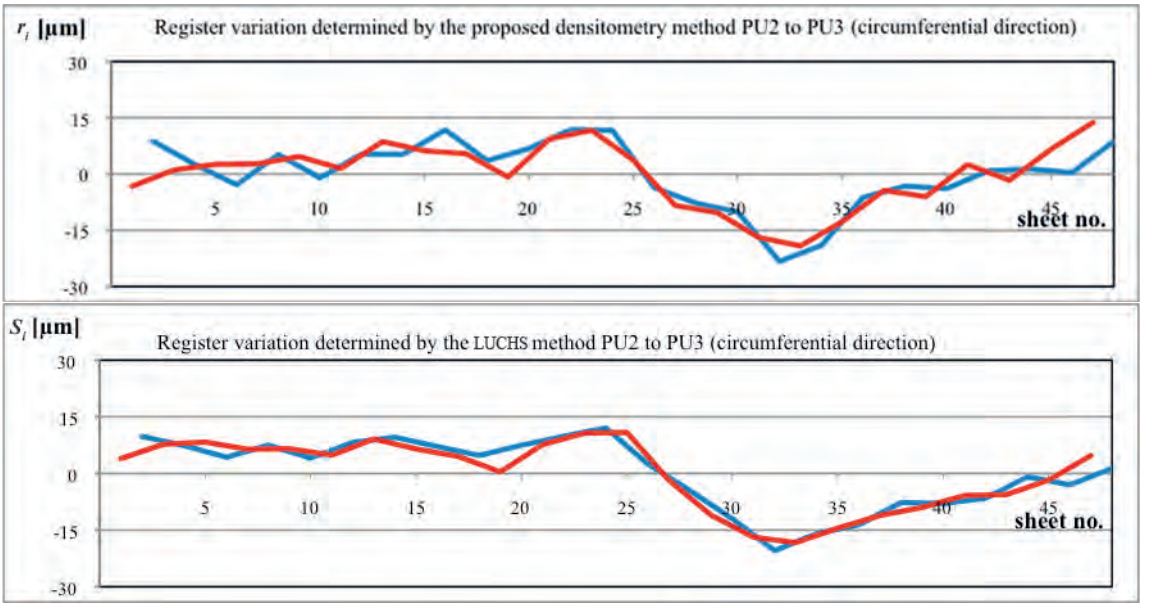

Figure 7: The comparison of the register variation graphics between the LUCHS (s_i) and the proposed method (r_i); the red curves demonstrate the odd and the blue ones the even results of the register position

5. Conclusion and discussion

As demonstrated, the achieved results of the proposed method are comparable to the image processing method. The proposed method can be applied to all other offset printings (web offset printing) because it is the same optical principle in the measurement methodic and generally the print quality of the lines (base and reference line) in sheet-fed and web offset printing is comparable. However, at the moment this method has only been tested for offset printing. Whether this method can be applied to determine register variation for other printing processes, such as flexography, screen printing and gravure printing, is going to be investigated in future work.

The register variation can be determined in any printing company dependent on their measuring equipment, either the Densitometry method (presented in this

paper) or the Spectrometry method (Hauck und Gooran, 2011), can be used. The needed measuring tool is available in almost all printing companies. The biggest advantage of the proposed method is that it is less expensive compared to the image processing method. Dependent on the paper size and the number of LUCHS elements and evaluated sheets the image processing method can be time consuming and not ergonomically satisfactory for the operator. In a press with ink inline control system using a densitometric system, the evaluation of register variation can be done automatically. Therefore, the proposed method in combination with inline ink control press can be fully automatic, which saves time, human resources and costs.

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Effects of awareness to security features on the confidence in banknotes

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Abstract

The value of a banknote is dependent on people's subjective trust in the banknote, and the resistance against counterfeiting is a key factor of people's confidence in the banknote. An experiment was conducted to investigate the relationships between the awareness to security features on banknotes and the perceived resistance against counterfeiting in those banknotes. It was found that the more security features subjects found by themselves on a banknote, the more resistant they perceived the banknote, which suggests that people's awareness to security features affects their confidence in the banknote. The perceived resistance was irrelevant to the number of public security features disclosed by the central banks, but was relevant to the familiarity to the note, which suggests the importance of practical experience with banknotes rather than the knowledge about them only. These findings can give a quantitative ground to the evaluation of the design of security features on banknotes.

Keywords: banknote, security printing, counterfeit deterrence, image quality

1. Introduction

A banknote doesn't have the same use-value as its face value. For example, if you used a €100 note as a tissue paper, its use-value would be the same as a piece of tissue paper, probably less than a cent, even though the face value is €100. Actually, the usability of banknotes as tissues would be terribly poor, and they don't have any practical use-value. The production cost of a banknote is much less than its face value (de Heij, 2010). A €100 note is actually produced at the cost of only €0.07. A €100 note has the value of €100 just because people exchange the note with another commodity that is worth €100. The exchange value of a banknote as the face value is guaranteed by people's trust in the banknote. There are a number of factors affecting people's confidence in a currency including the money supply in the market and the monetary policy of the central bank, and the resistance of the banknote against counterfeiting is an important factor. Even if a banknote is hard to counterfeit physically, people won't accept it unless they *believe* that the note is hard to counterfeit. Confidence in currency is a subjective matter of people's trust in banknotes.

There are a number of security features on a banknote. Security features are often categorized to three levels (Wielandt, 1998; Heinonen, 2007). Level 1 features are overt features that are easy to be authenticated by the general public without special inspection devices and proactively advertised by the central banks, which include intaglio portraits, watermarks, security threads, optically variable devices (OVDs) (van Renesse, 2005). Level 2 features need special inspection devices, such as magnifying lenses, ultra-violet lamps, magnetometric sensors, or infra-red cameras, and are for retailors and vending machines. Most of machine readable level 2 features are covert and the central banks are reluctant to disclose them. Level 3 features are covert and used only by central banks and forensic experts with sophisticated analytical instruments. Among these levels, level 1 features are the most important for the general public's confidence in banknotes and specific to banknotes compared to other payment methods, such as checks, credit cards, or electronic money systems. As legal tender, banknotes should be passable in any situation even on the street, and it is desirable that they can be authenticated merely by human senses, without inspection devices.

The importance of human perception studies on the design of banknotes has been recognized for a long time (Croney, 1970; 1974), but very few studies have been reported publicly. Collins et al. reported their perception studies to know how people could discriminate counterfeit U.S. banknotes from genuine notes and what security features were responsible for those decision (Collins, Mayerson and Worthey, 1985). In this report, a series of perception studies by Prof. Ivor Stillitz in 1970s for British pound notes were also reviewed thoroughly. The main conclusion of these studies was that banknotes should be designed to extend the time people spend

observing the notes. Recently, psychophysical studies on the discriminability of counterfeit banknotes from genuine notes were conducted with United States (Hillstrom and Bernstein, 2002) and Canadian (Klein, Gadbois and Christie, 2004) banknotes. These studies revealed people's performance in the detection or discrimination of counterfeits, but their confidence in the banknotes were out of scope of these studies. People's confidence in banknotes has been of interest for central banks of the world, and has been surveyed with Euro in the Netherlands since 2005 and Canadian banknotes since 2004 (de Heij, 2006 and 2007; Visser and Dijkers, 2013; Taylor, 2006). However, these surveys were conducted by telephone interviews without presenting actual banknotes to the participants, thus the relationships between the confidence in banknotes and the sensory perception of security features are still unknown. The indices of confidence in banknotes on average between 2005 and 2011 were 7.1 for Euro notes and 5.5 for Canadian notes out of 10 (de Heij, 2012). However, the index of the Netherlands was measured by the rating in 0–10 scale to one question, and the index of Canada was constructed from the answers to four questions that were extracted from nine questions by a factor analysis. These indices can be used to track the fluctuation of confidence in each country over time, but their absolute levels are difficult to compare to each other between different countries.

In the present study, we investigated how the general public's confidence in banknotes is affected by people's awareness to security features on banknotes. In Section 2, the experimental methods are explained in detail, and the results of the experiment are shown in Section 3. The results are interpreted and discussed in comparison with previous studies in Section 4. Finally, conclusions are drawn in Section 5.

2. Methods

2.1 Overall methodology

The present study tried to reveal the relationship between the people's confidence in banknotes and the awareness to security features on the banknotes. The scale of confidence was constructed from the rank order data of the banknotes according to the perceived resistance of banknotes against counterfeiting. The awareness to security features on banknotes was estimated by counting the number of security features noticed by subjects while they were observing the banknotes freely at hand.

2.2 Materials

Nine banknotes, shown in Table 1 and Figure 1, were chosen on a hit-or-miss basis and used for the experiment. Three of them, RON1, RON50, AUD5, were polymer notes, and the others were paper notes. They had been in normal use, and showed slight wear and tear including folds and wrinkles, but the damage was minimal and negligible.

2.3 Subjects

Sixteen subjects participated in the experiment. They were staff and students of the Faculty of Computer Science and Media Technology at Gjøvik University College, but were not experts in banknote and security printing. They are all color normal, and normal or corrected-to-normal sighted. The youngest and oldest subjects were 24 and 52 years old, respectively, and the average age was 32. Two of them were females. The instructions to the subjects were given both orally and in writing, and were understood clearly. The familiarity to each banknote was inquired to each subject by a questionnaire before each experimental session.

2.4 Procedures

Experimental sessions were conducted in a viewing booth with D50 simulating fluorescent lamps, as shown in Figure 2. The illuminance, measured by Konica-Minolta CL-200, on the tabletop of the booth was 1 400 lx.

Table 1: Banknotes used for the experiment in alphabetical order of the abbreviations; the series shows the first issue year of each note

Abbrev.	**Banknote**	**Series**	**Substrate**
AUD5	Australian 5 dollar	1995	Polymer
CNY100	Chinese 100 yuan	2005	Paper
DKK100	Danish 100 kroner	2010	Paper
GBP10	United Kingdom 10 pound	2000	Paper
INR1000	Indian 1000 rupee	2012	Paper
NOK100	Norwegian 100 kroner	2003	Paper
RON1	Romanian 1 leu	2005	Polymer
RON50	Romanian 50 leu	2005	Polymer
USD5	United States 5 dollar	2008	Paper

Figure 1: Pictures of the banknotes used for the experiment (the inscriptions of "SPECIMEN" were overprinted only to avoid the reuse of these pictures, but were not on the original notes used in the experiment); only the front sides of the notes are shown here, but the subjects were able to observe both sides at will

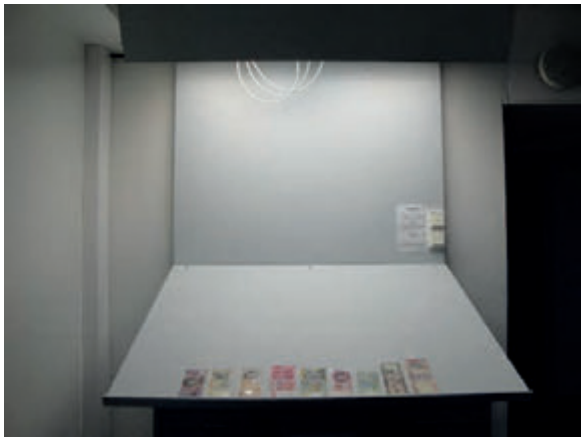

Figure 2: Experimental viewing booth – the tabletop was 120 cm wide, 85 cm long, 24 degree tilted, and illuminated at 1400 lx by D50 simulating fluorescent lamps through a diffuser; the scene was recorded by a video camera from behind

All the nine banknotes were set on the tabletop in a random order before each experimental session. The subject picked up each banknote by hand one by one, and inspected it without time limit. They were allowed to inspect the banknotes in any nondestructive way. The ceiling lamp was suitably installed so that the watermarks were clearly observed by the transmitted light. They reported aloud every time they found any security feature, and articulated whatever they found, pointing out the place of the feature by their fingers. When the oral report by the subject was not clear, the experimenter followed up to clarify what was meant by the report. However, no suggestions or questions to lead the subjects were made. The experimental sessions were video recorded, and the reports by the subjects were transcribed later. In the transcription of the video recording, the number of security features found on each banknote by each subject was counted. When a single physical entity consisted of several security features and the subject pointed out each feature separately, each security feature was counted as one point. For example, when a subject found a security thread and pointed out that the thread was windowed and had an OVD on it, the number of security features with this thread was counted as three points (thread, windowing, OVD). On the other hand, when several security features were pointed out by subject A, and subject B pointed out those features as a single feature as a whole, each security feature found by subject A was counted as one point, whereas the total point given to the features found by subject B was one point, and the point was equally divided to those features. For example, when subject A made a distinction between the background patterns by dry offset press and the portrait by intaglio press, each security feature was counted as one point. On the contrary, when subject B didn't make distinction between the two, and just pointed out the fine detail of overall printing as a security feature, each feature (background pattern and intaglio portrait) was counted as 0.5 point. The security features sought were limited to those detectable only by human senses such as sight and touch. When the subject mentioned features that are machine readable or that need special inspection devices such as a magnifying lens, ultra violet lamp, or chemicals, those features were ignored and not counted.

After the inspections of all the banknotes, each subject ranked the banknotes in an order according to their perceived resistance of each banknote against counterfeiting to be analyzed by the rank order scaling method (Engeldrum, 2000). More "hard-to-counterfeit" banknotes were placed to the left, and more "easy-to-counterfeit" banknotes were placed to the right.

3. Results

3.1 Number of features found

Figure 3 shows the numbers of security features found by the subjects for each banknote. Filled bars show the net number of features without overlap of the same feature. Hatched bars show the average number of the features found by each subject on each banknote. The net number had a large variability with a standard deviation of 4.15 ranging from the minimum of 8 to the maximum of 22. On the other hand, the average number was 3.9 for with a standard deviation of 1.7.

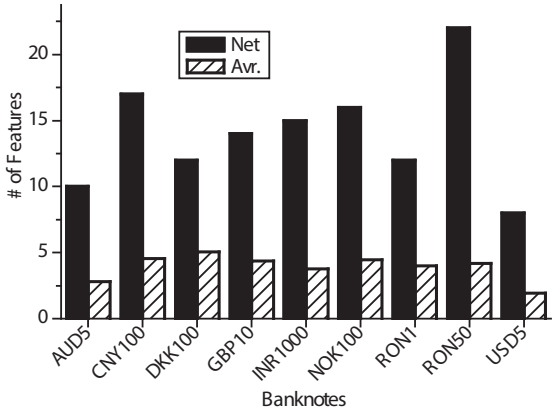

Figure 3: Number of security features found by the subjects on each banknote – filled bars show the net numbers of the features without overlap across subjects found on each banknote, and hatched bars show the average numbers of features found by each subject on each banknote

3.2 Perceived resistance against counterfeiting and number of features

The rank order data were interpreted as paired comparison data (Cui, 2000), and z-scores were calculated as the interval scales (Engeldrum, 2000) of the perceived resistance against counterfeiting for the banknotes using Colour Engineering Toolbox (Green and MacDonald, 2002). The result is shown in Figure 4. The error bars show the 95 % confidence intervals. Danish and Norwegian 100 kroners showed high resistances, which means they were recognized as "hard to counterfeit." On the other hand, Australian and United States 5 dollars were recognized as "easy to counterfeit."

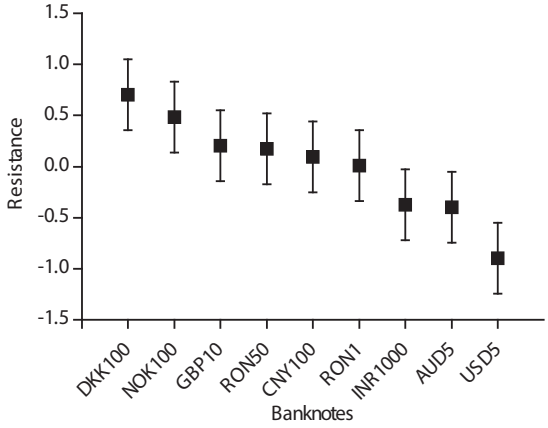

Figure 4: Perceived resistance against counterfeiting of each banknote; the ordinate shows the z-scores calculated as the interval scale from the rank order data; note that the ordering of the banknotes in this figure is according to the perceived resistances of the notes, and is different from those of Table 1, Figures 1 and 3

To know what is affecting the perceived "resistance," the correlation between the z-scores and the number of security features was shown in Figure 5. The horizontal axis of Figure 5(a) is the net number (without duplication of the same feature) of security features found by the subjects on each banknote. On the other hand, the horizontal axis of Figure 5(b) is the average number of security features found by the subjects on each banknote. The net numbers have poor correlation (coefficient of determination $R^2 = 0.2321$; analysis of variance (ANOVA), $p = 0.19$) to z-scores (perceived "resistance"), whereas the average numbers have very good correlation ($R^2 = 0.8769$; ANOVA, $p << 0.01$).

3.3 Effect of familiarity on the banknote

In the present experiment, we had 16 subjects and 9 banknotes (Table 1). Therefore there were 144 pairs

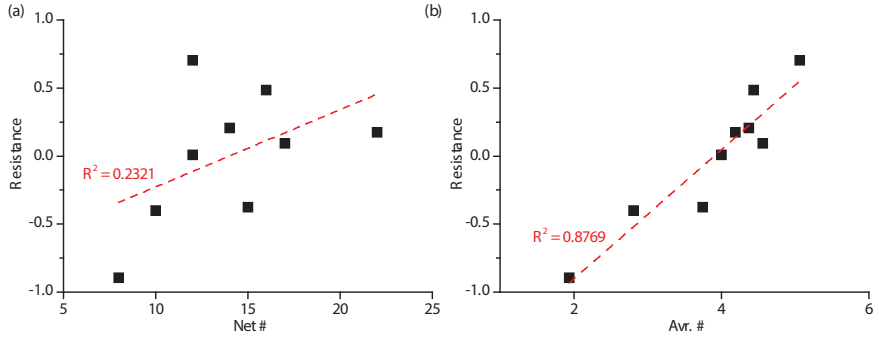

Figure 5: (a) Correlation between the perceived resistance against counterfeiting and the net number of security features found on each banknote; (b) correlation between the resistance and the average number of security features found on each banknote by each subject

of subjects and banknotes. In 38 pairs among them, the subject was familiar to the banknote, that is, the subject are or used to be using the banknote routinely. To know the effect of familiarity to banknote on the number of security features found, the number of security features found by each subject on each banknote was normalized against the average number of security features found on each banknote. Figure 6 shows the result. It shows a slight tendency that the subject found more security features with familiar banknotes than with unfamiliar ones although the difference was not significant (2-tailed t-test, $p = 0.28$).

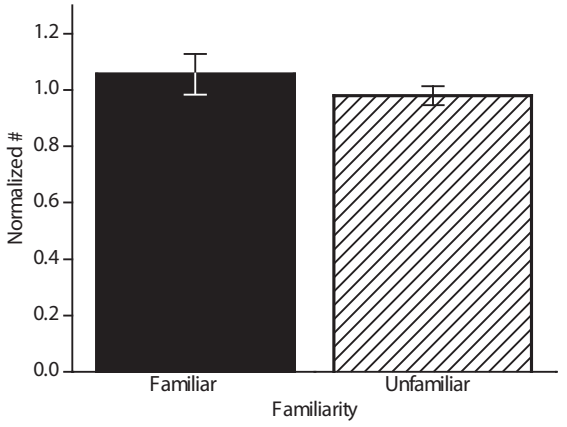

Figure 6: Number of security features normalized against the average number of features found by each subject on each banknote – the filled bar shows the average across familiar banknotes, and the hatched bar shows the average across unfamiliar banknotes; error bars show the standard errors of the means

On the other hand, as shown in the histogram of Figure 7, familiar banknotes (filled bars) are more likely to be assigned to higher ranks than unfamiliar ones (hatched bars), which is statistically significant (Mann-Whitney U-test, $p << 0.01$). Note that each point on the horizontal axis of Figure 7 does not correspond to each banknote, but to the rank of perceived resistance. This histogram shows how many banknotes were assigned to each rank by the subjects for each familiarity. Rank 1 is the highest rank and the most resistant to counterfeiting, and rank 9 is the lowest rank and the least resistant.

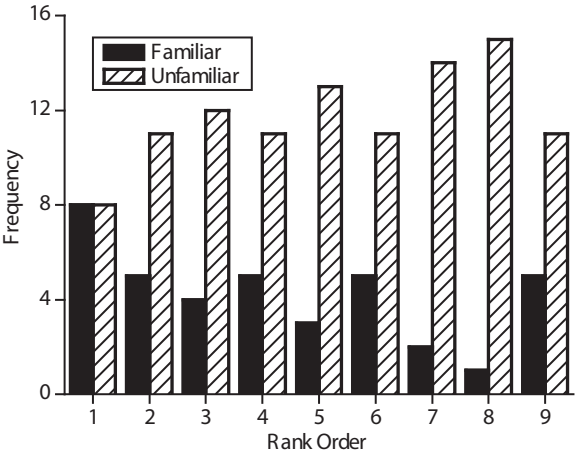

Figure 7: Histogram of the rank orders of the perceived resistance against counterfeiting – filled bars show familiar banknotes, and hatched bars show unfamiliar notes

3.4 Public security features

The numbers of public security features disclosed by the issuing central banks are obtained from their websites (Reserve Bank of Australia, n.d.; Changchun Central sub-branch The People's Bank of China, 2009; Danish National Bank, n.d.; Reserve Bank of India, n.d.; Norges Bank, 2014; National Bank of Romania, 1 leu, n.d.; National Bank of Romania, 50 lei, n.d; Bank of England, n.d.; United States Currency Education Program, n.d.), and compared with the net and average numbers found by the subjects, as shown in Figure 8.

The average number of public features was 7.7, the average number of features found by subjects, 3.9, was almost a half of the average of which. The number of public features had very poor correlation with the actual numbers found by the subjects (Net numbers, Figure 8(a): $R^2 = 0.1553$; ANOVA, $p = 0.29$. Average number, Figure 8(b): $R^2 = 0.0068$; ANOVA, $p = 0.83$). Naturally, the number of public features had no correlation with the perceived resistance against counterfeiting, as shown in Figure 9 ($R^2 = 0.0078$; ANOVA, $p = 0.82$).

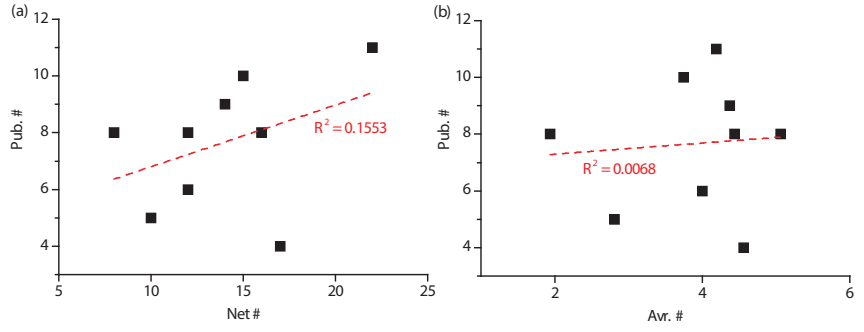

Figure 8: (a) Correlation between the number of public security features disclosed by central banks and the net number of security features found by the subjects; (b) correlation between the number of public features and the average number of features found by each subject on each banknote

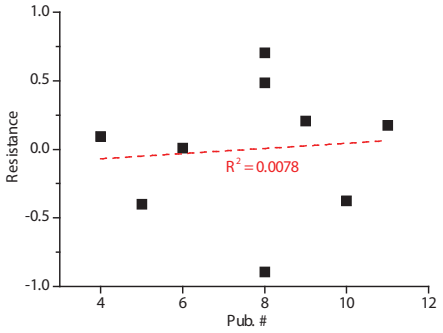

Figure 9: Correlation between the perceived resistances against counterfeiting and the number of public security features disclosed by central banks

4. Discussion

In the present study, the subjects were able to find 3.9 security features in average across all the banknotes tested, which is more than the numbers with previous studies. A research by European Commission's Anti-Fraud Office (OLAF) reported an average knowledge of 1.3 security features with 53 non-expert subjects (Gentaz, 2005). De Nederlandsche Bank (DNB) commissions an opinion poll on euro banknotes every two years (de Heij, 2008), and in the latest 2013 poll, Visser and Dijkers investigated the awareness of security features by telephone interview with a sample of 1 000 persons, and reported that 2.6 security features were mentioned in average across all the age groups, and 3 security features by the age group of 18–35 years old (Visser and Dijkers, 2013). In these studies, the subjects had to answer without observing actual banknotes, whereas in our study, the subjects had banknotes in their hands during the session. The differences in methods and ages of subjects might have caused the difference in the numbers of found security features.

The perceived resistance against counterfeiting of banknotes, which is thought to be one of the key factors of people's confidence in the banknotes, were estimated from the rank order data. The estimated resistance had very good correlation only with the average number of security features actually found by the subjects themselves on each banknote. Even though the average number had a small variance, it explained the variability of the perceived resistance of banknotes very well. No other metrics showed good correlation with the resistance. The more features people find on a banknote by themselves, the more secure or reliable they think it is.

On the other hand, the net numbers or public numbers of security features showed poor correlation with the perceived resistance, which means that even if a lot of security features are designed and installed on a banknote, they won't work unless they are noticed by the general public. Level 1 security features for the general public should be designed user-friendly and self-explanatory (de Heij, 2010; van Renesse, 1998). Banknotes should be designed to lead the users to notice the security features on them by themselves spontaneously. Our findings can give a quantitative ground to this conventional guideline for the design of banknotes, and can contribute to develop metrics for the evaluation of security features and the design of banknotes.

It is often said that people accept a banknote as a genuine one when its quality is high enough. People don't have any mental model of the genuine banknote to be compared with the banknote under reference. The genuineness of a banknote is directly perceived from the note, not from the appraisal by comparing between the test note and the ready-trusted genuine specimen as in forensics. The poor correlation between the number of public features and the perceived resistance supports this view.

Only a half of public features advertised by the central banks were actually found by the subjects in the present study. In addition, the number of public features had very poor correlation with the number of found features. These facts suggests that the information of the general public on security features has limited effect on anti-counterfeiting (de Heij, 2006; Lancaster, 2006; European Central Bank, 2007). On the contrary, familiar banknotes were more likely to have more security features found on them and perceived as more resistant against counterfeiting. These facts suggest that the knowledge alone is not enough to detect security features. If the effect of familiarity to a banknote on the detectability of security features is not a matter of knowledge or a cognitive effect, it can be an effect of perceptual leaning (Kellman, 2002). Previous experience of inspecting the banknote might have improved the ability of subjects to find more security features on that note. Not only knowledge on banknotes but also hands-on practice with actual objects is needed to detect security features, which in turn leads to increase the perceived resistance against counterfeiting. Klein et al. conducted psychophysical experiments in

which subjects discriminated genuine and counterfeit Canadian banknotes, and found that the performance of the subjects was improved even after the subjects just repeated the same discrimination experiment without receiving any informative training as much as the improvement by video or leaflet training (Klein, Gadbois and Christie, 2004), which is consistent with our results.

5. Conclusions

The value of a banknote depends on people's subjective confidence in the note. We investigated the confidence in banknotes from the viewpoint of the perceived resistance of the notes against counterfeiting. We found a correlation between the average number of security features found by subjects on each banknote and the perceived resistance of the note, which suggests that the awareness to the security features on a banknote affects people's confidence in the note. It is also suggested that the awareness to security features on a banknote is irrelevant to the knowledge of the note but is relevant to the familiarity to the note, which implies the need for not only informative education but also perceptual hand-on training with actual samples to improve people's confidence in banknotes. Our findings can give a quantitative ground to a conventional guideline that security features on banknotes should be self-explanatory, and can contribute to develop new metrics for the quality evaluation of banknotes.

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Security offset printing with twin colors by means of CMYF separation

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Abstract

A new method of security printing is introduced in this work, thus creating highly protected documents by ink management in three spectrally separated ranges. A numerical experimental color setting has been developed, considering ink properties in three wave ranges: 200–400 nm, 400–700 nm and 700–1 000 nm. Separation is carried out with process and spot inks, aiming at concealing the graphic in visible spectrum. Such a graphic can be recognized instrumentally in the ultraviolet (F) and infrared (Z) spectra. Extending the Infraredesign method, the ultraviolet spectrum is included through the properties of the dark brown UV ink, thus giving fluorescent green in UV spectrum, while the absorption value is 38 % for parameter Z in the NIR spectrum. A separate, third image is visible by the naked eye. By algorithmic mixing of F-ink, having absorption properties in UV and IR ranges, a unique solution for the security printing of documents and valuables is accomplished. CMYF method differs from the CMYKIR method, since the K ink does not have the same properties, while their Z factor is completely different under the same printing conditions. With this new method – CMYF separation – formulations and standards are set for determining the differences between the original and the forgery.

Keywords: security design, fluorescent ink, document protection, hidden graphics, spectrophotometry

1. Introduction

With the development of the printing technology, printing inks are varying depending on the application: offset printing (Kipphan, 2001), screen printing, digital printing. Current investigations of inks are oriented towards the graphics in the visible portion of the spectrum, which are described with three values: RGB, HSB or CIELAB). With the programming of the structure of graphic elements characteristics of the inks are utilized, thus creating new graphic protections (Schell, 2007). Suggested separation of images on the same print is a new approach of marking and recognizing of visual information by the means of printing technology.

IRD theory (Pap, Žiljak and Žiljak-Vujić, 2010) is based on the characteristic of process inks from the scale: cyan, magenta, yellow and black. C, M and Y inks do not absorb light over 740 nm, while carbon black ink (Pekarovicova and Pekarovic, 2009), besides visible light, absorbs also NIR emission, which is in the range over 740 nm.

In this investigation black process ink is replaced with the visible dark brown UV fluorescent ink (F ink), which has response in three different spectral portions: ultraviolet (UV), visible (Vis) and near infrared (NIR). The novelty is in the investigation of offset printing inks, by which multiple images could be obtained, with the response in the UV, Vis and NIR spectral ranges. After experimental determination of color setting for spot UV and IR inks (Yousaf and Lazzouni, 1995), an ink is developed, which will serve as a hidden protection in two spectra outside the visible area. Such an ink enables indefinite number of methods for the protection of documents (Nickell, 2005). Each following print run of the protected document can have another authorized security design. By the CMYF separation, through the properties of the F ink, the separation is extended to UV, Vis and NIR range.

The objective of this research is production of highly protected document in offset printing, by managing inks in three spectrally separate ranges. With algorithmic mixing of UV and IR inks, an unique graphic solution is obtained for security printing of the protected documents. Within this, a graphic is planned with three different information, deliberately created in one image for the three different spectral ranges. The CMYF method was carried out with offset printing inks with the aim of planning, concealing and detecting of information in the areas outside the visible spectrum.

2. Materials and equipment used

The following materials, equipment and instruments were used in carrying out the experiments and measurements:

- Offset process inks: Huber Rapid Cyan, Magenta, Yellow and Black; Petrel – Black fluo green offset ink 05011
- Offset printing press: Heidelberg Speedmaster 74
- Platesetter: Agfa Excalibur 45
- Plates: Agfa Thermostar P970 positive thermal plates
- Papers: protected Mould 95 g/m^2 chemically reactivated, with watermark and fluorescent fibers, and art paper 115 g/m^2.
- Devices: Scanner for barrier scanning Projectina Docubox Forensic System PIA 6000/Multispectral Imaging Module; Spectrophotometer X-Rite SpectroEye; densitometer; register of colors, grey step wedge.

3. Experimental

In offset security printing, protective inks that are used the most are invisible fluorescent UV inks, which do not have the property of infrared adsorption, and their Z value (Žiljak, Pap and Žiljak Stanimirović, 2012) is zero (Z = 0). Here, process cyan, magenta and yellow inks are related to the ink F, which has the value of Z = 87 %. A controlled separation is carried out in UV an NIR spectra, by means of which the CMYKIR method (Žiljak, Pap and Žiljak, 2010) is extended to the CMYF method. All experiments and testings are performed under the conditions of real printing; therefore, the results of barrier scanning can be applied in different products (for example official forms, valuables, ID documents).

Concealment of the elements is obtained by CMYF separation, based on the continuous space of substitution of CMY and F. A series of 11 experiments were carried out in order to obtain correct formulations of color values. As a result, instead of an image visible in NIR spectrum only, a concealed image is attained, visible in UV as well as in NIR range. For accomplishing the described steganography, it was necessary to find an appropriate offset ink, having the response both in UV and NIR spectra. Concealed images will be better visible in UV and in NIR spectra if they contain greater share of F ink and lower share of CMY components and vice versa; if there is no F component present, the image will not be visible neither in UV nor in NIR spectra. All colors in the visible range are described with the following standards: CIELAB; RGB (Red, Green, Blue); HSB (Hue, Saturation, Brightness).

F/Z graphic, containing CMYF offset inks, is concealed in the color tone created from CMY inks. A new ink scale for offset printing is determined by multiple testings. CIELAB color space is used for the analysis of the measured results, adapting and mixing of inks for offset printing. Graphics concealed in UV and IR spectra are detected by instrumental barrier scanning. Separation solutions for three different spectral ranges are made with an indefinite number of color tones. Process inks are ensuring the basis for setting of the algorithm for the concealment of the graphic in UV and NIR spectra. NIR spectral ranges in highly protected printed document. For the determination of the value of offset ink F, the full tone of 100 % was printed on different printing substrates: protected Mould 95 g/m^2 and art paper 115 g/m^2. The obtained values of prints were measured by X-Rite SpectroEye spectrophotometer. For the applied spectrophotometer, the requirements of colorimetric calculations were examined by using illuminant D50, with 2° standard observer.

A visible dark brown UV ink is used in the experiments, which – exposed to the UV radiation – gives fluorescence in green color. With this fluorescent offset UV ink (F), a CMYF separation with IR properties was obtained. The aim is getting an image which will be visible in UV and an image visible in IR range, respectively. Both images are given by F ink with Z value. These two images are geometrically equal, but UV image is fluorescent green and reveals under UV emission, while IR image is grey and revealed under IR emission.

4. Results and conclusions

4.1 The F ink

New fluorescent color is different than the one that can be seen by the naked eye. F ink printed on the paper is dark brown in the visible spectral range, but exposed to wavelength of 365 nm it is fluorescenting in green.

This ink has also the property of infrared absorption with the value Z = 0.87. Prints with F ink have different values in CIELAB color space, depending on the type of paper they are printed on (Table 1).

4.2 ΔE^*_{ab} and iterations

All measurable properties of colors are accommodated to the CIELAB color space, with the aim of concealing the image in ultraviolet and near infrared range. Offset test prints were made with 32 different colors (Figure 1).

Table 1: Values of the F ink full tone prints (100 %) on different printing substrates

Offset Ink	Printing substrates	CIELAB			Z original [%]	Color Settings
		Min.	Max.	Avg.		
The F ink	Mould protected 95 g/m²	42,62 0,10 8,39	46,05 0,48 9,84	44,83 0,30 9,08	87	RGB: 109, 106, 92
	Sihl protected 95 g/m²	41,69 −0,37 7,51	43,97 0,1 8,59	42,92 −0,26 8,12	87	RGB: 106, 101, 88
	Art paper 115 g/m²	36,24 0,39 12,24	38,21 0,60 12,91	36,98 0,44 12,50	85	RGB: 93, 87, 66
	Offset white 100 g/m²	36,64 −0,48 5,56	38,96 −0,23 6,07	37,86 −0,34 5,82	87	RGB: 93, 89, 80

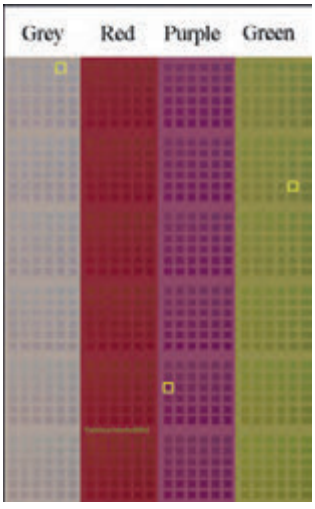

Figure 1: Four CMY colors with 216 combinations of CMYF color tones each (Iteration 3)

The experiments have had three iterations with a shift in the value of each particular color of 4 %, 3 %, 2 % and 1 % in the steps of the closest six positions. Each color tone in every iteration has six groups of 36 samples (squares, fields), thus obtaining 216 near-by tones ($6 \times 6 = 36$; $36 \times 6 = 216$). Only one of these tones with the lowest ΔE^*_{ab} entered the following phase of the experiment, as placed in the centre of 216 fields. Each field of color tone (hereinafter referred as to sample) has different CMYF value, so that the change of 1 % in one of the three process colors marks the shift to the first next sample. For the first tests ΔE^*_{ab} was measured between 32 basic colors which were printed on the substrate (CMY, F = 0) and 216 deduced combinations of the tone of this basic color (CMYF, F = 40). For further experiments, samples of color tones were taken, which had the lowest values of color difference, ΔE^*_{ab}. From these samples of color tones a new setting for printing was created. Each of the chosen samples with the lowest ΔE^*_{ab} was placed in the centre of the group to which it belongs and from there other samples were derived with the lowest alteration of CMYF values. The experiment was over when ΔE^*_{ab} was established as lower than 2. It was shown that the ideal tone is different for prints on art paper, offset and protected papers, so that the same ink had different CIELAB values when changing the printing substrate (Table 1). CIELAB values, with which the printing has started, were only the source, while the differences occurred due to the behavior of the ink on different papers. Each of the material elements – ink and paper – brings additional variations in definitions.

4.3 Twin colors

Twin colors were defined by experimental methods, while the formulations were determined by the type of paper, type of ink and the printing technology. From the calculated and measured colorimetric values of process inks, cyan, magenta and yellow – which do not contain F ink – a color tone of F = 0 ink was created, while twin ink F = 40 has in its composition a pre-defined value of the F ink. In the visual range of the spectrum twin inks are completely covering one another, while the determined color difference ΔE^*_{ab} is bellow 2.

Table 2 shows dot areas of colors which are matching the conditions for "twin colors", with $\Delta E^*_{ab} < 2$. It was printed in offset technique on the protected paper Mould with CMYF inks. Copies are first visually observed, so that the congruence between the color tones was determined by the bare eye. After visual identification of the twin colors on the printed copy, five series of measurements were carried out with the spectrophotometer in order to determine the average value of ΔE^*_{ab}. Column with red figures does not show visual congruence of color tones. The lowest determined value in congruence of red color is 7.95.

Table 2: Compositions with determined color differences $\Delta E^*_{ab} < 2$ for grey, red, purple and green

Color	Color samples	F = 0; CMY	F = 40; CMYF	ΔE^*_{ab}
Grey		33, 33, 33	6, 6, 0, 40	0.25
Red		43, 95, 90	15, 92, 70, 40	7.95
Purple		44, 81, 42	22, 81, 12, 40	1.95
Green		41, 39, 86	25, 17, 78, 40	0.62

Graphic images with twin colors are produced, hiding within an image which is revealed by barrier scanning. In ultraviolet range at the wavelength of 365 nm an image is revealed, glowing in green, while in the near infrared range at the wavelength of 1 000 nm, BW image is exposed in all tones of the grayscale. These two images are presenting the same concealed object, which is revealed under different emissions of radiation.

New standards are developed in the protection of documents, which are manifested through the new methods of mixing CMYF inks, with the response in UV, Vis and NIR spectra. The application of CMYF is aimed at security printing, which is thus entering a new area, expanding graphic security systems within enhanced graphic technology. Management of the offset inks is extended with two opposite invisible spectral ranges, aiming at the creation of a new technology of security printing. Forgeries can be recognized by barrier scanning. New color scales are created, as well as new color settings for offset process inks, for the F ink and for the protected paper.

4.4 CMYF separation

With the replacement of carbon black from the CMYK scale with the dark brown UV fluorescent green (F ink), during the first tests the obtained results have shown significant alteration in color differences (ΔE^*_{ab}) between CMY (F = 0) and CMYF (F = 40) color tones. Great differences have been established between CMYKIR (Žiljak, Pap and Žiljak, 2009) and CMYF separations. Due to high preciseness required for the concealing of images, a high number of tests were carried out. Tests were performed by offset printing on a Heidelberg Speedmaster 74. The third iteration was printed on the protected paper Mould 95 g/m^2, where the value of the F ink is CIELAB = 45, 0, 9. Samples were selected from CMYF with the lowest color difference ΔE^*_{ab} in comparison to the stable CMY printed on the substrate. From these selected color tone samples with F/Z graphics have been created by mathematical simulation. In this way, two identical color tones were created, which are identical in the visual system, having previously determined UV and IR values. All CMYF color samples contain exactly 40 % of the F ink, so that colorimetric value can be precisely determined. The fixed value of 40 % was set because all the following experiments were carried out with other UV inks, having the IR effect. It was shown that such two inks could be mixed in an indefinite number of combinations with cyan, magenta and yellow, thus giving new color tones.

4.5 State F_{40} and F_0

The aim is obtaining the same color tone from the CMY and CMYF inks. For 216 combinations of CMYF color samples (hereinafter referred to as State F_{40}), which are placed in the square fields on the substrate of the basic CMY color (hereinafter referred to as State F_0), visual compliance is looked for. This way, 19 corresponding color samples were obtained, i.e. 19 twin colors. The CMY system is used as a base for creating the formulation, because the determined values of cyan, magenta and yellow "control" color are constant, while each field has different composition of CMYF. CIELAB values are determined on prints by a spectrophotometer. State F_{40} and State F_0 are experimentally equalized. Color setting for the papers and inks used in this research does not exist, but visual equalization of State F = 40 (F_{40}) with State F = 0 (F_0) was determined with a sequence of multiple tests.

State F_0 is invisible under the influence of the near infrared spectrum of wavelength of 1 000 nm and there is no reflection or response in the ultraviolet part of 365 nm (Table 3). State F_{40} has a specific response in both, UV and NIR spectra. Under the ultraviolet emission it transits into green, while aroused with IR radiation it converts into grey.

Table 3: State F_{40} and F_0 for selected samples of grey, purple and green color tone

Color	State of ink	Color value	Max. Z values [%]	λ = 1000 nm	λ = 365 nm
Grey	State F_{40}	$C_6M_6Y_0F_{40}$	38 %	Grey	Fluorescents green
	State F_0	$C_{33}M_{33}Y_{33}$	0 %	Invisible	No effect of fluorescence
Purple	State F_{40}	$C_{22}M_{81}Y_{12}F_{40}$	38 %	Grey	Fluorescents green
	State F_0	$C_{44}M_{81}Y_{42}$	0 %	Invisible	No effect of fluorescence
Green	State F_{40}	$C_{25}M_{17}Y_{78}F_{40}$	38 %	Grey	Fluorescents green
	State F_0	$C_{41}M_{39}Y_{86}$	0 %	Invisible	No effect of fluorescence

Figure 2.1: Pine color

Figure 2.2: Turquoise color

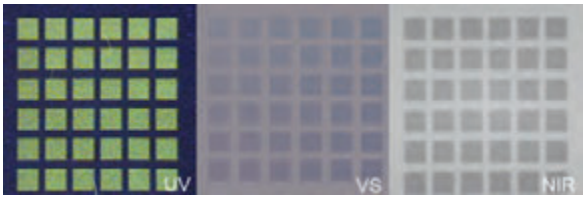

Figure 2.3: Light Grey color

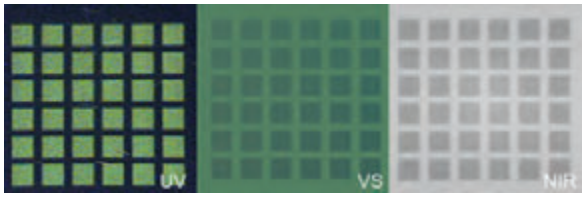

Figure 2.4: Green color

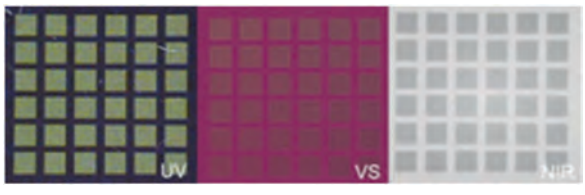

Figure 2.5: Chestnut color

By means of the barrier scanner, selected color samples (fields), for which the lowest ΔE^*_{ab} was determined, were scanned with the wavelengths of 365 and 1 000 nm. For all color tones of the sample F_{40}, the color value is 40 %. Fluorescent green tones (after being exposed to UV radiation), are different for all colors. As the differences in colors are higher, that higher is the difference in the fluorescent green tones of the selected samples. Differences in tone samples of the fluorescent green, scanned with the wavelength of 365 nm, are clearly eye-visible (Figures 2.1 to 2.5). An example for this are the differences between the color Pine (Figure 2.1) and color Light Grey (Figure 2.3). Pine color (Figure 2.1), $F_{40} = C_{67}M_{59}Y_{65}F_{40}$, scanned with wavelength of 365 nm, gives CIELAB: 50, −16, 26, while Light Grey color (Figure 2.3), $F_{40} = C_{28}M_{16}Y_0F_{40}$, scanned with the same wavelength, has CIELAB: 66, −21, 35. The same samples, scanned with the wavelength of 1 000 nm, do not show difference in color tones. The Z factor is therefore the same for all samples and equals to 38 % (Table 4).

4.6 F/Z graphics

The aim is the concealment of the graphic when observed by the naked eye. F/Z graphic can be recognized instrumentally in the UV range with the wavelength of 365 nm (F state) and in NIR range with the wavelength of 1 000 nm (Z value of the color matter). Two different graphics are mutually linked and printed within the same form. The visibilities in UV and NIR portion are not equal, but depend on the wavelengths of the barrier settings of the respective scanner. The influence of CMY process inks is completely eradicated at 1 000 nm.

The color tone is understood as an experience of color in the visible spectrum, when observed by the naked eye. The environment of UV graphic is obtained with cyan, magenta and yellow, which do not have UV characteristics. In this way, the UV graphic is independently concealed in the visible spectrum. CMY inks can form an independent single color or multi-color graphic in the visible spectrum.

Table 4: Values of selected fields scanned with λ = 365 nm and λ = 1000 nm

Num.	Color	λ = 365 nm		λ = 1000 nm
		CIELAB	RGB	Z [%]
1.	Pine	50, −16, 26	111, 126, 79	38
2.	State Turquoise	56, −28, 30	113, 146, 84	38
3.	Light Grey	66, −21, 35	148, 169, 99	38
4.	Green	61, −30, 35	124, 160, 88	38
5.	Chestnut	52, −8, 21	122, 126, 89	38

Figure 3.1: Target projected image of the church, hidden in the graphic and detected in the UV spectrum of 365 nm

Figure 3.2: Target projected image of the church, hidden in the graphic and detected in the NIR spectrum of 1000 nm

An effect was discovered on the influence of CMY components on the F ink. This breaking through of color tones from the image under the wavelength of 365 nm is caused by different layers of process inks (Figure 3.1). When observing the image at infrared range of 1 000 nm, this effect cannot be noticed (Figure 3.2), but at a wavelength of 780 nm cyan (Figure 4) has such an influence, which is at this wavelength visible together with IR color. Particular quantities of CMY are acting differently on the response of F ink at 365 nm, so certain parts of the image are darker or lighter, although the F factor is the same (38 %). Due to that, F/Z graphics are not of the same contrast in UV and IR range.

Figure 3.3: Scanned copy of an abstract graphic, which in itself contains a hidden image of a church with the content of coloransts in UV, Vis and NIR range, Vis scan from 400 to 700 nm

The abstract graphic (Figure 3.3) is typical in document protection. IR spectrum clearly describes the graphic (Figure 3.2), while in the UV spectrum it depends on the share of CMY inks (Figure 3.1).

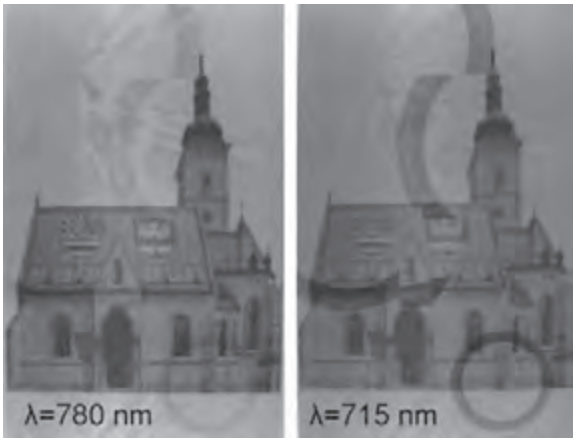

Figure 4: Influence of cyan, NIR 780 nm and 715 nm

Using computer graphic, two photos were processed and merged into one image (Figure 5). The graphics are mutually concealing each other. Related to the mixing of CMY process inks, the concealed image in UV space is modulated and on particular areas has lower or higher response, although the F component is always 40%.

Figure 5: Channels of cyan, magenta, yellow and F.

5. Conclusions

CMYF method enables concealment of the image and its recognition in UV and NIR range. The application of CMYF is referred to the security printing, which is entering a new area, expanding security systems within the graphic technology. New standards are developed in the protection of documents, which are manifested through new methods of mixing CMYF inks, with the response in UV, Vis and NIR spectra. Management of the offset inks is extended with two opposite invisible spectral ranges, aiming at the creation of a new technology of security printing. Forgeries can be recognized by barrier scanning. New color scales are created, as well as new color settings for offset process inks, for the F ink and for the protected paper. Although CMY inks are used, in the final industrial application it will be a mixture of these inks according to the specific formulation, which will be available as one single spot color. This color – with the built-in characteristics of process inks – is used when calculating the values within the known CMY system.

When creating an image in image, the designer should elaborate planning of the F/Z graphic with the Vis content, taking into consideration which technology is enabling the F/Z graphic. The education of designers is therefore necessary in application of such protection. If authorized types of screening are also included in the protected graphic, it would result with a highly protected document, which is impossible to reiterate. Technical standardization is clearly essential as a technical application or ready-made technical matrix. In designing the F/Z protection, the way and technology of the F ink application are strictly related to the color coordinates of the CIELAB color space.

Although the standardization of the criteria under which the application of the F/Z protection will be designed is important, equally essential is the standardization of the criteria by which something will give the status of necessary protection. In technical standardization of the F/Z methods of protection, it is therefore crucial to answer the following questions: how to apply, where to apply and what to apply. So, when adopting the standardization criteria and with every new design of a document, the following is established: formulations of colors and inks, concealed contents, visible contents, type of printing substrate and production technology.

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Multi-channel dot-off-dot halftoning compensating for slightly chromatic gray inks

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Abstract

Printing using more than four ink channels visually improves the reproduction but causes challenges with the ink layer thickness that could lead to ink bleeding and color inaccuracy. A color image is commonly prepared for print by first being separated into the colorant channels the intended print device utilizes. The separations are usually halftoned independently, resulting in random dot overlap with possible spots where all colorants are printed. A multilevel halftoning algorithm that processes each channel so that it is printed with multiple inks of the same hue value has already been applied to three achromatic inks – photo gray, gray, black – in a real paper–ink setup. Results proved a successful multilevel halftone implementation workflow using multiple inks while avoiding dot-on-dot placement. However, in this approach, the gray inks were assumed to be neutral and lighter versions of black, an assumption that may cause a ΔE^*_{ab} color difference as high as 5. In the present paper an alternative approach, based on dot-off-dot halftoning avoiding dot overlap, is proposed and applied to the same three inks. A look-up table driven separation procedure of the original image into the three channels is also proposed, which, combined with dot-off-dot halftoning, results in a ΔE^*_{ab} color difference not larger than 1.8. Results show that the dot-off-dot halftoned images are visually pleasant without any artifacts in tone transitions. The proposed approach has three main advantages to the commonly used independent halftoning. One being that dot overlap between different inks is completely avoided, i.e. photo gray, gray and black in the present work. The other one is that the results are less grainy compared to independent channel halftoning. The third one is that dot-off-dot halftoning consumes less ink than independent halftoning when reproducing the same color.

Keywords: multilevel halftoning, dot-off-dot halftoning, dot gain compensation, multi-channel printing, graininess

1. Introduction

In color reproduction, the original image to be printed is firstly separated into the colorant channels that the print device utilizes. Traditionally, the channels used are cyan (C), magenta (M), yellow (Y) and black (K), but in the interest of reducing graininess and augmenting the color gamut for high quality color printing, additional channels are introduced (Jang et al., 2005). These additional channels can be light cyan (Lc), light magenta (Lm), gray (GY), photo gray (PGY), red (R), green (G), blue (B), orange (O), etc. Introducing additional channels is a solution to achieve high quality prints in many printing technologies.

In color print, after the original image is separated, each channel is commonly halftoned (transformed to a bitmap) independently of the other channels. The separated channels are halftoned because of the common nature of the vast majority of printing technologies, where placing ink onto a media substrate is a choice of either depositing or not depositing a drop of ink onto a specific position. The printed image is therefore a result of either printed or non-printed dots and if the printed dots are small enough, the human eye that acts as a low-pass filter perceives the printed image as being continuous tone.

Once the channels are halftoned, the printing system transfers the corresponding channel's ink (C, M, Y, K, etc.) onto the media substrate. A certain light–ink–paper interaction then happens, known as dot gain or tone value increase, which causes the printed image to appear darker than the original digital image. Dot gain is the reason that there is a differentiation between the ink coverage value sent to the printing system (reference coverage) and the resulting printed coverage, called effective coverage (Namedian and Gooran, 2011). That is why, before halftoning, the initial image is accounted for dot gain so that the printed image has the intended effective ink coverage. One of the models used to account for dot gain is the well-known Murray-Davies model based on the measurement results of a number of printed halftone patches (Murray, 1936).

As mentioned, multi-channel printing (printing with more than four channels) increases the gamut and improves the overall image quality. Nevertheless, a high number of colorants imposes new computational challenges and physical limitations, one of them being a too large number of ink layers printed on top of each other, which causes ink bleeding and color inaccuracy (Zeng, 2000). Certain halftoning algorithms can help to overcome these issues. One of them is channel dependent halftoning or dot-off-dot halftoning, which can be applied to two or more channels simultaneously and dependently, avoiding dot overlap as much as possible, see Section 2.2.

In Zitinski, Gooran and Nyström (2014) another approach, multilevel halftoning, was applied aiming at avoiding dot overlap when several colorant channels with the same hue values (e.g. magenta and light magenta) were used, see Section 2.1. This approach was applied to three achromatic inks – PGY, GY and K – using an inkjet printer. Besides the method's simplicity, one of the main advantages of this approach was that no dot overlap occurred, resulting in more homogenous prints. In addition, compared to the case using single black ink K, the proposed multilevel halftoning method resulted in increased print image quality in terms of graininess and detail enhancement (Zitinski, Gooran and Nyström, 2014). However, in the proposed multilevel halftoning approach, the gray inks PGY and GY were unjustifiably assumed to be neutral in color and considered to be lighter versions of K halftone with almost the same hue value. For instance, the ΔE^*_{ab} color difference between fulltone PGY and the closest halftone of K is a non-negligible 4.2. In the present paper, an alternative dot-off-dot halftoning approach is proposed with the main goal of avoiding dot overlap in the digital bitmaps while keeping the color difference between the three-inks print and the single K ink print within an acceptable range. A look-up table driven separation procedure of the original image into the three channels is proposed.

2. Previous work

2.1 Multilevel halftoning approach

In Gooran (2006), a multilevel halftoning method was proposed. Its implementation to achromatic inks in multi-channel printing was described and examined in Zitinski, Gooran and Nyström (2014) and is summarized in this section.

Most multi-channel printers utilize multiple inks with almost same hues but with different lightness/intensities or saturation. Multilevel halftoning algorithms are therefore becoming more important as the capabilities of the printers improve (Xujie et al., 2012). For instance, many printers use black and one or two gray inks, cyan and light cyan, magenta and light magenta. Since in this paper the focus is only on the achromatic inks, let us limit the discussion to the case with black (K) and two gray inks, photo gray (PGY) and gray (GY), PGY being the lightest one. The common method to use all three inks is to first separate the original image into its PGY, GY and K channels and then bi-level halftone the three channels independently. Nevertheless, assuming the gray inks to be lighter versions of black, the original achromatic channel could instead be multilevel halftoned and then separated to the PGY, GY and K bitmaps, with the advantage of no dot overlap.

The first step in applying multilevel halftoning is to identify the gray levels each of the lighter inks represents. The darkest ink at fulltone coverage, K, is represented by 1 or 100 %, and the paper by 0. In order to find the gray level for the other two inks, their CIE Y values at 100 % coverage are compared to those of the printed K patches at different reference coverages. According to the measurement results in our paper–print setup, 100 % PGY and GY correspond to 42 % and 62 % coverages of K, respectively. The original image is therefore multilevel halftoned to four levels, i.e. 0, 0.42, 0.62 and 1, and separated into three PGY, GY and K bitmaps. This is done by setting all pixel positions where the multilevel halftoned image holds e.g. 0.42 to 1 in the PGY bitmap and to 0 in GY and K bitmaps. Similarly, GY and K bitmaps are created. Since the pixels in multilevel halftoned image only hold one of the values 0, 0.42, 0.62 and 1, there will not exist any pixel position set to 1 in more than one bitmap, guaranteeing no dot overlap. For more details, interested readers are referred to Gooran (2006) and Zitinski, Gooran and Nyström (2014).

2.2 Dot-off-dot halftoning

Many instances of dot-off-dot halftoning algorithms exist. Lau, Arce and Gallagher (2000) introduce green-noise halftone patterns designed to avoid, when possible, ink overlap between multiple channels. Bernal et al. (2014) introduce a clustered stochastic halftoning algorithm in which both the dot shape and dot placement are controlled. They also introduce an extension of the algorithm to produce dot-off-dot structures, enhancing the texture smoothness and increasing the gamut while reducing ink consumption. Kawaguchi et al. (1999) propose a method based on the vector error diffusion, taking into account the reflectance spectra and therefore improving the spectral image quality.

In multi-channel printing, the channels of the original image are commonly halftoned independently, leading to possible spots where multiple inks are printed. In

Gooran (2004), a color halftoning method was proposed that halftoned the color channels dependently, maximizing dot-off-dot. As a result, dot overlap is avoided when the sum of coverages of the channels is less than or equal to 100 %. When the sum exceeds 100 %, minimum dot overlap occurs. For example, dot-off-dot printing of two channels with coverages of 80 % and 60 % will give the minimum overlap of 40 %.

The color halftoning method used in this paper is based on Iterative Method Controlling Dot Placement (IMCDP), an iterative halftoning algorithm for grayscale images, proposed in Gooran (2004), where the dots are placed iteratively with the goal of reducing the difference between the original and the halftone image. The creation of the halftone image starts with a blank image of the same size as the original. The total number of dots to be placed in the halftone image is known beforehand, as it is dependent on the original image's overall lightness/darkness. Starting with a blank image, in the first step, the algorithm finds the position of the darkest pixel (the pixel holding the maximum value) in the original image and places the first dot at that location in the halftone image. In the next step, the low-pass filtered version of the halftone image is subtracted from the low-pass filtered version of the original image. The low-pass filter used is Gaussian filter with standard deviation 1.3 truncated to 11 × 11 pixels. This operation is addressed in Gooran (2004) as the feedback process. Subtracting the filter from the image around the found pixels reduces the pixel values in a neighborhood of that pixel, meaning that the chance of the neighboring pixels to be picked as the next maximum is reduced. Then, the location of the maximum pixel value of the subtracted image is found and at that location on the halftone image the next dot is placed. The process continues until the known number of dots is placed, and the final halftone image is achieved. Due to the nature of IMCDP, it is easily extended to a color halftoning method utilizing dot-off-off as much as possible. Since in this paper the dot-off-dot strategy will only be used to halftone two channels, e.g., PGY and K, let us for the sake of simplicity explain the method on these two channels. The algorithm starts with two blank images representing PGY and K. It finds in advance the number of dots to be placed in PGY and K, respectively. The algorithm starts with finding the position of the maximum pixel value in the two channels; say it is found in the PGY channel. Then, that pixel in PGY is set to 1; the feedback process is performed as in IMCDP, not only on PGY but also on K as well. Consequently, the pixel value at this position in K is also reduced, making this position in K skipped as maximum until all other pixels are set to 1. By using this strategy, dot-off-dot is ensured if the sum of the coverages in PGY and K doesn't exceed 100 %. Since the dot-off-dot halftoning method is described in detail in previous publications, the interested reader is referred to Gooran (2004).

The only concern regarding the proposed approach is its computational speed. The separation is performed using a look-up table, created once, resulting in a swift separation procedure, see Section 3. The only possible time-consuming part is the dot-off-dot halftoning. The dot-off-dot halftoning in this paper is based on the approach explained, creating different threshold matrices for different separations (Gooran and Kruse, 2015). These threshold matrices are created once and stored. The halftoning process is therefore reduced to comparing each pixel value in each separation with a threshold value in the corresponding threshold matrix. This means that the halftoning process is as fast as it can be. To give an indication of the processing speed, a 1536 × 1536 pixel image was halftoned by IMCDP and thresholding. The former one took 196 seconds while the latter one only took 0.03 seconds in Mathworks Matlab (2011b) using the same computer. How to generate the threshold matrices is out of the scope of this paper and the interested reader is referred to Gooran and Kruse (2015).

3. Channel separation based on dot-off-dot halftoning

From now on in this paper, capital letters (e.g. PGY) denote an ink or colorant, while the subscript "ref" (e.g. PGY_{ref}) will indicate the ink's reference coverage.

As discussed in Section 2.1, in the multilevel halftoning applied to achromatic inks the thresholds are chosen based on the CIE *Y* value of the black ink at different area coverages. For example, in our print setup the black ink K halftones at 42 % and 62 % have the closest CIE *Y* values to fulltone PGY and fulltone GY, respectively. The multilevel halftoning approach would work perfectly if the PGY and GY inks were as "neutral" as the K halftones. According to our measurement results presented in Section 4 and 5, the ΔE^*_{ab} color differences between fulltone PGY and GY and K halftones at 42 % and 62 % are 4.2 and 4.57, respectively. Hence, although fulltone PGY has almost the same CIE *Y* (or CIE *L**) value as 42 % K, the color difference between them is 4.2, which is not acceptable in many applications. The proposed dot-off-dot approach copes with this issue by adding K inks in regions where K was not used in multilevel halftoning approach. In addition, contrary to the multilevel halftoning, in the new proposed approach the image is first separated into three different channels, PGY, GY and K, and then halftoned dependently by the dot-off-dot printing strategy described in Section 2.2.

Despite the differences, two of the main goals of the new approach are the same as those of the multilevel

approach. One of them is to reduce the image graininess, compared to using only one K or to independently halftoning the PGY, GY and K channels. The second common goal is to completely avoid dot overlap. The new approach in addition aims to reproduce the same neutral colors as halftones of K. Notice that in this paper we refer to the colors reproduced by a combination of K inks and paper, i.e. K halftones, as neutral colors.

As the separation of an image into its PGY, GY and K channels represents the main challenge of this approach, it is described in this section for a given pixel value in the original image (or reference coverage of K) into three channels with coverages PGY_{ref}, GY_{ref} and K_{ref}. In order to do that, a number of test patches has to be printed: single ink PGY, single ink GY, single ink K, PGY and GY (PGY&GY), PGY and K (PGY&K) and finally GY and K (GY&K). Notice that since one of the goals is to completely avoid dot overlap, the sum of the coverages of the two involved inks should not exceed 100 %. In the next step, the printed patches are measured and interpolated.

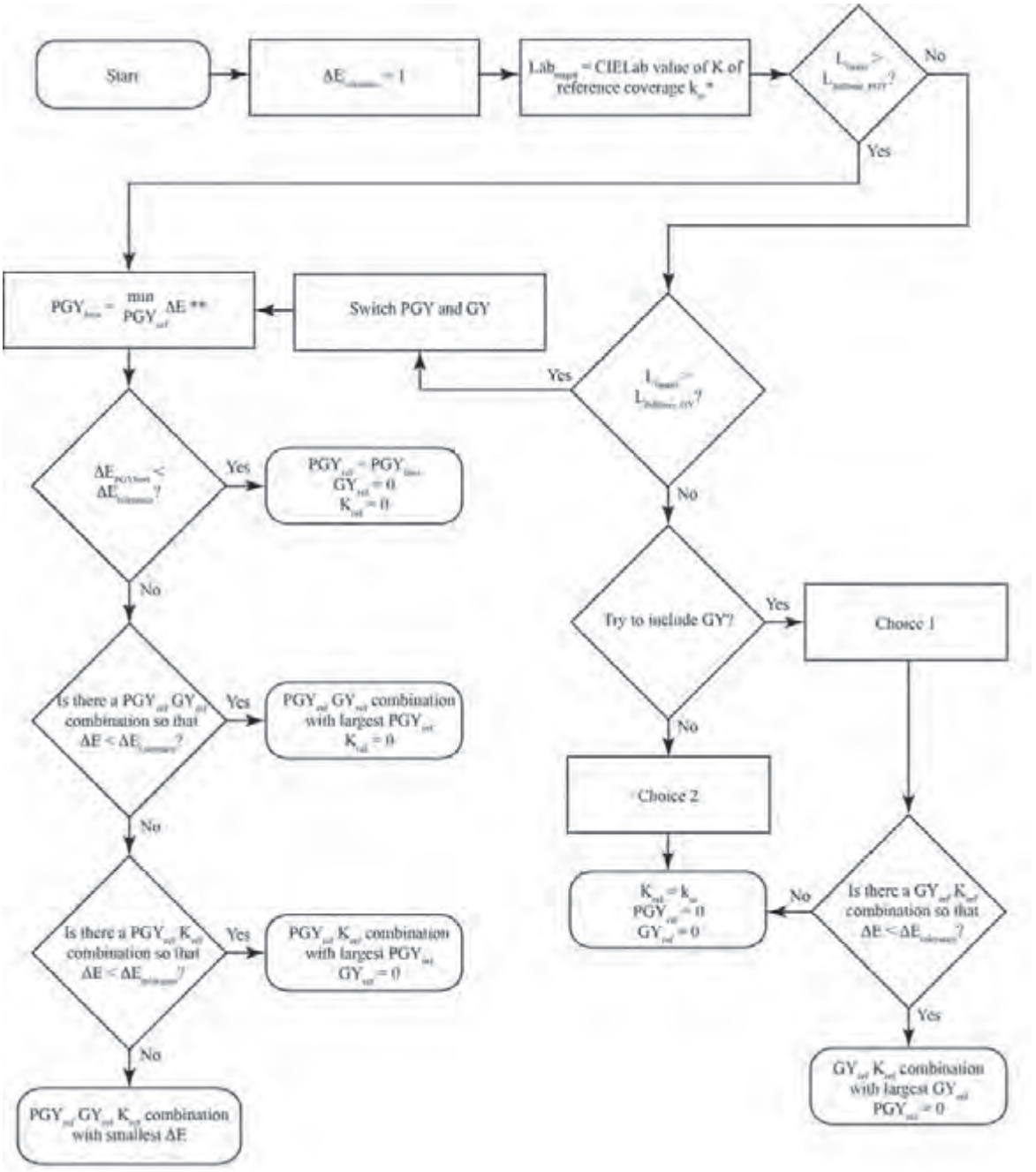

Figure 1: Channel separation workflow (ΔE stands for ΔE^*_{ab} and L for L)*

Table 1 shows the ink combinations considered in the three different regions in the proposed separation model. The separation approach is performed after collecting the measurement data and performing the interpolations, displayed as flowcharts in Figure 1.

Table 1: The ink combinations considered in each region

Region number	1	2	3
Region interval	[0, 0.42]	[0.43, 0.62]	[0.63, 1]
Region ink combinations	PGY PGY&GY PGY&K	PGY&GY GY GY&K	GY&K K

In Figure 1 the input reference K coverage (or the pixel value) is denoted by k_{in}. The outputs are PGY_{ref}, GY_{ref} and K_{ref}, which are the pixel values at the corresponding pixel position in the separated PGY, GY and K channels, respectively.

The tolerance for ΔE^*_{ab} color difference is chosen as 1 in this paper. Marked by * in Figure 1, for each given input pixel value, i.e. k_{in}, the CIELAB value of the K halftone corresponding to the reference coverage of k_{in} is found by using the interpolated CIELAB measurement results for the printed K halftones. This is then used as the target CIELAB value denoted by (L^*_{target}, a^*_{target}, b^*_{target}).

Marked in Figure 1 by **, the ΔE^*_{ab} between all the interpolated CIELAB values for PGY (single PGY) and the target CIELAB value are calculated and the PGY_{ref} that minimizes ΔE^*_{ab} is found and denoted by PGY_{best}.

4. Experimental setup

In order to be able to verify dot-off-dot printing in the used print setup and to find the channel separations, a number of patches is printed and measured. The measurement results are dependent on the ink combination, type of substrate, halftoning method and print resolution. The following specifications were applied:

For single ink prints, patches with 0 to 100 % reference ink coverage, in steps of 10 %, were printed for all three inks, yielding 11 patches for single printed PGY, 11 patches for single printed GY and 11 patches for single printed K, totally $3 \times 11 - 2 = 31$ single ink patches. The value 2 was subtracted because 0 % patch was included three times.

For two ink combinations, as marked in Figure 2 with gray, the following three specifications were applied.

PGY&K: 28 PGY&K patches were printed (dot-off-dot and no overlap), with PGY_{ref} ranging from 30 to 90 %, with a step of 10 %, and K_{ref} ranging from 10 to 70 %, with a step of 10 %. For PGY_{ref} values smaller than 30 % it is not necessary to involve K to get close to the target color. K_{ref} larger than 70 % means dark tones where PGY is obsolete. Observe that the condition of no dot overlap should be fulfilled, meaning $PGY_{ref} + K_{ref} \leq 100$ %. Therefore, only combinations marked with gray in Figure 2 fulfill this condition, making the total number of needed patches 28.

PGY&GY: 28 PGY&GY patches were printed (dot-off-dot and no overlap). PGY_{ref}, ranging from 30 to 90 %, with a step of 10 %, and GY_{ref} ranging from 10 to 70 %, with a step of 10 %.

GY&K: 42 GY&K patches were printed (dot-off-dot and no overlap). GY_{ref}, ranging from 10 to 90 %, with a step of 10 %, and K_{ref} ranging from 10 to 70 %, with a step of 10 %.

The total number of the printed patches is therefore 129. Notice also that the patches are printed, measured and then interpolated, creating a look-up table. This results in a swift separation where the right combination in the look-up table is obtained given an input pixel value k_{in}.

All prints were made using an inkjet 12-channel printer Canon ImagePROGRAF iPF6450. All samples were printed on 170 g/m² matte coated paper at a resolution of 600 dpi. Nevertheless, the same workflow can be

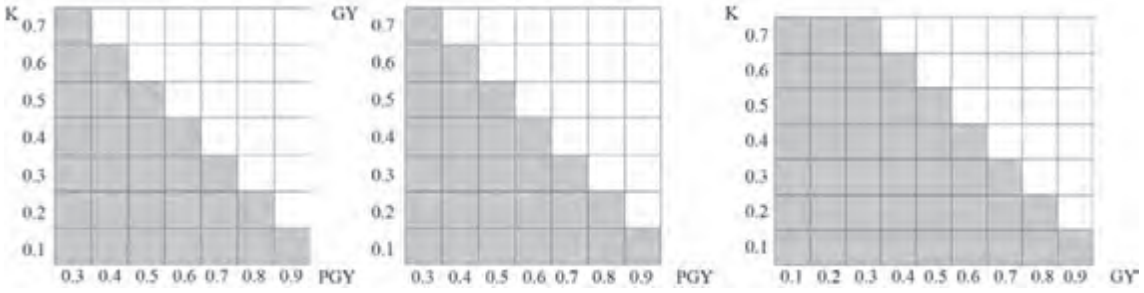

Figure 2: Ink combinations of printed patches; only combinations marked with gray are printed

applied to other media substrates and other printing resolutions. The CIEXYZ and CIELAB values of the printed patches were measured using the spectrophotometer BARBIERI electronic Spectro LFP RT, illuminant D50 with 2° standard observer. The data were then linearly interpolated with a step of 0.001. Cubic interpolation was also tested but it had no considerable impact on the results. Therefore, due to simplicity and calculation speed, we recommend the linear interpolation when, as in this case, the coverage steps are up to 10 %. Cubic interpolation may cause oscillating polynomials that could result in errors when no measured data is available for the parts of the created table usually filled with constant default values.

5. Results and discussion

The first important task for the multilevel halftoning approach is to localize the thresholds. The thresholds for the above experiments were found to be 0.42 and 0.62. Each interval is separated into three regions, as shown in Table 1.

In all calculations, the tolerance for the ΔE^*_{ab} color difference was set to 1. One of the interesting results was that the single GY and the PGY&GY combination never produced a colour difference smaller than 3, meaning a significant discrepancy of these ink arrangements from neutral for this type of digital printers and inks. Therefore, from now on they can be discarded from the alternatives, thus reducing the number of needed printed patches for future characterization to 91.

5.1 Color difference

For the sake of comparison between the proposed approach and multilevel halftoning approach, suitable multilevel halftoned patches were printed, measured and interpolated.

In order to verify the dot-off-dot halftoning approach proposed in Section 3, the reference K value (k_{in}) was varied from 0 to 1 with a step of 0.01. For each k_{in}, the corresponding steps in Figure 1 were performed and the achieved ΔE^*_{ab} was calculated. The same was done for the multilevel halftoning approach. Figure 3 shows these calculated ΔE^*_{ab} for both multilevel and dot-off-dot halftoning approaches versus k_{in}. For the dot-off-dot approach, the separation according to both, choice 1 and choice 2, shown in Figure 1, was used.

As seen in Figure 3, the color difference is much higher for multilevel halftoning, reaching $\Delta E^*_{ab} = 5$ for some k_{in} (dotted curve). The color differences using the dot-off-dot halftoning approach are always low, sometimes exceeding the chosen tolerance of 1 (solid and dash-dot curves).

Let us analyze the color difference of dot-off-dot approach in the three tonal regions. In region 1, there is an interval (between 0.1 and 0.42) at which it was not possible to find any combination giving a color difference smaller than the tolerance, i.e. $\Delta E^*_{ab} = 1$. However, the maximum color difference is around an acceptable 1.8 (occurring at $k_{in} = 0.19$).

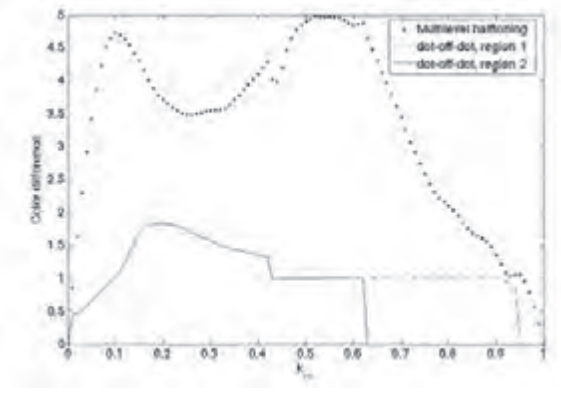

Figure 3: ΔE^*_{ab} color difference for multilevel and dot-off-dot halftoning approaches based on interpolated CIELAB values

In region 1 the lightest tone values were possible to reproduce with PGY, while for the tones between 0.16 and 0.42 the algorithm always found the best combination among PGY&K.

In region 2 the color difference is always less than the tolerance. In region 3 the color difference using choice 2 in Figure 1 is, as expected, always zero. In the case of dot-off-dot printing using choice 1, the color difference is always lower than the tolerance, being zero for tones darker than 95 %, as there the single K was chosen as the best alternative.

It is worth mentioning a reference to chroma. Since in the multilevel approach the CIE Y (or CIE L^*) is used to find the coverage of PGY and GY inks, the ΔL^* between K and its corresponding PGY and GY separations is equal to zero. This means that the absolute value of the chroma difference, $|\Delta C^*_{ab}|$, is always smaller than or equal to ΔE^*_{ab} (dotted curve in Figure 3). Nevertheless, for the dot-off-dot approach, the CIE L^* values between K and its corresponding PGY, GY and K separation are very close but not necessarily equal, resulting in very small ΔL^* even in this case. Therefore, $|\Delta C^*_{ab}|$ is smaller than or equal to the ΔE^*_{ab} values shown in Figure 3 (solid and dashed curves).

An important point is that the GY&K combination was not considered in region 1. The error is however acceptable and this combination can easily be added if one would aim on reducing the error further.

The graphs shown in Figure 3 were computed using the measured and interpolated CIELAB values for 129 patches. In order to verify the graphs shown in Figure 3, patches with coverage k_{in} ranging from 0 to 100 % with a step of 2 % were created and halftoned in three different ways. First, they were halftoned by a bi-level algorithm and printed with single K ink. Then they were multilevel halftoned and printed with PGY, GY and K. Lastly, they were separated by the approach proposed in Section 3 (choice 1 was used) and the PGY, GY and K separations were halftoned by the dot-off-dot halftoning method.

The CIELAB values of these $3 \times 51 = 153$ printed patches were measured and the ΔE^*_{ab} values between each patch and the corresponding K patch were calculated and are shown in Figure 4. As seen, the color differences based on the measurement results are very similar to those shown in Figure 3, proving a successful characterization with low error.

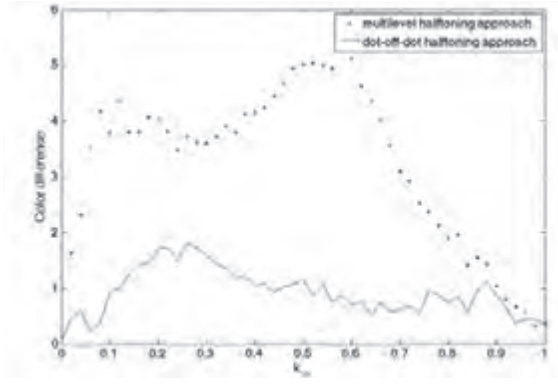

Figure 4: ΔE^*_{ab} color difference for multilevel and dot-off-dot halftoning approaches based on measurement results

5.2 Graininess

One of the main advantages of adding PGY and GY inks is graininess reduction (Zitinski, Gooran and Nyström, 2014). A graininess evaluation measure is the standard deviation of the pixel values of the halftone. For this purpose, patches with coverage ranging from 0 to 100 % with a step of 1 % were created and halftoned by three halftoning methods, bi-level (with single K), multilevel and dot-off-dot (with PGY, GY and K). The standard deviations of the pixel values of the halftones were then calculated and shown in Figure 5. As seen, the graininess for multilevel halftoning (dash-dot curve) is mostly lower than the other two. The reason the standard deviation is zero at the thresholds is that at these coverages the patches are represented by fulltone PGY and fulltone GY, respectively. Figure 5 also shows that the dot-off-dot halftoning approach (solid curve) always results in less grainy halftones than when only using single K ink (dotted curve).

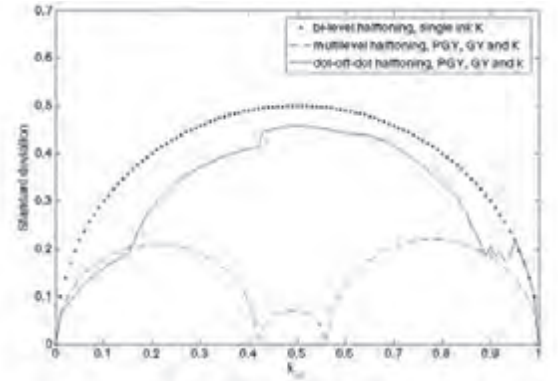

Figure 5: Standard deviation of the pixel values of patches halftoned with bi-level, multilevel and dot-off-dot halftoning

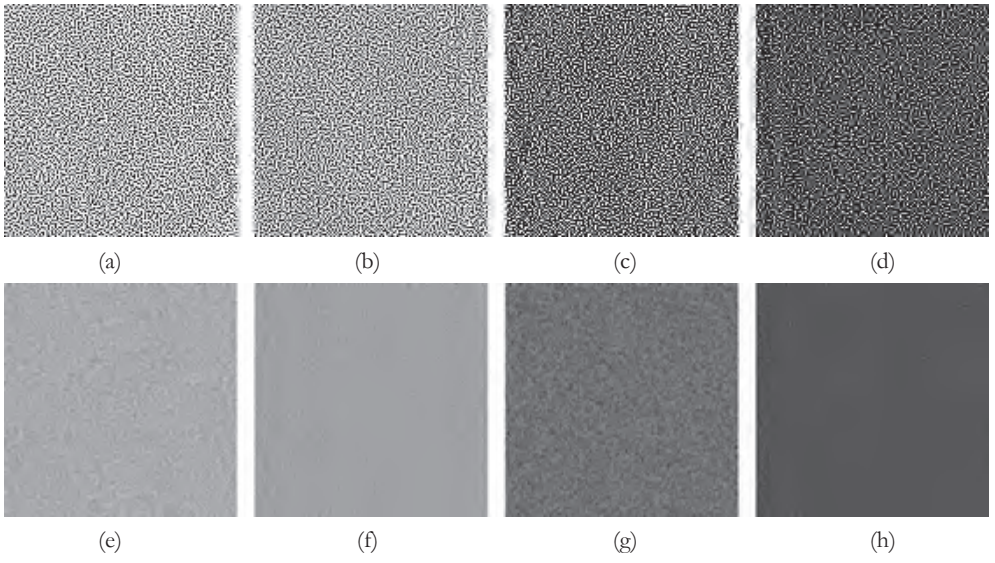

Figure 6: Two patches representing K at 40 and 80 % reference coverage were separated to PGY, GY and K channels; the channels were halftoned by a) and c) independent halftoning, b) and d) dot-off-dot halftoning; a), b), c) and d) are enlargements of e), f), g) and h), respectively

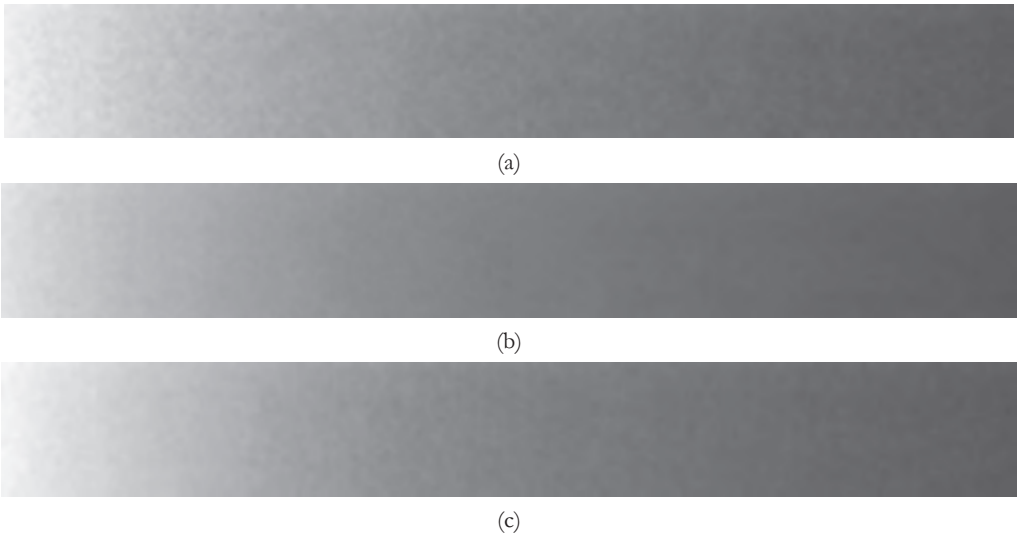

Figure 7: Scanned versions of the printed gray scale ramp with reference coverage ranging from 0 to 50 % – a) bi-level halftoning, only K is used; b) multilevel halftoning, PGY, GY and K are used; c) dot-off-dot halftoning, PGY, GY and K are used

The reason dot-off-dot reduces graininess more than multilevel between 0 and 0.16, despite using the same PGY ink, is the increased coverage necessary to approximate K.

Dot-off-dot halftoning approach has at least three advantages compared to independent halftoning of PGY, GY and K channels, i.e. less graininess, less ink consumption due to the smaller area covered by ink and no ink overlap. In order to demonstrate these, two patches were halftoned independently and with dot-off-dot corresponding to 40 and 80 % of K (i.e. k_{in} = 0.4 and 0.8). The dot-off-dot separation approach separates these patches into (PGY_{ref} = 0.3 and K_{ref} = 0.28) and (GY_{ref} = 0.28 and K_{ref} = 0.59), respectively. Assume that a separation for an independent halftoning would give the same coverages. The digital representations of the resulting halftones are shown in Figure 6, demonstrating less grainy results with dot-off-dot halftoning. The standard deviations for images shown in Figures 6b and 6d are 0.41 and 0.33, while those for the images in Figure 6a and 6c are 0.43 and 0.44, respectively. In order to show the halftone structures, the images e to h in Figure 6 were enlarged 3 times and are shown in a to d. The images in Figure 6b and 6d look darker than the correspondent one using independent halftoning because the channel separation was performed for dot-off-dot halftoning and not independent halftoning. If the same original images were separated for independent halftoning they would surely result in larger coverages for PGY and K separation, resulting in even larger standard deviations and grainier results. It would also require more ink to reproduce the same tones. In the images shown in Figure 6a and 6c, there is 0.3 × 0.28 = 8.4 % and 0.28 × 0.59 = 16.5 % dot overlap, respectively, while in the images shown in Figure 6b and 6d no dot overlap occurs.

5.3 Tonal transition smoothness

One of the biggest challenges when involving several inks is to attain smooth transitions between tonal values. The best image to verify the smoothness with is a gray scale ramp with a continuous transition from 0 % to 100 % coverage.

Such a ramp was created, separated with the proposed approach and dot-off-dot halftoned. The ramp was also halftoned by a bi-level and multilevel halftoning. All three ramps were then printed at 600 dpi. Unlike in Section 5.2, the simulation of the results cannot be a good representation of the printouts, because the separation process for dot-off-dot halftoning approach is dependent on the printer, resolution, paper and inks. The chosen way to illustrate the results was to scan the printouts at 600 ppi, shown in Figure 7. Higher resolution was not applied, since the overall impression of the printouts was of interest rather than the halftone structure. In order to more clearly illustrate the transitions, only the tonal values between 0 % and 50 % are shown, as the other half of the ramp is too dark, moreover, since no dot gain compensation has been made at this point. As seen in Figure 7, the tonal transitions of all the ramps are smooth and without any tonal discontinuities. Possible visible discontinuities in the three images are a result of the scanning distortions. It can also be seen that the multilevel halftoned image is the least grainy one and that the bi-level halftoned one using only K is the grainiest one.

5.4 Dot gain compensation

One of the main challenges in any printing workflow is to achieve full control over dot gain. Here, we describe how an image can be compensated for dot gain, per-

formed during the separation from k_{in} to PGY_{ref}, GY_{ref} and K_{ref}. The only difference is the calculation of the target CIELAB value. When no dot gain compensation was involved, the target was the CIELAB of K halftone at the input reference coverage k_{in}. This target is what differs when performing dot gain compensation.

First the relationship between the effective coverage (a_{eff}) and the reference coverage (a_{ref}) has to be found for K by Murray-Davies formula, Equation 1,

$$a_{eff} = \frac{Y - Y_p}{Y_{ink} - Y_p}, \qquad [1]$$

where, Y, Y_p and Y_{ink} are the measured CIE Y values for K patches with a_{ref} = 0 to 100 % with a step of 10 %, the CIE Y value for paper and the CIE Y value for fulltone K, respectively. By using the interpolated data for single K halftones, the reference coverage (a_{ref}) giving the effective coverage $a_{eff} = k_{in}$ is found, denominated k_{new}. The CIELAB value of K halftones that corresponds to reference coverage k_{new} is found and used as the target CIELAB value.

Therefore, in order to carry out dot gain compensation for linear dot gain response, the calculation of the CIELAB target value in Section 3 is modified as follows. Find the relationship between a_{eff} and a_{ref} for K. For each given pixel value, i.e. k_{in}, find the corresponding reference coverage, $a_{ref} = k_{new}$ giving $a_{eff} = k_{in}$. Then find the CIELAB value of the K halftone that corresponds to reference coverage k_{new} and use it as the target CIELAB value (L^*_{target}, a^*_{target}, b^*_{target}). The rest of the separation remains unchanged.

In order to verify the linear dot gain response, patches with reference coverage ranging from 0 to 100 % with a step of 2 % were created and separated to their PGY, GY and K channels as described. The separated patches were then halftoned by dot-off-dot halftoning, printed and measured. Figure 8 shows the effective area coverage versus the reference area coverage. As seen in Figure 8, the plot is a straight line, proving a successful dot gain compensation and dot gain control. Notice that the plot shown in Figure 8 was found by using CIE Y values. Nevertheless, CIE X, CIE Z and the reflectance spectra were also used to find the curve, demonstrating identical results.

5.5 Printing with only PGY and K

After compensating for dot gain, it was noticed that the GY&K combination was only used for reference tone values between 89 % and 100 %. This along with the fact that the single GY and the PGY&GY combination were never among the best choices led us to the possibility of using only PGY and K inks, disregarding GY. The separation process would be the simplified version of the separation approach explained in Section 3. For region 1, lighter than 42 %, two possibilities exist, PGY or PGY&K. For regions 2 and 3, darker than 42 %, PGY&K or K are contemplated. Excluding GY further reduces the number of needed measured patches to 49. Figure 9 shows the calculated ΔE^*_{ab} for dot-off-dot halftoning approach only using these two inks. As seen in this figure, the color difference peaks at around 1.8. Therefore, GY can be ignored if the linear dot gain response is required or a slightly larger color difference between 42 % and 82 % is tolerated (compare Figure 9 with Figure 3).

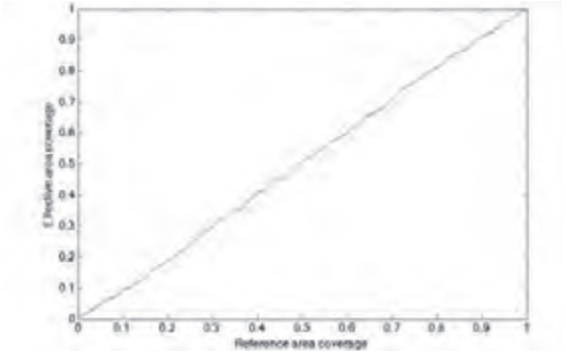

Figure 8: Effective versus reference area coverage for dot-off-dot halftoning approach, compensated for linear dot gain response

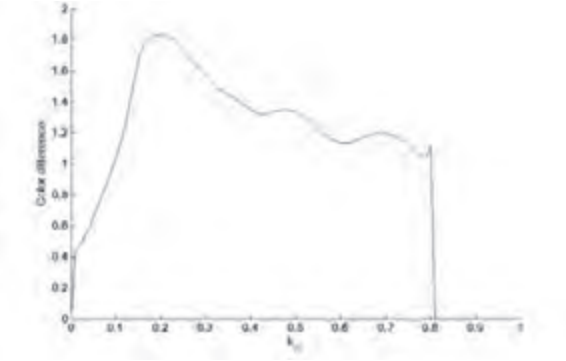

Figure 9: ΔE^*_{ab} color difference for dot-off-dot halftoning approach using PGY and K inks based on interpolated measurement of CIELAB values

6. Conclusions and future work

Dot-off-dot halftoning approach has been implemented in multi-channel printing using three different inks – gray (GY), photo gray (PGY) and black (K). This approach was suggested as an alternative to the multilevel halftoning approach, proposed in Zitinski, Gooran and Nyström (2004), as a way to neutralize the PGY and GY

inks. The separation approach from a given reference K value (pixel value) to PGY, GY and K separations was described. The calculations were based on the measurement results of a total of 129 printed patches. As it was verified, some ink combinations can be excluded from the measured patches in future characterization of similar print setups, making the total number of needed patches 91. The results have shown that the dot-off-dot halftoning approach is able to reproduce all tones of K with a maximum error of 1.8, without ink overlap. It was also shown that dot-off-dot halftoning not only results in less grainy halftones but also requires less ink than both single K prints and independent halftoning. The smoothness of tonal transitions was also verified by printing a gray scale ramp. The dot gain compensation procedure was described in detail and the plot of the effective versus reference area coverage shown in Figure 8 verified that the proposed dot-off-dot halftoning workflow for the printer, inks and substrates used was successfully controlled and can be applied to other frameworks.

The proposed approach has the potential to be applied to multi-channel printing using other inks besides PGY, GY and K, such as C, Lc, M, Lm and Y. If the proposed dot-off-dot halftoning approach is to be used, providing that only the graininess is the concern and not the expansion of the color gamut, the original image only needs to be separated to four channels, C, M, Y and K. The K channel itself is halftoned using PGY, GY and K with no ink overlap, as described in this paper. The C and M channels are halftoned using C and Lc and M and Lm, respectively, with no ink overlap, in a workflow similar to the one described in this paper. Finally, the Y channel is halftoned for itself. This way, there will not be any spot with more than four inks involved and most of them can be replaced by one ink or two inks on top of each other.

In order to be able to reach a larger gamut than CMYK can offer with the proposed approach, coverages whose sum exceeds 100 % need to be included, resulting in some ink overlap. However, the overlap will occur only when necessary for reaching a specific CIELAB target outside CMYK gamut.

The separation can be done similarly to what was described in this paper, yielding dot-off-dot halftones with minimum ink overlap. The benefits of reduced graininess and ink consumption will remain. Since, in this case, increased coverage of the lighter colorants, i.e. PGY, GY, Lc and Lm, is involved, the difference in graininess and ink consumption between the two methods will be more evident.

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The effectiveness of multilingual marketing/advertising messages by Nigerian manufacturers

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Abstract

A well designed product's package is very essential for effective communication as it facilitates the delivery and accurate decoding/interpretation of the marketing message(s) it contains. However, communication can become complicated when the marketing message is conceived to be bilingual or multilingual in view of targeting linguistically heterogeneous consumers. Because multilingual messages/texts' designers usually make extensive use of typography and graphic design (to differentiate between linguistic codes involved in the composition of the message and to ultimately make these compositions readable and intelligible to potential decoders), we used a textual analysis and a user study to reveal incidences of reduced effectiveness – nay ineffectiveness – of marketing messages featuring on the packages of some products made in Nigeria or marketed by Nigerian firms. This study is based on a content analysis and two focus group discussions. The content analysis involved a dozen marketing messages by Nigerian manufacturers from the food and drugs sectors. It considered multilingual phrases and sentences contained in the messages as units of analysis. The paper presents a critique of these multilingual marketing messages with respect to the use of typography and graphics. It analyses the presence and use of typographical markers and graphics in advertising messages to differentiate between languages. It reveals that most Nigerian designers dominantly use punctuation and less spacing to differentiate between the linguistic codes employed in the construction of marketing/advertising messages. Furthermore, some of the multilingual phrases and sentences do not have typographical markers to emphasize these linguistic differences. The texts therefore remain mostly compact and hardly or less legible. The two focus group discussions conducted with multilingual and unilingual expatriates helped elicit consumers' capacity to spot information presented in the multilingual message as well as explain how (in)effective the advertising messages may be in explaining the characteristics of the products been advertised. The discussants identified a number of weaknesses that pointed to the reduced effectiveness of the advertising messages.

Keywords: typography, graphic design, multilingual marketing messages, effective communication

1. Introduction

The systematic use of multi-lingual messages is progressively becoming a dominant and practical approach in the advertising and marketing of Nigerian manufactured products. A considerable number of Nigerian multinationals (from almost all industrial sectors) increasingly target international markets in the Economic Community of West Africa (ECOWAS) region and even beyond and are consequently bound to increasingly resort to translation or multilingual communication in their marketing and advertising campaigns (Endong, 2013, p. 34; Salaudeen, 2008, p. 42; Leurent, 2008, p. 45; Goura and Obi, 2001, p. 16). They formulate marketing/advertising messages in multiple languages. These multilingual messages are artfully designed and delivered via product information featuring on packages. Information delivery is, in principle, in a way as to distinguish the English versions of these messages from their translations into other modern European languages, notably French, Portuguese, Spanish and the like. The mobilisation of translated advertising and marketing messages has thus led to the use of multilingual texts (inscribed on packages) for the promotion of Nigerian manufactured products.

Setting a multi-lingual message on a package is a veritable complex task, especially in situations where the package offers a relatively reduced space. In line with this observation, Balius (2012, p. 32) insightfully posits that linguistic differences between different language and reduced space are often sources of headaches to the designers. He contends that "languages determine the way we see texts, their particular hues and the amount of space we need for a certain amount of text (its length). Some specific combinations of letters appear more frequently in one language than in another, so each language defines its own visual conventions that affect the reading process".

The designer is often bound to work under serious constraints. He has to maximise the space available and design the package – deliver the message through the package – in a way that the linguistically heterogeneous consumers being targeted will all be effectively reached (Cater, Day and Meggs, 2012; Stanway, 2014; Ishida, 2001; Pareek and Khunteta, 2014; Achoimre, 2014; Balius, 2012). In other words, the designer is to design the textual contents of the package in a way as to facilitate the effective dissemination/transmission and decoding or interpretation of the marketing/advertising message in all the languages involved. As Nakilcioğlu (2013, p. 35) succinctly puts it, the most important characteristic of a print message is that "it carries the communication message directly to the reader. The reader should be able to read and understand the message carried to him/her as fast and as easily as possible".

In his efforts to facilitate effective communication with a variety of targeted consumers, the designer often employs phenomena such as typography and punctuation among other reader devices (Chan Ik and Ho Eun, 2013, p. 393; Learner, 2012, p. 1; Ashipu, 2009, p. 116). The designer equally relies on such devices as drawings, images and graphical illustrations as the primary components of visual language to support the conception and visualization of marketing ideas, information and messages (Learner, 2012, p. 1). Though visual communication may be exploited to effectively deliver a multilingual message, typography appears the most appropriate and commonly used by designers. As Nakilcioğlu (2013, p. 52) insightfully contends,

> The fundamental function of writing is to transfer thoughts and knowledge. During this communication, typography is the fundamental element that makes the writing legible and elegant. Even in the books that were written by hand a hundred years ago, the fundamental concern is legibility. No matter how aesthetically perfect the writing is, if it cannot be read, it cannot fulfil its fundamental function of "transferring knowledge to its readers".

Using a textual analysis and a user study, this paper is based on two principal objectives. It seeks both to:

a. Examine the use of typography and graphic design in the construction of multi-lingual marketing messages appearing on the packages of a dozen products made in Nigeria or marketed by some Nigerian firms.
b. Show – through a user study – the extent to which the use of such devices is effective in differentiating the various versions of the marketing messages as well as in presenting (in the various languages) the characteristic of the products being advertised/marketed.

2. Conceptual framework

In this section, we give attention to the explication of two key – concepts namely multilingualism and effective communication. The two concepts enjoy multiple definitions by theorists and communication professionals. For the sake of clarity, the study will hinge on specific conceptual definitions of the terms.

2.1 Multilingual communication

Multilingualism is associated with the use of two or multiple linguistic codes in one and same communication context. It inevitably involves the use of code switching or code mixing in the delivery of the message in a communication situation (Achoimre, 2014; Bulawka, 2012; Isdhida, 2001; Balius, 2012; Liali and Omobowale, 2011; Ugot, 2009). It is based on this conception of multilingualism that this study defines multilingual advertising/marketing messages as information conceived in various languages and contained in a same marketing/advertising message. In the context of Nigerian product advertising, ideas and information are often conceived in English and partially or totally translated in multiple languages including French, Spanish, Portuguese or Arabic). These messages target linguistically heterogeneous readers/consumers.

2.2 Effective communication

Though enjoying various definitions, the concept of communication is generally viewed as a process involving the sending, reception and reaction to messages. In effect, in a communication context, a message is sent by the source, to a person or a group (communicatee), ideally in a manner that the latter will understand it. No doubt, Oyewo (2000, p. 157) defines communication as "the process of transmitting, receiving and acting upon message/information, thoughts, ideas, attitudes and feelings through mutually agreed understandable/determined codes/symbols". This definition indicates that for communication to be effective, the encoding of the message by the source should be effected according to linguistic codes and other conventional signs that are mutually intelligible (understandable by both the sender and the receiver). As Liali and Omobowale (2011, p. 474) succinctly put it, "true communications through the use of certain language(s) with social circles requires mutual intelligibility of meanings for appropriate understanding to avoid the problems of (mis)interpretations". This brings to the fore the imperativeness to produce meaning during the information exchange. In line with this, Nwamuo (2010, p. 21) views communication as the deliberate creation of meaning through the

systematic use of signals and symbols. Nwamuo (2010, p. 21) further offers the following definition of effective communication:

> Effective communication is the act of sending a message in such a way that the decoder or receiver understands clearly the full meaning of the message. Whether it be intra-personal, inter-personal, the group or mass communication, the major purpose is to effectively communicate ideas to the receiver.

In this study, focus will be on seeing how typography and design are used by Nigerian firms to effectively communicate their marketing/advertising messages to multiple (linguistically heterogeneous) consumers.

3. Literature review

This section of the paper is principally concerned with a review of studies devoted to the use of typography in multilingual print communication. It addresses two issues, namely the importance of typography in effective advertising/marketing communication and the typographical treatment of multilingual messages.

3.1 Typography, graphic design and effective communication

A vast literature has sought to examine typography, graphic design and effective communication across various visual, print and audio-visual media (Stanway, 2014; Chan and Ho-Eun, 2013; Nathaporn, 2013; Leaner, 2012; Carter, Day and Meggs, 2012; Ashipu, 2009; Staniscia, 2008; O'Sullivan et al., 1994). These studies argue that the appropriate use of typography and graphic design is mainly for the purpose of (effective) communication. No doubt typography has often been viewed as the study of how letterforms are used to create effects from bold to elegant, and from delicate to aggressive (Ampong, 2011).

The postmodernist perspective in print message design, advocates a reader-based communication approach as it stipulates that "a piece of graphic design as well as art, is incomplete until the reader interprets it" Staniscia (2012, p. 2). In the same line of argument, Nathaporn (2013, p. 26) asserts that "in communicating by means of letters […], the sender must consider the readability and recognition of the audience. Otherwise, the message sent out may trigger miscommunication". This post-modernist concept of the reader is in line with Barthes' declaration that effective communication should be based on of the "Death" of the author (the encoder) in favour of the "Birth" of the reader (the decoder). The post-modernist conception of typography deviates remarkably from the Modernist's one, whose aim was to reach universality, objectivity, and functionality. Typography is, according to the post-modernist perspective, subordinated to the text and its content. According to this school of thought, "it is not the designer/typographer's business to interpret literature in his own way. Literature can speak for itself. His task is to make easier reading". However, to some post-modernist critics as Warde cited in Staniscia (2012, p. 2–3), "it is left almost completely open to the typographer to interpret the copy in his own personal way" in advertising communication. "The importance of the message […] must be brought out by typographical means, for it is the visual impact on the public that matters and not so much the legibility".

Typography is used in various print communication contexts, notably the setting of text messages. Ashipu (2009, p. 116) has identified it as a rhetorical device in some newspaper (print) communication in Nigeria. He notes that, most newspapers lay-outs exploit typography to give "a distinctive journalistic characteristic in media writing generally". However, typography is to be apprehended as a reader device. A proper use of typographical markers and graphic design (spacing, punctuation, boxing, colouring, capitalisation and the like) inevitably reduces a number of barriers to communication, notably syntactical and semantic noises. It enables the communicator to design the print message in a more meaningful and readable way. Typography is therefore a potential tool for a more expressive and effective communication. Hostetler (2013, p. 28) notes that:

> The use of typography is the primary means of presenting ideas and messages for expressive communication […] Typography has a dual role: to represent a concept, and to do so in a visual form. This interplay of meaning and form brings a balanced harmony into the stage both in terms of function and expression.

Nakilcioğllu (2013, p. 47) asserts that the first and most important duty of the designer is to choose the appropriate letter and typeface. When this choice is made correctly, the first design problem is resolved. According to him, when used properly, the different font specifications of writing (notably typefaces, sizes and so forth) make the script (product package) attract more attention to the parts it wants to direct the reader's attention and thus makes sure the subject is better understood (Nakilcioğllu, 2015, p. 52; Nathaporn, 2013, p. 26; Chan and Ho-Eun, 2013, p. 394; Kidd, 2011, p. 12; Heller and Ilic, 2012, p. 11; Learner, 2012, p. 4). In line with this, Hostetler (2013, p. 27) further observes that:

> Each typeface has its own individual identity because of different proportions and a variety of line weights, widths, directional slants and so on. These individual qualities clearly determine that each typeface demonstrates a different use and purpose for expression. A well-combined variety of typefaces bring variations of expression and harmony to the design. Awareness of these classifications is an essential tool in developing a designer's ability to select an appropriate typeface that enhances the expressive message in typography.

Studies in information design and psychology have equally shown that typeface in particular can affect readers (audiences) in two principal ways. The first way is by creating connotations (for instance novelty, potency, elegance) above and beyond the denotative message contained in the text (Rowe, 1982; Bartram, 1982) and the second way is through interaction between the connotative meaning of the typeface and the denotative meaning of the text. This means that when there is consistency between the typeface and meaning of the text, the perception by audiences of the message (of the text) is strengthened (Foltz, Poltrok and Potts, 1984; Lewis and Walker, 1989).

3.2 Use of typography and design in multilingual advertising messages

Multilingualism in print advertising plays multiple functions ranging from symbolism and identity formation to globalisation. The symbolic and identity formation functions of multilingualism are viewed in the fact that certain languages are considered to function as symbolic vectors of stereotyping and requisites for the reproduction of fixed images about native speakers of those languages.

Citing Hamaan and a number of other authors, Bulawka (2012, p. 65) contends that a number of positive ethno-cultural stereotypes have often been associated with particular international languages (notably French, English, German, Italian among others) and by extension, with native speakers of these respective languages. Such stereotypes are often creatively mobilised by advertising copy writers and designers in labelling the product they advertise.

> The cultural stereotypes are surprisingly similar in [many different] cultural and linguistic contexts. Thus, French conjures up image of elegance, sophistication, refinement and fashion, […] Italian evokes association with tasty cuisine and 'sporty elegance' while German symbolises good quality and prestige. As the above examples demonstrate, the use of linguistic symbolism capitalises on the positive stereotyping and has as its main goal evoking favourable associations in the mind of the reader (Bulawka, 2012).

Globalisation is perhaps the most obvious function of multilingualism in international advertising. In effect, the hidden power of ethno-symbolism evoked through the use of different linguistic codes in advertising is in line with the worldwide trend toward the internationalisation of information in general and the internationalisation of the commercial text in particular. It is generally believed that by using many linguistic codes, the advertising message is aimed at many linguistic communities. According to Balius (2012, p. 32), multilingualism is dictated by the forces of economic globalisation. It should imperatively be envisaged in the promotion of a product aimed at the global market. He notes that:

> Languages are usually the first barrier we encounter when we have to communicate with or relate to other cultural realities. Being able to express ourselves in one language is insufficient nowadays. Economic globalisation compels us to treat markets with respect, so if a product hopes to successfully survive it must position itself respecting local idiosyncrasies, just as any expression that aspires to be cultural (a publishing product, for instance) and hopes to transcend its local context will have to address multilingualism as a true necessity.

Multilingualism therefore follows the informational paradigm – one of the various approaches that examine the effect of language in advertising. This approach focuses on how easily consumers can comprehend and respond to information provided in a particular language. It stipulates that, for communication to be effective, information should be presented in the language of the targeted consumers. In line with this paradigm, English would be ineffective if consumers in an ethnic subculture could not comprehend the advertising message (Achoimre, 2014). Multilingualism (through translation of information on product and product use) offers the possibility to reach diverse audiences and linguistically heterogeneous consumers. However, as earlier mentioned, implementing a multilingual message is often a complex task for the designer. Indeed, such a task is very much characterised by a panoply of linguistic, cultural, aesthetic and ethical dimensions (Achoimre, 2014; Bulawka, 2012; Ishida, 2001). The designer in such a context is always compelled to observe a number of subjective – and more or less intuitive – approaches as well as a number of conventions and principles that normally varies depending on a number of factors. These factors include the linguistic differences between the languages involved in the composite text and the space available (the message expand) and the ultimate function of the text (Bouayad-Agha et al., 2004; Paris et al., 2012; Balius, 2012; Kodie and Ciarlone, 2008; Achoimre, 2014).

Ishida (2001) notes that what is paramount in multilingual texts construction is the splitting of the text in meaningful units of information. The splitting should be

in a way that will not impend translations into the various languages involved in the multilingual communication. He further notes that designers in such situations must consider linguistic differences in the implementation of the messages, especially when the message is to be accompanied with translations into various languages. "Designers must be careful about how they split up and reuse text on screen, since the linguistic differences between languages can lead to real headaches for localisers and may in some cases make a reasonable translation impossible to achieve" (Ishida, 2001).

This aspect of designing is very important as the purpose of labelling any product is to provide consumers with all of the relevant information about the product they are buying (Achoimre 2014, p. 78). For the designing of a multilingual advertising message to be effective, it is essential that the translation be accurate and reflects the true nature of the product in the various languages. "Misspellings and poor translations can prove costly, even though the packaging may only contain a few words. Such errors may also reflect badly on the organisation in question" (Achoimre, 2014).

The linguistic differences between languages involved are closely related to other considerations that border on the space available to display the multilingual text. Sadek and Zhukov (1997) corroborate this view when they insightfully contend that:

> Languages affect our vision of texts, their specific colour and the amount of space we need for a given volume of text (its length). The Latin alphabet can present different textures, according to the language used for writing. Even so, changes in texture and colour are much more obvious when different writing systems are employed.

This indicates that typography is the principal strategic tool to surmounting obstacles linked to the implementation of multilingual text. A good mobilisation of typographical markers such as colour, spacing, boxing, font size, typefaces and the like may enormously help in differentiating between the different versions of the advertising message presented on same package. Shimp's (2007) VIEW-model aptly illustrates this fact. According to this model, four principles should guide package design, namely visibility, information, emotional appeal and workability. Visibility refers to the ability of a package to attract the attention of both the multilingual and the monolingual reader or viewer at the point of purchase. This visibility can be achieved through appropriate use of typographical markers (colouring, type face, space, point size and the like).

The second principle underscored by the VIEW-model (Information) refers to the inclusion of the right type and the right quantity of information in the various languages involved in the composition of the advertising message, this without clustering the text. The information principle is the most relevant, with respect to multilingualism as it borders on the amount of information to be communicated in the various languages against the available space provided by the package. The third principle (Emotional appeal) refers to the package's ability to evoke a particular emotion and a desired mood. This is equally achieved through appropriate use of typographical markers. The last principle (Workability) has to do with how the package functions in terms of storage, protection and accessibility rather than its informational potentials.

All these observations indicate that through typography and graphic design, specific components of the message are given distinctive characteristics. In multilingual print messages, a careful exploitation of typography may permit the product package to differentiate between the different languages used to communicate proprieties of the products in promotion to various targeted consumers. This clearly enhances the effectiveness of the marketing and advertising message. The guiding principle in multilingual text design is that readers from all the targeted heterogeneous linguistic communities be effectively reached (Stanway, 2014). As Carter, Day and Meggs (2012, p. 114) insightfully observe, typography – as a dynamic representation of verbal language – must communicate. This functional role is fulfilled when the receivers from various cultures and linguistic communities clearly receive the typographic message and accurately understand what is in the mind of the transmitter (encoder).

4. Research methodology

This study is based on two methods of data collection – namely, a textual analysis and two focus group discussions.

4.1 Content analysis

The content analysis considered over 100 multilingual phrases and sentences contained in multilingual advertising/marketing messages appearing on the packages of a dozen randomly selected products. The products considered in the study are made in Nigeria or marketed by Nigerian firms. They included *Aquabar Table Water, Annapurna Salt, Closeup Toothpaste, Mummy Kitchen, Fally White Vinegar, Omo Multiactive, Milo, Golden Penny Twist; Golden Penny Spaghetti, Indomie Instant Noodles, Golden Penny Sugar, Gossy Table Water* and *Ballourah Perfume*. The study considered this sample as the aforementioned products have multilingual messages inscribed on their

packages, contrarily to others that are exclusively unilingual (composed exclusively in English). The multilingual nature of the package therefore indicates their designers' attempts at reaching a heterogeneous readership and an international market.

According to a number of studies, these products (those selected in this study) are commercialised in French and Portuguese speaking country within the ECOWAS sub-region and Cameroon (Leurent, 2013, p. 63; Soule and Obi, 2001, p. 234; Endong, 2013).

The study considered as multilingual the messages that combined/mixed information presented in different languages. Most of the messages presented in products' packages offer information conceived or formulated in English, and completely or partially translated into other languages (French, Spanish, Portuguese, Arabic).

The study equally considered only multilingual phrases and sentences of the messages as units of analysis and aimed at eliciting the firms' use of typography and graphics to differentiate between the different languages involved in the composition of the marketing/advertising messages. It measured the extent to which the firms make use of graphology and graphic design for effective communication of their marketing messages.

The data collected through content analysis was statistically analysed and presented in tables.

4.2 Focus groups

Qualitative data was equally collected through two focus group discussions with some heavy consumers of Nigerian products. The two focus group discussions were separately organised: the first involved 15 English-French and English-Spanish multilinguals and the second 15 unilingual expatriates. In each of the discussions, 9 of the participants were female. The focus group discussants had read and examined information presented on 5 of the selected packages (*Annapurna Salt, Closeup Toothpaste, Mummy Kitchen, Omo Multiactive* and *Golden Penny Twist*), in view of assessing the encoders' (designers') use of typographical markers and graphics. The investigation was designed to establish the (in)effectiveness of the multilingual messages presented on the packages, their ability to differentiate between different languages and their effectiveness in presenting product qualities in view of persuading readers and motivating consumption of the products. The questions addressed by focus group discussants included the following:

a. Could you easily spot information in French or Spanish on the package?
b. How readable is the information presented in French or Spanish?
c. How coherent is the information on product or product use in French or Spanish?
d. Does the package information layout discourage you from consuming the product?

5. Results and discussion of findings

5.1 Use of typography and graphics in multilingual advertising messages

Findings reveal that most of the advertising/marketing messages contained typographical markers to differentiate between the English versions of the phrases and sentences and their translations into other languages. This is shown in Table 1. The use of these typographical markers in 69 % of the texts indicates that some of the messages may potentially be partially readable and partially understandable.

Though representing a relatively small portion of the advertising and marketing messages, the parts that do not contain typographical markers may reduce the effective communication of the messages as messages are bound, under such conditions, to theoretically be partially readable. This will be explained in greater details in the second part of this section through presentation of the results of the user study.

As explained earlier, multilingual texts are more readable and understandable when the different languages involved in their composition clearly stand out. Normally, from simple sight, the reader is supposed to spot the different versions (languages) and select the sections of the messages that present information in the language he/she understands or uses. He/she should therefore be enabled to see where begins and where ends the different phrases and sentences in the languages involved. For this reason, the typographical treatment of the text should be in a way as to separate the various versions, thereby facilitating effective communication.

As indicated in Table 2, punctuation is the typographical marker which is dominantly exploited in the presentation of the various marketing messages. It enjoys a percentage use of 55%, followed by spacing (35 %) and font size/typeface (20 %). Punctuation is used as principal reader device in the marketing/advertising messages of more than 8 of the 12 marketing messages considered for the study. The recurrent punctuation marks featuring in these texts include slashes [/] and full stops [.]. This can be illustrated with Figures 1, 2 and 3, showing typographical solutions respectively applied in implementing multilingual text in *Closeup Toothpaste* and *Annapurna Salt*.

Table 1: Phrases and sentences with typographical markers used in the studied packaging

Product's name	With typographical markers		With no typographical markers		Total	
	n	%	n	%	n	%
Aquabar Table Water	7	100	0	0	7	100
Annarpurna Salt	6	55	5	45	11	100
Closeup Toothpaste	6	67	3	33	9	100
Mmunny Kitchen	3	100	0	0	3	100
Fally White Vinegar	1	100	0	0	1	100
Omo Multivariate	8	44	10	56	18	100
Milo (Energy drink)	10	83	2	17	12	100
Golden Penny Twist	11	79	3	21	14	100
Golden Penny Spaghetti	10	71	4	29	14	100
Golden Penny Sugar	4	50	4	50	8	100
Gossy Table Water	2	100	0	0	2	100
Ballourah Perfume	1	100	0	0	1	100
Total	69	69	31	31	100	100

Figure 1: Enlarged section of side-view of Closeup Toothpaste.

Figure 2: Front view of the package of Closeup Toothpaste.

In Figures 1 and 2, the package of *Closeup Toothpaste* offers a range of product information in three languages (Spanish, French and English. Slashes [/] are used to differentiate a language from the other. In Figure 3, *Annapurna Salt* rather uses a bullet [·] to separate the English from the French version of the message. The slash and the dot are therefore the principal punctuation marks used by the designers of the packages considered for the study. As one may easily notice, punctuation often causes the text to be over clustered.

Table 2: Typographical markers used

Product's Name	Spacing		Point size / typeface		Colouring		Punctuation		Total	
	n	%	n	%	n	%	n	%	n	%
Aquabar Table Water	1	14	0	0	0	0	6	86	7	100
Annapurna Salt	0	0	0	0	0	0	6	100	6	100
Closeup Toothpaste	2	33	0	0	0	0	4	67	6	100
Mummy Kitchen	3	100	0	0	0	0	0	0	3	100
Fally White Vinegar	1	100	0	0	0	0	0	0	1	100
Omo Multivariate	1	12.5	6	75	1	12.5	0	0	8	100
Milo (Energy drink)	8	80	0	0	2	20	0	0	10	100
Golden Penny Twist	1	09	4	36	0	0	6	55	11	100
Golden Penny Spaghetti	1	10	4	40	0	0	5	50	10	100
Golden Penny Sugar	4	100	0	0	0	0	0	0	4	100
Gossy Table Water	1	50	0	0	0	0	1	50	2	100
Ballourah Perfume	1	100	0	0	0	0	0	0	1	100
Total	24	35	14	20	3	4	28	41	69	100

Figure 3: A section view of Annapurna Salt

The appropriate use of punctuation helps to maximize space and present as much text as possible. Though being relatively suitable for text presented in reduced space, this typographical marker (punctuation) has the disadvantage of leaving the multilingual text more or less compact and clustered. This is true to the messages communicated on the packages of *Closeup Toothpaste* and *Golden Penny Sugar* (see Figure 1 as well as 4 and 5) among others, where succession of such multilingual (trilingual/quadrilingual) phrases and short sentences are made.

Figure 4: Other view of Anapurna Salt package

It may be relatively difficult for the reader in such context where text is somehow clustered to differentiate between the different languages at first sight and gather the information aimed at him/her. One needs to thoroughly read in between the lines to find the version of the information in the language he/she understands. This fact will also be demonstrated in the second part of this section.

Figure 5: Uni-coloured and clustered text on Golden Penny Sugar

There is no doubt that these messages could be more effective if such typographical markers as spacing, capitalization (font size/typeface) and colouring were carefully employed in the presentation of the message (Hostetler, 2006). Nakilcioğlu (2013, p. 48) notes that:

> The spacing between typographic elements makes the script easier or harder to read. Excessive spacing makes the message repulsive, too little spacing jams the words and lines and disrupts the appearance of the writing and makes reading problematic as well […] Just as how sound and silence are the indispensable elements of music, letter shapes and spacing are the indispensable elements of writing. Each letter occupies a different area. And depending on the chosen font, the space occupied by letters changes as well. It is difficult to read scripts with very jammed or loose letters.

It has equally been argued that appropriate colouring can be a reader device. In effect, colour gives meaning to content (Kidd, 2011). It is not difficult to use colour, but it is important to use the right colour. Proper and balanced usage of colour is an indispensable part of a good package design (Nakilcioğlu 2013, p. 51).

Figure 6: A visual of Indomie Instant Noodles

As typographical markers, spacing, capitalization and colouring enable the different versions of the information to be distinct in the multilingual text. For example, a multicoloured text – presented with different colours to separate languages – is susceptible to be more effective for the communication of the marketing message. Such multicoloured text could be seen on the package of *Indomie Instant Noodles* and *Golden Penny Spaghetti* (see Figures 6 and 7).

In Figure 6, the black and the red colours are employed to differentiate between the English/Arab and the French version of the product information being communicated. The design and typographical solutions

adopted here clearly permit the different languages involved to stand out. It facilitates readers' spotting of the version aimed at him or her. The same comment may be made on *Golden Penny Spaghetti*'s package.

Another factor reducing the potentials of some of the marketing messages to effectively communicate product information is the fact that the phrases and sentences with no typographical markers are often trilingual or quadrilingual. Some packages are even inconsistent in the implementation of the various versions of their messages in that they present some information in two languages and in some other instances present information in three languages. Good examples are *Closeup Toothpaste* and *Golden Penny Spaghetti* (see Figure 2 and 7). In Figure 7, the package of *Golden Penny Spaghetti* presents a range of information in English which it inconsistently translates into Italian or French. This inconsistency, of course, renders the availability of particular information (which may be necessary) unpredictable by the reader.

Figure 7: Multilingual texts on Golden Penny Spaghetti

In Table 3, the findings indicate that most (77 %) of the phrases and sentences with no typographical markers are bilingual (English and French).

Table 3: Phrases and sentences with no typographical markers

Product's Name	Bi-lingual		Multi-lingual		Total	
	n	%	n	%	n	%
Annapurna Salt	5	100	0	0	5	100
Closeup Toothpaste	0	0	3	100	3	100
Omo Multivariate	8	80	2	20	10	100
Milo (Energy drink)	2	100	0	0	2	100
Golden Penny Twist	2	67	1	33	3	100
Golden Penny Spaghetti	3	75	1	25	4	100
Golden Penny Sugar	4	100	0	0	4	100
Total	24	77	7	23	31	100

Far from insinuating that the marketing/advertising messages in the present forms do not communicate information about the products to the consumers, we strongly believe that their communicational potentials is highly reduced with the partial use of typographical markers or the use of less effective typographical markers.

5.2 Users' assessment of text design on product packages

Based on their reading of the information provided on product packages and their evaluation of designers' use of typography, the bilinguals and unilingual focus group discussants assessed the effectiveness and usefulness of the marketing messages presented in foreign languages on the packages (in French and in Spanish). A summary of key comments is presented below:

a. Information presented in foreign language is not easily spotted by readers because typographical markers are either hardly or inappropriately used in some of the packages to differentiate between languages used in composing the message. Text is generally compact (clustered) with no or limited use of space, point size, typeface or colour differentiation of languages. A focus group discussant noted that "from a scan of most of these packages (*Closeup Toothpaste*, *Mummy Kitchen*), I hardly see information in French. One may hardly believe there is use of French in the message they carry."
b. To decipher the messages, one sometimes needs to thoroughly explore the text and to select the

parts that are presented in foreign languages. This comment was principally made by bilinguals who, being versed with two languages, could differentiate between languages. On the other hand, most unilingual readers claimed not to be able to select the portion of the messages in French or Spanish.

c. The messages are hardly coherent in most cases where there is inconsistency in translation or utilization of typographical markers. This comment was principally made about packages of such product as *Omo Multivariate, Closeup Toothpaste* and *Milo*. The inconsistency in translation arises when some parts of the marketing message is translated meanwhile other portions are not.
d. The same, inconsistency in the use of typographical markers causes part of the messages to be compact (to appear in blocks with language mix) and less readable by unilingual readers.
e. Inconsistency in translation (partial translation) creates "lacuna" and disrupts the continuous flow of information about the product.
f. The fact that important parts of the messages like the slogan and the product's name are not translated, may discourage a unilingual reader from continuing reading the marketing message placed on the package.
g. Inconsistency in use of typographical markers creates difficulties in gathering information about the product in a wholesome way.

6. Conclusion

This paper has exploited a textual analysis and a user study to critique the marketing messages by Nigerian manufacturers. It sought to measure the extent to which these marketing/advertising messages may be effective; judging from a typographical point of view, it has identified two principal features in the marketing/advertising messages that may serve as barriers to effective communication. These include the non utilization of typographical markers in parts of the multilingual messages and the over exploitation of less effective typographical markers such as punctuation in the setting of these messages. It appears clear that such solution to typographical problems in package designing may be in line with most Nigerian manufacturers' attempt at saving packaging cost through the provision of a heavily "loaded" package for multiple countries. However, as observed in this paper, by using less effective typographical markers (such as punctuation markers which circumstantially causes text to be compact and relatively unreadable), the manufacturers' communication attempt may be unfruitful and their cost saving objective may not be realised.

This paper argues in conclusion that the mobilization of markers such as spacing, colouring and capitalization be very much envisaged by designers as they have greater potentials to differentiate the different versions of the messages, thereby enhancing the effectiveness of the marketing/advertising messages. The paper also recommends that instead of conceiving a tri- or quadri-lingual package which may cause information to be too compacted and relatively unreadable, it is better – especially when financial possibilities permit – to produce two different bilingual versions that will be more effective in advertising the product.

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Topicalities

Edited by Markéta Držková

Contents

News & more

New features offered by Enfocus PitStop Pro 13

Enfocus promotes three key enhancements to the new version of PitStop, which is available from spring 2015 – bleed creation in files where it is missing or insufficient, more specific and accurate preflight engine, enabling to limit preflight checks or fixes only to certain parts of a file, and possibility to improve communication, both with customers and within a company, by customized preflight messages.

While in previous versions only rectangular vector based objects could be extended in order to create bleed, the new Action to 'Add Bleed' works on all page content except text. This Action preferably uses the page content which is present in the bleed box, but hidden or masked; as a second option, a 'mirror' approach is used to create bleed. Different settings can be applied to different page edges and corners; in addition, 'Add Bleed' Action can respect the page binding. The generated mirrored objects are copies of the original objects and retain all their attributes (such as overprint settings or ICC tags). All colour spaces within a PDF file are supported.

The user interface of the Preflight Profile editor within PitStop 13 has been reorganized, with all the categories and checks on the left hand-side. However, the main addition consists in 'Restrictions'. This new functionality let users limit the Preflight process only to defined elements of the file, making it much more specific, i.e. more relevant and accurate. Restrictions are based on 'Select Actions', which can be easily customized, and also imported and exported. Once the Restriction is present, any added inferior checks or fixes will be bound by that Restriction. In case of need, multiple Restrictions can be combined. In this way, it is possible to define single Preflight Profile performing different checks and fixes e.g. for the first page and the remaining ones (except the first).

Customized Preflight messages can be based on variable information used by PitStop to create standard messages, or written solely using own words. Analogously, Action List messages can be customized.

Further, now it is possible to create and edit Action Lists within PitStop Server and convert PDF files to images and output PNG and JPEG files through its command line version.

Other features in the new version of PitStop Pro and PitStop Server include improved 'Log Selection' Action, new Action 'Select page by gray surface' enabling to find pages with only slight colour shade and convert them to Gray for printing, and several new Action Lists. PitStop Workgroup Manager now shows the connected users as well as the history of those who were connected in the monitor panel and also allows to disconnect users when there is a need to free up a PitStop Pro license.

Adobe Acrobat DC/2015 is supported, whereas Mac OS X 10.6 and 10.7, and Adobe Acrobat 8 and 9 are no longer supported.

Kodak Prinergy Workflow 7 with integrated Callas software technology

Kodak Prinergy is one of the industry's most popular workflow automation software and provides functions supporting job creation, collaboration, file processing, trapping, proofing, imposition and colour management. To further reduce inefficiencies and enhance printing quality, the recently released version of Prinergy Workflow offers several improvements.

Better quality control and reduced manual touch points can be achieved thanks to Preflight+ which allows the integration of callas software pdfToolbox preflight profiles. (PDF technology from callas software is utilized e.g. in Adobe Acrobat DC.) This extends the range of validation and correction features that are essential during PDF data quality control and preparation. Thousands of files can be preflighted, corrected and repurposed for print production and electronic publishing on a fully automated basis.

Further, error detection in files with multiple layers for versioned printing was improved in Prinergy Workflow 7. Even more importantly, it is possible to control multiple devices, ranging from Kodak and third-party digital presses and CTP devices to the conventional presses. This way, efficient and automated production of all job sizes can be realized. Job ticketing parameters can be controlled both manually and through Rules Based Automation while monitoring and reporting their status.

ColorGATE
Version 9 RIP software

In May, ColorGATE has presented its solutions at FESPA 2015 and LIGNA 2015. The Version 9 RIP Software family consists of the core product, Productionserver, specialized Filmgate, Plategate and Proofgate products, and extensions with modules for output, colour, job, and workflow management. The range of functions covers all process stages (design import, prototyping, production, finishing and also reprinting).

Within colour management solutions, ColorGATE offers Rapid Spectro Cube, an ultra-fast measurement device suitable for industrial printing, which is capable to measure patches as small as 1 × 1 mm. The new Industrial Productionserver Editions, dedicated to textile, décor and ceramics printing, should help producers facilitating conventional printing techniques to use existing printing data in the inkjet print production workflow. Besides processing of complete design files, utilizing separated and screened data is possible as well. Together with Wemhöner, ColorGATE presented its intelligent control software, SmartControl Industrial Printing Operating System (IP OS).

Label Traxx
Job management software

Label Traxx is the system consisting of twelve modules designed for narrow web flexographic and digital label printing or in-line roll converting e.g. on hot stamp, rotary letterpress or web combination presses. Label Traxx JDF Link allows bidirectional communication with pre-press software, the first being Esko Automation Engine. With new features presented at DSCOOP X, Label Traxx is now able to pass specifications for lead-in and lead-out frames, used to register the labels on the finishing equipment, to Automation Engine. For estimating, the new model of HP Indigo 20000 click charges is included as well.

Less than one year to drupa 2016

Second drupa Global Trends report

The report is available since March 2015 and analyses a global survey conducted in October 2014, in which 810 printers and 304 suppliers participated (513 and 194 of them representing Europe, respectively). Current economic condition of company was described as good by 34 % and as poor by 13 % of printers; in case of their suppliers, it was 36 and 17 %, respectively. Even more optimistic are the prospects for 2015 – the improvement was anticipated by 48 % printers and 51 % of suppliers, while only 7 % of printers and 8 % of suppliers expected their economic position to decline. This optimism is supported by the investment plans cited both by print service providers and supplier firms. In virtually all regions, the situation is better for Packaging and Functional markets than for Commercial and Publishing ones.

Analyzing the trends in more detail, sales for print service providers continue to rise (increase was reported by 39 %, decrease by 22 %), but they are less pronounced; moreover, the margins continue to fall (reported by 43 %, while increased margins just by 16 %). The widening gap appears in digital printing, because whereas its share is growing fast, the most turnover still comes from traditional print. Similarly, just 27 % of printers achieved more than 10 % of their sales with services outside the print sector.

Monthly series of expert articles has started

The first expert article "Smarter print to market" has been released in the middle of June. Discussing the factors affecting print market, Gareth Ward says that to build for the future and to make print a successful communications medium, the print has to be relevant and the printer must offer customers a full service. Print is still needed, but it has to be more specific or advanced – or both. To achieve this, new printing, converting and finishing technologies alone are not enough. Information technologies must be understood and efficiently used to create automated workflows, as well as to deliver 'smarter' print to market. Another good point in the article is related to the investment strategy of printers, often preferring to invest in a new printing press rather than in IT: "A faster press magnifies the problem of handling more jobs in less time without introducing errors." This opens the question of print management skills which might need to be improved.

BDT Media Automation wide-format autoloader and stacker

In May, these new BDT products have been presented at Digital FESPA 2015. Patented BDT Tornado Technology is incorporated to provide flexible transport and soft handling of all media with thickness from 200 µm to 51 mm and maximum format size of 3200 × 3200 mm, with feed rate up to 100 boards per hour.

The U.S. patent 8,960,666 B2 – Method and device for the generation and/or conveyance of a shingled stream of flat, flexible objects – was received in February 2015. Described shingling method relies on BDT Tornado modules, creating a low pressure zone to attract and control the media. Each module operates independently and is fully controllable. This way, overlapping streams of packaging materials, including very light weight media, cardboard and flexible bags, can be created and employed in commercial printing and automated packaging lines, for variable length sheeting and stacking without the need for mechanical intervention or adjustment.

Bookshelf

Functional Polymers in Food Science: From Technology to Biology, Volume 1: Food Packaging

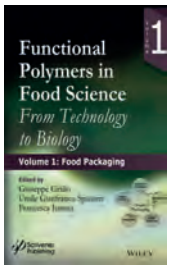
Polymers, being versatile materials which can be tailored to meet specific needs, find wide range of applications in everyday life. The two-volume set published within series on Polymer Science and Plastics Engineering concerns the use of polymeric materials in food science. This first volume covers the application of polymers in food packaging and reveals future trends. Recent research in this area is aimed especially at finding the most suitable materials for intelligent packaging, preserving the food quality and prolonging the shelf-life of the products, which represents a promising direction for future printing.

After a short introductory overview of polymers in food packaging written by the editors, the second chapter deals with various aspects of food shelf-life extension and respective innovative polymers. Next, food-packaging interaction and mass transport processes in food/packaging system are explored, including effects of different parameters on partition coefficient, model migrants and instrumental analyses.

The main part of the book consists of chapters describing individual types of polymers relevant to food packaging – production, chemistry and properties of biopolymers in food science, modification strategies of proteins, films based on native and modified starches, polysaccharide materials, inorganic-organic hybrid polymers, and antimicrobial active polymers.

Food packaging for high pressure processing is also mentioned, including modified atmosphere packaging, active packaging materials, challenges encountered after high pressure processing and laminate selection for high pressure processing both at low and high temperatures. Labelling and printing steps are shortly discussed as well, dependent upon requirements on water resistivity and pressure stability. Final two chapters are dedicated to the recycling of food packaging materials and to legal issues and safety concerns related to food applications of active and intelligent packaging.

For those interested also in the nutraceutical field, there is the second volume. It begins with short outline of functional polymers for food processing, followed by chapters related to agriculture, where specific polymers are used to increase the efficiency of treatments and reduce the environmental pollution. There are discussed impacts of polyacrylamide addition on soil structure and stability, agricultural use of functional polymeric membrane, and enzymes used in animal feed. During food processing itself, focus is on interaction of biomolecules with synthetic polymers. Next chapters cover rheological properties of non-starch polysaccharides, polysaccharides as bioactive components, functionality and use of milk proteins, bioactive peptides from meat proteins, and antioxidant polymers. Finally, biopolymers for administration and gastrointestinal delivery of functional food ingredients and probiotic bacteria, cyclodextrin as a food additive, and enzymes and inhibitors in food and health are described.



Functional Polymers in Food Science: From Technology to Biology
Volume 1: Food Packaging
Editors: Giuseppe Cirillo, Umile Gianfranco Spizzirri, Francesca Iemma
Publisher: Wiley-Scrivener
1st ed., May 2015
ISBN: 978-1-118-59489-6
456 pages
Hardcover
Available also as an eBook

The New Shop Class: Getting Started with 3D Printing, Arduino, and Wearable Tech

Authors: Joan Horvath, Rich Cameron

Publisher: Apress
1st ed., May 2015
ISBN: 978-1484209059
232 pages
Paperback
Also as an eBook

The New Shop Class is written by a systems engineer, management consultant and educator Joan Horvath, experienced in connecting people from diverse fields which can learn from each other, and 3D printing expert Rich Cameron, who has been a key member of the RepRap 3D-printer development community. The authors aimed this book at readers ranging from aspiring scientists to makers and from teachers to students, or even kids. They all can get started with the technologies like 3D printing, Arduino and simple electronics, their costs and the ways of their utilization by innovators and scientists.

Besides the above-mentioned technologies, the first part also introduces Raspberry Pi, programming or robots and drones. In the second part, the authors discuss the innovative environment, the applications like wearable electronics or internet of things and communities like cosplayers. Next part is dedicated to scientists – their way of thinking and working. The fourth part points out the importance of learning by failing, covering e.g. problem-based learning or iterative problem solution, and reflects on learning science by making – or scientists learning from makers.

State Aid for Newspapers: Theories, Cases, Actions

Editor: Paul C. Murschetz

Publisher: Springer
2nd ed., 2013
ISBN: 978-3642356902
402 pages, 29 images
Hardcover
Also as an eBook

This title in Media Business and Innovation Series is focused on the print news media, struggling for several years, and the role of state

Manufacturing Flexible Packaging: Materials, Machinery, and Techniques

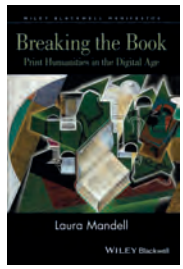
This book is guided by the idea that designing and manufacturing 'fit-to-use' and 'fit-to-make' products is a key to efficient and profitable production of quality flexible packaging, particularly in food and medical sectors of the packaging industry. The content should help engineers, product designers and materials scientists to improve existing raw material selection and processes for manufacturing functional flexible packaging as well as to minimize waste and idle time in production.

Thomas Dunn touches all aspects – from the processing methods over the machines and raw materials to the testing issues. Basics of web processes are followed by chapters on processes, options and innovations in rotogravure and flexographic printing, adhesive lamination, extrusion lamination or coating, finishing, and slitting. Next, in-line processes, overall equipment effectiveness, efficiency and cost accounting are covered. The chapters introducing corresponding machines start with the basics of current control systems and end with considerations important for quality management. Following part on raw materials deals with papers, foils, plastic films, various kinds of resins, inks, varnishes, adhesives and primers. Last chapters are dedicated to the conditioning, intrinsic material properties, such as tensile, elongation, modulus and elastic and plastic regions, and secondary quality characteristics, including seal and bond strengths, friction coefficient, oxygen barrier and moisture vapour barrier.

Manufacturing Flexible Packaging:
Materials, Machinery, and Techniques
Author: Thomas Dunn
Publisher: William Andrew
1st ed., September 2014
ISBN: 978-0-323-26436-5
304 pages
Hardcover
Available also as an eBook

Breaking the Book: Print Humanities in the Digital Age

Laura Mandell's manifesto contributes to the timely discussion on print and digital media, analysing their relationship with the humanities in general, and literary criticism in particular, and exploring the reasons why the traditional humanities disciplines are resistant to 'digital' humanities. Learning from the book history and its influence on the way people think and feel, projected into scholarly practice, the book presumes how the digital revolution is going to change disciplinarity, expertise, and the institutional restructuring of the humanities. The danger of repeating the same errors is recognized. In concluding part, four kinds of book failure which can be overcome by digital humanities are identified and discussed.



Breaking the Book: Print Humanities in the Digital Age
Author: Laura Mandell
Publisher: Wiley-Blackwell
1st ed., May 2015
ISBN: 978-1-118-27455-2
240 pages
Hardcover

Food Industry Design, Technology and Innovation

The content of the book, appearing in the Institute of Food Technologists Series, is in line with the mission of the Institute – "to advance the science of food contributing to healthier people everywhere". Expanding from common considerations of packaging, logos, fonts and colours only, the food design is now impacting more on the food supply, with a chance to make it better and play essential role in defining and executing business strategies and business processes. However, to achieve this, food designers need to master related technologies, systems and organizations. In the first part, the authors describe the role of design in the food industry and identify the drivers of its current change (with 3D printing closing the list). The relation of food design to ingredients, materials, technologies and processes employed is discussed, as well as design future in academia and business world. This part is concluded with real-world examples from big food corporations. The second part stresses the importance of innovation, enabled by the right people, tools and partnerships.

Food Industry Design, Technology and Innovation
Authors: Helmut Traitler, Birgit Coleman, Karen Hofmann
Publisher: Wiley-Blackwell
1st ed., November 2014
ISBN: 978-1-118-73326-4
312 pages
Hardcover
Available also as an eBook

Communication Design: Insights from the Creative Industries

Derek Yates with Jessie Price used their connections to the creative industries to write the book showcasing the current practices in graphic design, still not forgetting the historical context. The book, which was promoted with special care within the creative community, has become popular short after publication. The aim was to provide graphic arts students and practitioners with a relevant and contemporary information on the new skills required to succeed in the field. The reason is the change in the communication environment, with the balance between four key elements – content, form, audience and context – recently shifted.

The text is supported by case studies and interviews with more than twenty experts, and organized into seven chapters. Brand explores systems, strategy, ecosystems, authenticity and heritage. Experience introduces e.g. motion graphics, play and experiential marketing. Conversation tracks the steps of collaboration, iteration, prototyping and user testing. Participation deals with behaviour change, generative systems, advertising and open source. Navigation talks about information overload and data presentation. Advocacy discusses activism, social responsibility and sustainability. Critique, the last chapter, touches for example design discourse and speculative design.

Communication Design:
Insights from the Creative Industries
Authors: Derek Yates, Jessie Price
Publisher: Fairchild Books
1st ed., April 2015
ISBN: 978-1472534408
208 pages, 200 images
Paperback
Available also as an eBook

aid support in high-quality press output funding. Experts in media economics, media governance, and modern management theory give theoretical explanations for state intervention, with discussion on state and industrial subsidies, their effects on journalistic quality, legal issues and trends, followed by case studies and government actions in various European countries, Australia and USA.

Design Thinking for Visual Communication

Author: Gavin Ambrose

Publisher: Fairchild Books
2nd ed., April 2015
ISBN: 978-1472572714
184 pages, 200 images
Paperback
Also as an eBook

This book written by an experienced author is popular for its approach to design as a problem-solving activity, guiding readers through the whole process – from starting a design project by defining its aim, over generating ideas and concepts in response to a design brief and prototyping, to selection of the best option and its successful implementation; learning from the project closes the loop. The second edition contains contributions from a broader international range of design practices and adds depth to existing case studies by looking in greater detail at some of the processes used, better revealing ideas and methods applied by other designers and clearly explaining discussed concepts.

Contemporary Color: Theory and Use

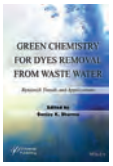
Author: Steven Bleicher

Publisher: Cengage Learning
2nd ed., March 2011
ISBN: 978-1111538910
224 pages, Paperback
Also as an eBook

Besides a new chapter on global colour, the chapter on digital colour was thoroughly updated and other chapters significantly expanded for the second edition of the book, which combines colour theory basics and advice on effective digital colour use.

Green Chemistry for Dyes Removal from Wastewater: Research Trends and Applications

Editor: Sanjay K. Sharma



Publisher:
Wiley-Scrivener
1st ed., April 2015
ISBN: 978-1118720998
496 pages
Hardcover

Two leading scientific publishers have recently offered the text on wastewater treatment with respect to the removal of synthetic dyes, which are increasingly used in various industrial processes, including paper manufacturing and printing.

This one, after brief introduction of organic dyes classification and common technologies for their removal from aqueous media, discusses in detail emerging 'green' techniques – namely, the novel carbon-based nanoadsorbents, advanced oxidation processes, photocatalytic processes, biowaste-derived adsorbents, fungal laccases and peroxidases for enzymatic treatment, single and hybrid applications of ultrasound, biosorption, adsorption on expanding three-layer clays and other non-conventional adsorbents, like various solid wastes, and, finally, hen feathers.

Microbial Degradation of Synthetic Dyes in Wastewaters

Editor: Shree N. Singh

Publisher: Springer
1st ed., 2015
ISBN: 978-3319109411
367 pages, 85 images
Hardcover
Also as an eBook

In this book, microbial degradation or decolourization, employing e.g activated sludge, pure cultures and microbial consortia or degradative enzymes, is highlighted as economical, effective and environmentally friendly option for wastewater treatment. Review articles by more than fourty international experts in the field explore the latest state of the art on the subject and explain various bio-degradative pathways of synthetic dyes, including those in paper factory effluent.

Electronic Textiles: Smart Fabrics and Wearable Technology

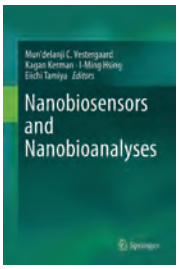
First part of this guide brings an overview of conductive fibres, yarns and fabrics for electronic textiles, mentioning conductive polymers and carbon nano-tubes. Next part covers various examples of textiles and electronics integration – design and manufacture of textile-based sensors, integration of micro-electronics with yarns, design and manufacture of heated textiles, joining technologies, and photovoltaic and piezoelectric energy harvesting. Final part deals with applications, describing examples of embroidered antennas for communication systems, electronic textiles for military personnel, geotechnical and civil engineering, and wearable sensors for athletes.

A few references to printed electronic textiles can be found, for example, on adding electronic functionality to a fabric using screen printed conductive inks. Further, literature describing printed sensors for humidity and moisture monitoring is referenced, as well as polymer tape with inkjet printed sensors, integrated into woven fabric. There is also one-page chapter on Printed sensors, however, it is in fact discussing textiles with light-emitting properties, identifying screen printing and drop-on-demand inkjet printing as the most promising technologies for this application.

Electronic Textiles: Smart Fabrics and Wearable Technology
Editor: Tilak Dias
Publisher: Woodhead Publishing
1st ed., April 2015
ISBN: 978-0-08-100201-8
156 pages
Hardcover
Available also as an eBook

Nanobiosensors and Nanobioanalyses

As in other fields, the importance of nanomaterials rapidly grows also in medical, pharmaceutical and environmental applications of biosensors and bioanalyses. This book summarizes information on established, cutting-edge, as well as future trends in this area. After the introductory chapter, nanobiosensing architectures are presented, including vertically aligned nanowire arrays, nanoimprinted plasmonic biosensors and biochips and employment of interferometric reflectance imaging. Third part discusses nanomaterial functionalization and nanobioelectronics development – namely, dual detection platforms (mentioning among others modification of screen-printed electrodes), electrochemical detectors and biosensors based on nanocarbon film, use of hybrid metallic nanoparticles, nanobiosensing using a focused laser beam, semiconductor quantum dots and energy transfer for optical sensing and bioanalysis, and detection of protein phosphorylations. Finally, the current applications, challenges and future outlook is reviewed for carbon nanotubes, specialized nanoneedles, plasmonic sensors, electrochemical scanning microscopes, and field-effect transistors.



Nanobiosensors and Nanobioanalyses
Editors: Mun'delanji C. Vestergaard, Kagan Kerman, I-Ming Hsing, Eiichi Tamiya
Publisher: Springer
1st ed., 2015
ISBN: 978-4-431-55189-8
379 pages, 146 images
Hardcover
Available also as an eBook

Bookshelf

Academic dissertations

Characterization of Halftone Prints based on Microscale Image Analysis

Doctoral thesis – Summary

Author:
Mahziar Namedanian

Speciality field:
Media Technology

Supervisors:
Sasan Gooran
Daniel Nyström

Defended:
14 November 2013 at Linköping University / Department of Science and Technology
Norrköping, Sweden

Contact:
sasan.gooran@liu.se

One of the most important phenomena which affects the colour of a halftone print is a dot gain. This is partly due to the ink spreading and penetration into the substrate. Further, lateral propagation of light in paper causes printed dots to appear larger than their physical size. Characterization of total dot gain, i.e. the combination of physical and optical dot gain, is an important issue in the study of paper properties and print characteristics. The aim of this dissertation was to go beyond the published macroscopic models that separately characterize physical and optical dot gains, and to study the halftone prints on a microscopic scale.

Three approaches based on the Murray-Davies model were proposed. In the first one, the total dot gain is approximated by minimizing the root-mean-square difference between the calculated spectrum and the measured reflected spectrum. The other two approaches are based on microscale images captured by a high-resolution camera and differ in the way of obtaining the grey tone of the full tone ink. A novel approach based on the histogram of microscale images was also proposed to separate physical from optical dot gain; it enables to determine the actual physical dot shape, by which the Modulation Transfer Function (MTF) of the paper substrate is estimated. The proposed approach was validated by comparing the estimated MTF of eleven offset printed coated papers to the MTF obtained from the unprinted papers using measured and Monte-Carlo simulated edge response. Further, it has been illustrated that the light scattering effect must be less sensitive to different wavelength bands and that it is possible to separate two printed colour inks by illuminating the halftone print with having light in the reflective wavelength band of one of the two colours. Finally, the comparison of the optical dot gain for different dot shapes and perimeters, but with the same area, shows the dependency on the dot shape perimeter. It verifies the fact that the amount of optical dot gain is different for different types of halftoning.

Arabic Type-Making in the Machine Age: The Influence of Technology on the Form of Arabic Type, 1908–1993

Doctoral thesis – Summary

Author:
Titus Nemeth

Speciality field:
Typography & Graphic Communication

Supervisor:
Fiona Ross

Defended:
4 December 2013 at University of Reading / Department of Typography & Graphic Communication
Reading, United Kingdom

Contact:
info@tntypography.eu

This thesis investigates the evolution of Arabic type-making under the influence of changing technologies of the 20th century, covering both analogue and digital eras. Its historical scope is limited by two events which marked significant turning points in technological development – in 1908 the first adaptation of Arabic to mechanical typesetting equipment heralded the beginning of machine-aided composition; and in 1993 the widespread adoption of the Unicode standard marked the end of equipment (platform) dependency for type.

The dissertation was intended to be informative for type, printing and design historians, and scholars from a range of related disciplines. Based on original archival research, this study mainly analysed primary sources to establish the principal factors that influenced decision making in the Arabic type design process. It aimed to contribute to the closing of considerable gaps in available literature, often marked by fragmentary, unsubstantiated or erroneous information. The thesis traced the characteristics of changing

manufacturing processes, as well as the composition equipment, stressing the impact that technical limitations of machinery conceived for the Latin script had on Arabic type. Further, the relative importance of technological constraints and economic pressure, as well as cultural and artistic considerations, were critically assessed through select case studies, chosen for their significance and influence on type-making. The study also briefly discussed the collaboration of Western companies with their customers and representatives in the Arabic script world, and in passing it contextualised typographic developments in the larger socioeconomic settings of the region.

In conclusion, the most influential trends and themes developed throughout the thesis were summarised in a concise discussion of the changing approaches to Arabic type-making, where the innovation often represented the compromise within given constraints of Arabic type creation and its use. Additionally, these approaches were evaluated in order to delineate characteristics of best practice for current practitioners and students.

Doctoral thesis – Summary

Author:
Magdolna Pál

Speciality field:
Graphic engineering and design

Supervisor:
Dragoljub Novaković

Defended:
29 November 2014 at University of Novi Sad / Faculty of Technical Sciences Novi Sad, Republic of Serbia

Language:
Serbian

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Development of a Model for Objective Control of Surface Damages on Coated Papers in the Folding Process

The object of this dissertation was the quality control process with respect to the folding process, where the coated papers show a significant rate of surface destruction. Damages of the coating layer and base paper caused by high tensile stress on the outer side of the folding line can impair the aesthetic appearance of printed product or even lead to the complete loss of its functionality. Since the folding process is one of the most commonly used operations in the graphical production and thus the damages during this process can have substantial economic and environmental effects, the improvement of the fold cracking resistance of coated papers has become a significant field of research. Along the mechanical characteristics measurements, the computer aided quality control gained ground recently. This method derives an objective assessment of surface damages by running a software analysis on digitalized samples. However, considerable deficiencies can be noticed in its application, as well as in the parameters used for the quality assessment. Therefore, the research conducted in this thesis aimed to improve the objective quality control of coated papers by means of unification of the quality control process and also by introducing new, structural features extracted from the digitalized samples.

All parameters relevant for the investigation were considered. First, the algorithm requirements for the pre-processing and image analysis methods were defined. For the fold cracking resistance assessment, the features of digitalized samples were proposed (i.e. white pixel percentage, perimeter-surface ratio and distribution of damages). Next, all relevant characteristics of the selected coated paper samples were determined by instrumental measurements and the reference measurements of the mechanical properties used for surface damage evaluation were done as well. The applicability of individual options was evaluated by comparative analysis of objective visual assessment and reference measurements. Results of the fold crack resistance reference measurements along with control parameters of sample preparation indicated that the developed algorithm fulfils the set requirements and the proposed features of digitalized samples reliably describe the analysed surface damages. None of the sample preparation and digitalization parameters showed superior performance in all aspects; therefore, a single set of best parameters for unique implementation cannot be proposed. The acquired knowledge of their influence on the final results of proposed features contributes to the improvement of coated papers quality control by standardized sample preparation and digitalization process in different fields of implementation.

Events

Science and Engineering of Printable Electronics
Early Researcher Summer School

Swansea, UK
13–17 July 2015

After successful summer school focused on printable electronics and organized within COST Action FP1104 at Swansea University in 2014, the second edition is prepared for the middle of this July. The program is aimed at those new to printed electronics, but having background in science or engineering.

Introduction to design and applications of printable electronics together with suitable substrates, inks and appropriate curing technology, as well as characterization methods, will be presented by speakers from academia across Europe and industry. The course will cover also all major printing techniques – flexography, screen printing, gravure printing, pad printing, offset lithography and inkjet printing – and 3D printing. Visit to the new pilot lines at the SPECIFIC IKC (Innovation and Knowledge Centre) will offer a measure of the potential for printed electronics. Practical skills can be gained during final two days in WCPC (Welsh Centre for Printing and Coating) well equipped laboratories for printed electronics.

High-Performance Graphics 2015

Los Angeles, California, USA
7–9 August 2015

This expert international forum, co-sponsored by Eurographics and Association for Computing Machinery's SIGGRAPH, is dedicated to performance-oriented graphics and imaging systems research.

In the Warren Hunt's keynote on virtual reality, the fact that performance needed to deliver a highly compelling virtual reality experience far exceeds the limits of present best real-time graphics and rendering systems is seen as a driver for the next great graphics revolution. Later the same day, Technical challenges of virtual reality will be the topic of the first panel discussion. The keynote lecture by Srinivas Narasimhan concerns with programmable automotive headlights for high-performance lighting and imaging. The panel discussion on High-performance image processing and its future applications is scheduled before Wrap-up.

Conference papers will be presented within four sessions on Efficient ray tracing, Future graphics pipelines, Rendering and display, and High-performance data processing. Two sessions are reserved for Hot3D. There will be talks on Disney Studios Hyperion renderer that employs a new ray batch streaming architecture and on particular challenges of texture-mapping reality for live performance; remaining topics include CPU-GPU shared memory on Intel Gen, Technical challenges of architecting NVIDIA GRID and PC game streaming, and Tegra X1 architecture and Shield Android TV. New Hot2D session will discuss the data flow, architecture, and design decisions made in building large-scale image processing systems at Facebook. The program will be complemented by poster 'Quick talks' and technical demos.

CONTENT TOKYO 2015

Tokyo, Japan
1–3 July, 2015

This event groups six exhibitions in the areas of entertainment content creation, distribution, licensing, technology, service and marketing. For the first time, Advanced Content Technology Expo is included, presenting 3D printing and 3D modeling technologies among others.

Serigrafia SIGN FutureTEXTIL 2015

São Paulo, Brasil
21–24 July 2015

As each year, this trade show will bring together qualified professionals to see industry launches in the printing, apparel or textile sectors, learn on the available substrates and dyes, and to track progress in photography, visual communications, cutting, engraving and LED signs. In addition, Digital Textile Conference can be attended as well.

Pack Print International 2015

Bangkok, Thailand
26–29 August 2015

Biennial 5th International Packaging and Printing Exhibition for Asia will be co-located with T-PLAS, International Trade Fair for the Plastics and Rubber Industries to network the companies from these related sectors.

Thanks to rapid socio-economic expansion, infrastructure and industrial developments within Southeast Asia, demands for packaging and printing products, machinery and services are expected to increase, which opens interesting investment and marketing opportunities for the industry.

WAN-IFRA Events

Besides the events mentioned below, Color Quality and INCQC tutorials will take place: the first in Kuala Lumpur, Malaysia (29–30 July 2015), and the second in Rio de Janeiro, Brazil (5–6 August 2015). Their topics are implementing ISO 12647-3 in all areas of newspaper production and an overview of the rules and regulations of International Newspaper Color Quality Club, INCQC 2016-18. Further, two study tours are scheduled for this September: Digital Innovation and Wearables in Japan (Tokyo, Japan; 8–10 September 2015) and Strictly Digital – Innovation & Online Video Moneymakers (Los Angeles, California, USA; 14–18 September 2015).

News Design Asia 2015

Kuala Lumpur, Malaysia
28–30 July 2015

Organized jointly with the Society for News Design, this conference and following workshop are aimed at the 'best practices' in news media design & redesign, for print and digital. One week earlier (20–21 July 2015), the course on specific challenges of Newspaper Design for Chinese Publications is offered in the same city. In next two days, Generating New Advertising Revenue course will be held in Singapore (22–23 July 2015).

WAN IFRA India 2015 Conference & Expo

Mumbai, India
2–4 September 2015

The pre-conference workshops on Energy audit, Increasing revenue in major verticals, and Newsroom integration, will be held parallelly on 1st September. The main programme incorporates summits on Printing, Newsroom and Cross Media Ad, and for the first time also Media Market. During the conference, the World Young Reader Prizes will be awarded to innovative news publishers.

SIGGRAPH 2015

Los Angeles, California, USA
9–13 August 2015 (exhibition 11–13 August 2015)

SIGGRAPH2015
Xroads of Discovery

SIGGRAPH, the 42nd International Conference and Exhibition on Computer Graphics and Interactive Techniques, is a widely recognized interdisciplinary event, providing the opportunity to publish computer graphics research, learn on the latest updates in digital art and interact with emerging digital systems through the conference's installations, and also to meet the leading innovators in the field and develop creative collaboration. Moreover, the knowledge can be gained by attending the short or half-day courses.

Before full presentations of technical papers in separate sessions, the summary is given in the 'Fast Forward' two-hour session, where the authors are allowed a little less than a minute to catch the attention of other participants. Talks sessions are dedicated to presenting the latest developments before publication, ideas that are still in progress, or showcasing how computer graphics and interactive techniques are actually implemented and used across many fields. Further, the conference program includes the announcement of ACM SIGGRAPH Awards and invited presentations given by their recipients, as well as final poster presentation of ACM Student Research Competition, recognizing research by individual graduate students or teams of undergraduates.

The conference also hosts the international SIGGRAPH Computer Animation Festival, showcasing time-based art, scientific visualization, visual effects, real-time graphics, and narrative shorts.

CVCS 2015 – Colour and Visual Computing Symposium

The Norwegian Colour and Visual Computing Laboratory

Gjøvik, Norway
25–26 August 2015

This year, CVCS is organized by the Norwegian Colour and Visual Computing Laboratory at Gjøvik University College for the eight time, offering contributions of both young researchers and well-known international experts in the field. The program starts with tutorials on three interesting topics – Colour in medical imaging with a focus on laparoscopy, Spectral image reproduction: workflow and application, and Illusory colours and what one can do with them. The main program consists of Colour and measurement, Printing, Indexing and retrieval, Colour and image processing, Quality and Multispectral Sessions, complemented by Poster session.

The opening keynote of Reiner Eschbach is named What is the colour of your eyes? The assumptions about what colour means when it comes to quality, the importance of quality definition and potential metric suitable for different purposes will be considered. First day will be concluded with Theoharis Theoharis invited talk on 3D object retrieval and its applications in biometrics and cultural heritage. Second invited speaker, José Manuel Soto Hidalgo, will start the other day with A fuzzy approach to model the semantics of colour in image processing. The closing keynote, The tale of the three worlds: about the relationship among light, images and appearance, presented by Alessandro Rizzi, will focus on the differences among the distribution of light intensity in a scene, its photographic acquisition and how it appears to the vision system of the observer. Taking these three 'worlds' as almost identical will be questioned.

42nd International iarigai Conference
Advances in Printing and Media Technology

Helsinki, Finland
6–9 September 2015

As each year in its long history, the iarigai conference will show how printing and media are moving forward in the 21st century.

This Helsinki conference is jointly arranged with COST Action FP1104, New possibilities for print media and packaging – combining print with digital. Therefore, the networking of industry experts, academic or industrial researchers, early career researchers and students will be further enriched by fruitful interaction with specialists from other disciplines.

To cite from the conference introduction, "Printing has been defined as the art of rapidly and accurately placing 'stuff on stuff'. By habit and tradition, we think of printing as a technology for putting ink on paper in order to reproduce text and images. But, today, the technologies and methods for efficiently and on an industrial scale placing other substances on other substrates are increasingly capturing the attention of researchers and industry alike." That is why the special attention will be given to innovative ways of using printing technology for totally new purposes, improvement of industrial processes and product development, synergies between digital and 3D printing as well as examples of novel applications, satisfying consumer demands in a multimedia world, and new business concepts and effect of digitalization on business models.

The six keynotes of the conference will cover wide range of topics, two on Monday morning – Future prospects of printed intelligence applications by Harri Kopola and The importance of sensory marketing in an ever growing digital world by Martina Greschonig, and four on Tuesday afternoon – New business through service innovation by Marja Toivonen, Transformation of media sector towards service business by Anna Viljakainen, Rich Content and Print in a Diverse Community by Andrew Hunter and Sustainability in the media sector by Malin Picha Andersson.

Scientific program will be organized into parallel sessions on Communication interfacing, Printed functionality, User and audience experience, Printing process, Print for packaging and Coatings.

COST Panel session is reserved for Consumption of news as democratic resources – cross cultural research. At Hybrid show on September 9th different parties from the COST network will present a wide variety of demonstrations on how mainly fibre-based materials can be connected with the digital world by utilizing several different technologies, such as printed electronics and augmented reality. Attendees can experience solutions as diverse as active fibre-based flower pot or packaging, incontinence sensors, innovative utilizations of printed products like newspapers, magazines and photobooks, using the future travel guide, and making a font in their personal handwriting.

cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY
COST is supported by the EU Framework Programme Horizon 2020
ESF provides the COST Office through an EC contract

3D Printshow

Istanbul, Turkey
10–13 September 2015

3D PRINTSHOW
GLOBAL 3D PRINTING EVENTS

On September 10th the new season of a global series of 3D Printshow events for industry, businesses, brands and consumers starts in Turkey, in partnership with Sign Istanbul. As a platform for the entire 3D printing and additive manufacturing industry, the shows will feature industrial AM machines, desktop 3D printers and everything in between.

ISS Imprinted Sportswear Show

Orlando, Florida, USA
10–12 September 2015

The annual ISS trade show is held from last year with Surf Expo. It focuses on Apparel, Clothing, Fashion, Ready-to-wear, Graphic arts, Paper, Printing and Reprography business sectors. Pre-conference workshops and conference seminars include tracks on Digitizing, Digital decorating and Screen Printing among others.

IGAS 2015
International Graphic Arts Show

Tokyo, Japan
11–16 September, 2015

IGAS2015

This international trade show organized by Japan Graphic Arts Suppliers Committee showcases the latest products, technology, and services related to printing, paper converting, and digital graphics.

Within the exhibition, more than a hundred special lectures, panel discussions, and seminars will cover topics such as the latest printing technologies, marketing, business style innovation and new business model. Special exhibition area will be dedicated to cutting-edge or emerging technology, future marketing and business models including 3D printers, printed electronics, next generation inkjet system and nanotechnology, etc.

GRAPH EXPO 2015
International Graphic Communications, Prepress, Printing and Converting Exposition

Chicago, Illinois, USA
13–16 September 2015

The exhibition covers all major digital and conventional, as well as hybrid technologies, products and services for all kinds of printing, publishing, mailing, in-plant, photo imaging, marketing and industrial printing industries. Pre-show Executive Outlook Conference provides economic and marketing information, technological reports, and print trends and forecasts. During the show, there will be more than fifty seminar sessions to choose from.

With the package printing industry offering increasing profit opportunities in today's marketplace, GRAPH EXPO 15 is co-located with CPP – the innovative converting and package printing tradeshow. Further, GRAPH EXPO is for two days overlapping with joined PROCESS EXPO, International Dairy Show and InterBev Process shows which feature issues and innovations related to food packaging, beverage processing and packing. These concurrent shows will offer an opportunity for printers, packagers, processors, and converters to explore the global scope of the graphic communications and packaging/processing industries.

Packaging Innovations London 2015

London, UK
16–17 September 2015

A step away from traditional packaging show, this two-day event co-located with Luxury Packaging combines the world of technology with the creative minds of branding to achieve shelf stand-out and reduce environmental impact of the product through the latest innovations in sustainability, design, luxury materials, print and branding.

NIP31/Digital Fabrication and Digital Printing 2015

Portland, Oregon, USA
27 September to 1 October, 2015

The NIP and Digital Fabrication conferences organized by the Society for Imaging Sciences and Technology reflect the convergence of printing technologies with the goal to bring together everyone working in the printing ecosystem – i.e. teachers, researchers, developers, practitioners, manufacturers, and distributors, to share ideas, learn from each other, and be part of the next wave of the future of printing.

Technical program presentations are divided into three tracks – Digital printing technologies, Materials, methods and performance, and Digital fabrication and 3D printing. The 2015 keynotes will focus on how the relevance of printing and imaging continues to expand beyond traditional printing to hybrid and new systems; not only in the areas of functional applications (printed electronics, bio-printing, and 3D printing), but also in the development of new techniques for traditional processes, like electrophotography. The third digital revolution is anticipated by Neil Gershenfeld – after communications and computing have become digitized, manufacturing today remains analog; emerging research on digitizing fabrication by coding the construction of functional materials will be presented, exploring its implications for programming the physical world. Richard Hague's talk on 3D deposition of functional materials for the additive manufacturing of smart devices covers the research which is primarily focused on various jetting techniques, including piezo electric based systems, for both functional and structural inks, functionalized 2-photon lithography for nanoscale fabrication, and the direct drop on demand jetting of high temperature metallics. The ability to three-dimensionally interweave biology with nanomaterials could enable the creation of bionic devices possessing unique geometries, properties, and functionalities. The 3D printed bionic nanomaterials keynote by Michael McAlpine discusses how the coupling of 3D printing, novel nanomaterial properties, and 'living' platforms may enable next-generation nano-bio interfaces and 3D printed bionic nanodevices.

In the state-of-the-art invited talk, Hiroya Tanaka will introduce the new file format for 3D printing, its extensions and applications. Roundtables on surface manufacturing and identifying the opportunities of security printing are scheduled as well. The conference short courses are planned in four tracks with both introductory and advanced classes. For digital printing technology, Role of inkjet in commercial and industrial printing applications, Paper recycling and ecolabels, deinking, and deinkability, Digital packaging and Security printing opportunities are on the list. The offer for 3D printing and digital fabrication technology includes Recent advances in nanotechnology, An introduction to digital fabrication: methods, materials, and applications, Introduction to 3D ink jet printing and 3D printing of metals, and Direct 3d fabrication and ink printing, industrial applications, and challenges. For ink jet technology, there are Fabrication materials & processes of ink jet printheads, Surface ink interactions and surface characterization, Colorants for inkjet applications, and Fluid dynamics and acoustics of ink jet printing. Finally, Introduction to toner technology, Liquid toner printing: technology and applications, Toner materials – engineering and print relationships, and Fusing physics and technologies are available for toner and electrophotography technology.

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Peer-reviewed quarterly Journal of Print and Media Technology Research is covering fundamental and applied aspects of the research in – at least but not exclusively limited to – the following fields

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- Emerging media and future trends

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- Social impact

  Media in a sustainable society; Environmental issues and sustainability; Consumer perception and media use; Social trends and their impact on media

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A peer-reviewed quarterly ISSN 2223-8905

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- Social impacts

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