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A letter from the Editor

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The first published article in the September issue is an original scientific paper on the prediction of ink-film thickness in offset lithographic printing using machine learning. The accuracy of prediction achieved in lab conditions is a promising alternative to the methods used for decades on production presses.

The next two papers were submitted for publication by experienced and well-known researchers in their specific fields. One of them, a review paper, brings an overview of already known methods in two-dimensional error correction on the web guiding on the printing and converting machines with upgrading by the next step in the development of an original idea for solving this issue. The other one, the position paper, is a challenge not only in terms of terminology but also in our understanding of phenomena related to printing and similar technology. I really hope we will receive some replies and maybe even open a discussion on the differences and the proper use of the terms 'surphase' and nowadays common use of 'surface' in describing (and understanding) the interactions at the boundary between two layers i.e. of the solid substrate in contact with a liquid material.

The fourth paper is a case study dealing with a visual language used in the design of packaging manufactured from natural materials where their composition, form, and visual presence show their origin and encourage their use in a sustainable way; however, the consumers may need more information and guidelines for their proper reuse, recycling or deposition after use.

An overview of newly accepted and re-confirmed ISO standards is presented in the News&more section of Topicalities, prepared by Associated Editor Markéta Držková (marketa.drzkova@jpmtr.org). On the Bookshelf, you can find a short introduction of the books on materials used in contemporary printed electronics, textile and industrial printing, book markets, and design of print products, as well on some other topics like Adobe tools used in pre-press and the history of printing.

Traditionally three theses from the fields within the scope of the Journal, defended worldwide, are presented. Tobias Bertel finished his thesis on image-based rendering of real environments for virtual reality at the University of Bath, United Kingdom. The thesis on analyzing droplet positioning in inkjet printing was defended by Claus Schneider at the Technical University of Darmstadt, Germany. The third presented thesis on printed and templated 3D MXene (inorganic nanomaterial consisting of layered metal carbide with functional groups) for energy storage applications was defended by Dahnan Spurling at Trinity College Dublin, Ireland.

In the Event section, an overview of conferences and symposia is presented, covering different fields from conventional printing, packaging, color and imaging, and printing history; also AI is a topic. Some of the events are organized as partly online or hybrid events; however, most of them can be attended in-person.

After the successfully finished joint 49th International Research Conference of iarigai and 54th Annual Conference of International Circle in Wuppertal, Germany, where a lot of interesting research results were presented, we are expecting some new contributions from the attendees. Besides the conferences, the future and some changes regarding the Journal were discussed. Currently, we are in the transition period, after which the already elected new Editor-in-Chief, Daniel Bohn from the University of Wuppertal, supported by his colleagues, will take charge after the December 2023 issue of the Journal. A part of this transition is also of a more technical nature, actually, moving the archived issues and other server content to the same ISP, where the iarigai website, including regular access to the Journal, is already hosted. We will do our best to keep the system working smoothly.

We are convinced that in the future the Journal will continue as an appropriate option for publishing the research results of our readers.

Ljubljana, September 2023

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Prediction of offset ink film thickness using machine learning

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Abstract

The wet film thickness of printing ink in offset printing process is an important parameter which is related with the print quality and cost. In this paper, the prediction of ink film thickness in offset printing based on machine learning has been proposed. For measurement and prediction of wet ink film thickness in offset process, an experimental inking model is designed and used to show the effect of various factors like machine speed, run time, ink color, ambient temperature, and relative humidity on it. The machine learning based prediction models can provide very close approximation of the accurate information about the control parameters so that the print technician could make a good setting work during real-time production process. With the help of this, the technician can make a good decision in the setting of control parameters for ink thickness based on this predictor. The results show that the prediction models can provide about 95 % accuracy in predicting the ink film thickness. Thus, the prediction system not only can help technicians and greatly improve their production efficiency, but also can save the cost of production.

Keywords: offset printing, prediction models, support vector regression, random forest regression

1. Introduction

Offset printing industries face lots of problems because of variations in ambient conditions and therefore, it is necessary to maintain a standard ambient condition of machine surroundings. The offset inks of all colors are also sensitive to temperature and relative humidity. In offset printing ink flows from the ink container to the inking system through the annular space between a series of rollers and for this co-axial cylinder viscometer can be chosen as a model where flow of non-Newtonian fluids is in between two concentric cylinders. But in offset printing machines, the rollers are not concentric where the radius of the outer cylinder or roller is treated as infinity. Rollers in the inking system are mainly rotated via gears and a wet ink film is formed by hydrodynamic effect generated from relative motions of the contacting rollers. The contact surface is nearly non-heavy load linear contact friction, so it may be considered as generalized elastohydrodynamic lubrication. Thus, it may be predicted that there is not a large difference between the ink film thickness and the film thickness of corresponding hydrodynamic lubrication. (Liu, Li and Lu, 2016)

The modern offset presses need a standardized model for flow of ink through the inking system of offset machines, for which optimum ambient conditions inside the machine room are required. Moreover, the inking rollers will be getting heated with machine run time and speed due to the friction, which may lead to the change in wet ink film thickness. To compensate this effect and achieve correct ink film thickness, the process parameters have to be calibrated each time, which is tedious and time consuming.

Prediction of optimum wet ink film thickness is a matter of concern, which is evident from various research works. An experimental study (Hsieh, 1993) conducted in laboratory showed an association between the ink film thickness and its splitting forces. The development of the ink key presetting system has been studied (Chu and Seymour, 1997), which could analytically preset ink keys and ratchets to shorten the make ready time. Estimation of ink tack in offset printing had been investigated (Gujjari, et al., 2006) by examining the printing speed and ink weight for different newsprint. Variations of ink thickness had been studied (Hersch, et al., 2009) by using spectral reflectance's prediction model. Elastic deformation of rubber ink roller and characteristics of ink flow through two ink rollers had been studied (Su, et al., 2012) under different conditions to determine the rate of ink transfer. Reynolds equation for ink transfer in offset inking system had been deducted (Liu, Li and Lu., 2016) on the basis of electro-hydrodynamic lubrication theory, and the effect of ink transfer on printing speed and roller gap was also analyzed.

Machine learning (Chopra and Khurana, 2023) is an emerging field nowadays. Due to significant development in hardware and software along with interfacing possibilities machine learning has become a popular tool for the prediction, classification and identification in diverse engineering problems. It has been used in automotive (Jain, et al., 2022), food engineering (Jiménez-Carvelo, et al., 2022), structural engineering (Thai, 2022), financial sectors (Rakshit, Clement and Vajjhala, 2022) and in almost all the major areas. It has been used in printing researches but recent literatures are mostly in the field of 3D printing and additive manufacturing (Zolfagharian, Bodaghi and Le Doigou, 2022). However, considering the huge reported literature of its applications in all fields other than printing and allied domains motivates towards exploring the scope of the work presented in this paper. This paper focuses on the possibilities of applying machine learning based prediction models to predict the ink film thickness in offset printing machines while major parameters of ambient press conditions are varied.

In this present investigation, a novel methodology of prediction of wet ink film thickness has been developed on the basis of variation of ink film thickness with respect to different speeds and run time for different ambient conditions using machine learning regression algorithms. This will allow proper standardization of ink film thickness and can be implemented in offset printing process.

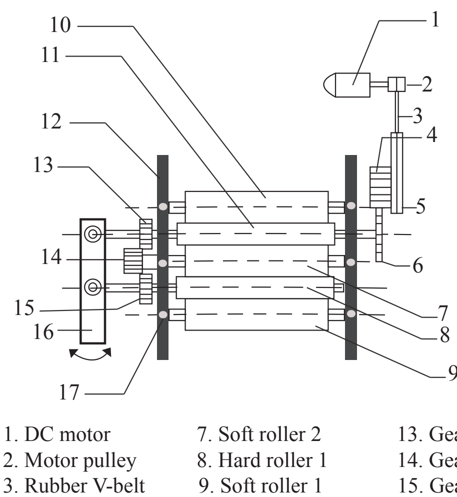
2. Materials and methods

A prototype of an inking roller arrangement that simulates the actual inking system of offset printing machines has been developed. The commercially available offset inks of process colors, namely, cyan (C), magenta (M), yellow (Y), and black (K) were used for measurement and prediction of purpose. Among different prediction models, two popular ones, namely, support vector regressor (SVR) (Steinwart and Christmann, 2008) and random forest regressor (RFR) (Breiman, et al., 2017) algorithms have been adopted here due to their simplicity and proven potential. A detailed dependency analysis between ink film thickness and different major parameters of ambient conditions that affect ink film thickness has been also presented towards understanding the degree of non-linearity in correlation. The results have been evaluated using three important evaluation metrics, namely residual plots, R^2 values, and mean squared error (MSE) (Freund, Wilson and Sa, 2006).

2.1 Experimental procedure

The experiments were performed on inking rollers, which are an integral part of an inking system in an offset printing machine. The experimental model of inking rollers was custom-designed and manufactured as shown in Figure 1. The model consists of two hard rollers driven by gears and a pulley connected to a DC motor by a V-belt. Hard rollers and soft rollers are arranged alternately and three soft rollers are driven by friction with the hard rollers. The hard rollers have both rotating motion and sliding motion, while the soft rollers have only rotating motion. The sliding motion of hard rollers helps to distribute the ink evenly throughout the whole length of the rollers.

The thickness of ink coating of different colors on rollers was measured at varying time and speed each at different ambient conditions. The ink thickness was measured systematically using a wet film thickness gauge, which has a combination of three rolling disc sections. The two outer discs are exactly the same diameter, whereas the middle disc is smaller and eccentric to the outer two discs. As the gauge is rolled through a wet deposition of ink, the eccentric middle disc would only pick up the ink from the inked rollers, as illustrated in Figure 2. Wet and dry bulb thermometers have been used for the measurement of ambient temperature and relative humidity.



1. DC motor	7. Soft roller 2	13. Gear 3
2. Motor pulley	8. Hard roller 1	14. Gear 4
3. Rubber V-belt	9. Soft roller 1	15. Gear 5
4. Gear 1	10. Soft roller 3	16. Oscillating lever
5. Gear pulley	11. Hard roller 2	17. Adjusting screws
6. Gear 2	12. Supporting frame	

Figure 1: The ink roller model used for the experiment

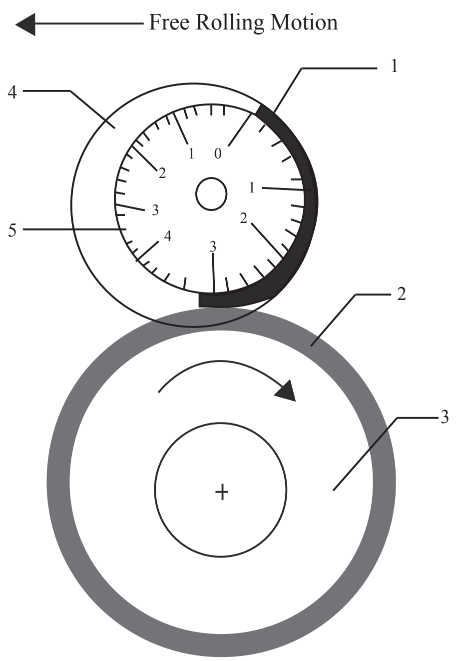


Figure 2: Ink thickness measuring gauge

2.2 Materials

The constituents of inks greatly affect the different parameters under consideration in this work. The general data on the constituents of the commercial offset inks used for experiments have been consolidated in Table 1 (Leach, et al., 1993). The inks were supplied by DIC India Limited, Kolkata, India. Experiments were conducted on the custom-made model of inking rollers (shown in Figure 1) by using these inks. The size of the roller was limited, hence limited amount of ink of 4.0 g/m^2 was used every time with a variation of about 0.1 g/m^2 for each color. After the ink was evenly distributed through all the rollers with the help of an oscillating lever attached to the hard rollers as shown in Figure 1, wet ink film thickness was measured on different sections of both soft rollers 1 and 3. The speed of the motor was modulated by varying the voltage of the supply current and measurements were conducted using the instrument called a tachometer. The process was continued until the maximum speed was reached.

2.3 Regression modeling to characterize ink film thickness

The choice of SVR and RFR regressors among many such regressors is driven by their computational simplicity, faster prediction and considerable accuracy in predicting non-linear dataset. It can also be noted that by principle these two algorithms work in a totally different manner. The SVR is a kernel-based operation to address the non-linearity in the data using support vectors while RFR is one of the most popular ensemble learning mechanisms that predicts based on the probability values resulting from different decision trees in the model. Brief discussions about these two supervised machine learning algorithms have been presented here for ready reference. The data as collected by the previously discussed method were subjected to both the models and the prediction abilities of the individual models have been assessed.

The implementation of the prediction models has been made with a train:validation:test data partitioning with 60:20:20 ratios. That means with 60 % of entire data the models were trained; 20 % of the entire dataset was used for validation, i.e. tuning the parameters, and 20 % for testing the generalization potential. A good generalization potential helps to avoid two important drawbacks of machine learning algorithms called over-fitting and under-fitting. In both cases the models can perform well with the training data but fail to perform equally in case of unknown data. The implementations are realized in a Python environment using Anaconda Spyder® and scikitlearn® libraries in the Windows® PC

Table 1: Generic ink formulation of cyan, magenta, yellow, and black (Leach, et al., 1993)

Type	Cyan	Magenta	Yellow	Black
Pigment	Lionol Blue FG-7330	Rubine L5B 01 VP 2746	Yellow CI number 12/ Lionol Yellow GRO	Regal 99R carbon black
	20.0 %	18.3 %	26.7 %	12.0 %
Polyester alkyd resin	40.0 %	40.0 %	33.3 %	45.0 %
Anti-fly paste	3.0 %	3.0 %	3.0 %	3.0 %
Solvent	14.0 %	15.7 %	14.0 %	17.0 %
Melamine formaldehyde resin	12.0 %	12.0 %	12.0 %	12.0 %
Catalyst	2.0 %	2.0 %	2.0 %	2.0 %
Lubricating oil	7.0 %	7.0 %	7.0 %	7.0 %
Stabilizer	2.0 %	2.0 %	2.0 %	2.0 %

platform. In both the cases the prediction of ink film thicknesses on the rollers has been made separately.

2.3.1 Support vector regression

The SVR generates different hyperplanes based on the calculated support vectors and optimizes to find the solution where these hyperplanes are separated to the maximum extent. The space of the hyperplane depends on the problem dimension. Being a supervised machine learning algorithm SVR conceptually constructs a tube around each of the hyperplanes by minimizing the prediction error, which fundamentally finds the distance between the expected value and the predicted value in order to achieve that SVR eventually narrows down the tube and approaches towards flatness. The flatness of the tube can be assessed by Equation [1] where M is the order of polynomial function, w is the normal vector to the hyperplane surface and both are real-valued. The order of polynomials depends on the type of problem and in our case order of 3 was found to be optimal.

$$f(x,w) = \sum_{i=1}^{M} w_i\, x^i \qquad [1]$$

In the case the data is not linearly separable, like in our case, a kernel mapping is used to map the data in higher dimensional space, which results higher prediction accuracy as well. In our case radial basis function (RBF) kernel has been used for that reason. The SVR also adopts a penalization parameter for predictions that are far from the expected value and it is measured in terms of width of the tube. Interested readers can read the details of SVR dynamics in the publication by Awad and Khanna (2015).

2.3.2 Random forest regression

Random forest is a supervised machine learning algorithm, which is popular due to many reasons like fast training and prediction, lesser number of tuning parameters and considerable potential to handle large dimensional problems with appreciable generalization power. It can be used in both classification and regression analysis. In our case the prediction of continuous data is needed hence random forest repressor has been adopted.

It is an ensemble learning process where the term 'forest' resembles number of decision trees (DTs). Each tree is associated with a collection of random variables that is represented as a vector X and the dimension p of X depends on the dimension of the problem as presented in Equation [2].

$$X = \left(X_1, X_2, \ldots, X_p\right)^T \qquad [2]$$

The RFR by means of its mathematical optimization process finds a prediction function $f(x)$ and each tree provides a vector of predicted values Y using $f(x)$. The prediction function is defined using a loss function which is most commonly the squared error and the algorithm iterates to minimize the estimated loss value $E_{XY}(L(Y,f(x)))$. Considering the ensemble learning phenomenon for regression the f is constructed as Equation [3] where h_j represents individual tree (alternatively called the base learner) and j is the index of tree. However, in case of classification a 'voting' mechanism is adopted. Interested readers can read the details of the algorithm in the publication by Cutler, Cutler and Stevens (2012). The parameter settings of SVR and RFR for the present study are given in Table 2.

$$f(x) = \frac{1}{J}\sum_{j=1}^{J} h_j\,(x) \qquad [3]$$

Table 2: Parameter settings for prediction models

SVR	RFR
Kernel – Radial basis function (RBF)	Bootstrap – True
	Optimization criteria – MSE
Epsilon – 0.1	Minimum sample leaf – 1
Tolerance – 0.001	Minimum sample split – 2
Verbose – False	Number of trees – 2 000
Cache size – 200	Random state – 0
	Verbose – 0

3. Results

The dataset used in this work had 6 columns, i.e. color, the run time (min), speed of rollers (rpm), average ink film thickness (µm), ambient temperature (°C), and relative humidity (%). The nature of the data correlation and degree of non-linearity were studied using scatter plots as shown in Figure 3. The accuracies of the individual models with different cases have been shown using percentage residual plots and R^2 values. Some of the prediction vs. actual plots for SVR and RFR are shown in Figures 4 and 5, respectively.

Residual plots are another important visual representation to see the coherence of predicted values to the actual values. It also shows the resulting outliers, which in turn can help to judge the potential of the model. The residual plots for SVR and RFR are shown in Figures 6 and 7, respectively.

The result of 10-fold cross-validation is shown in Table 3. The average prediction accuracy and standard deviation values for both the prediction models have been included in the table as well. The 10-fold cross-validation is one of the most popular metrics,

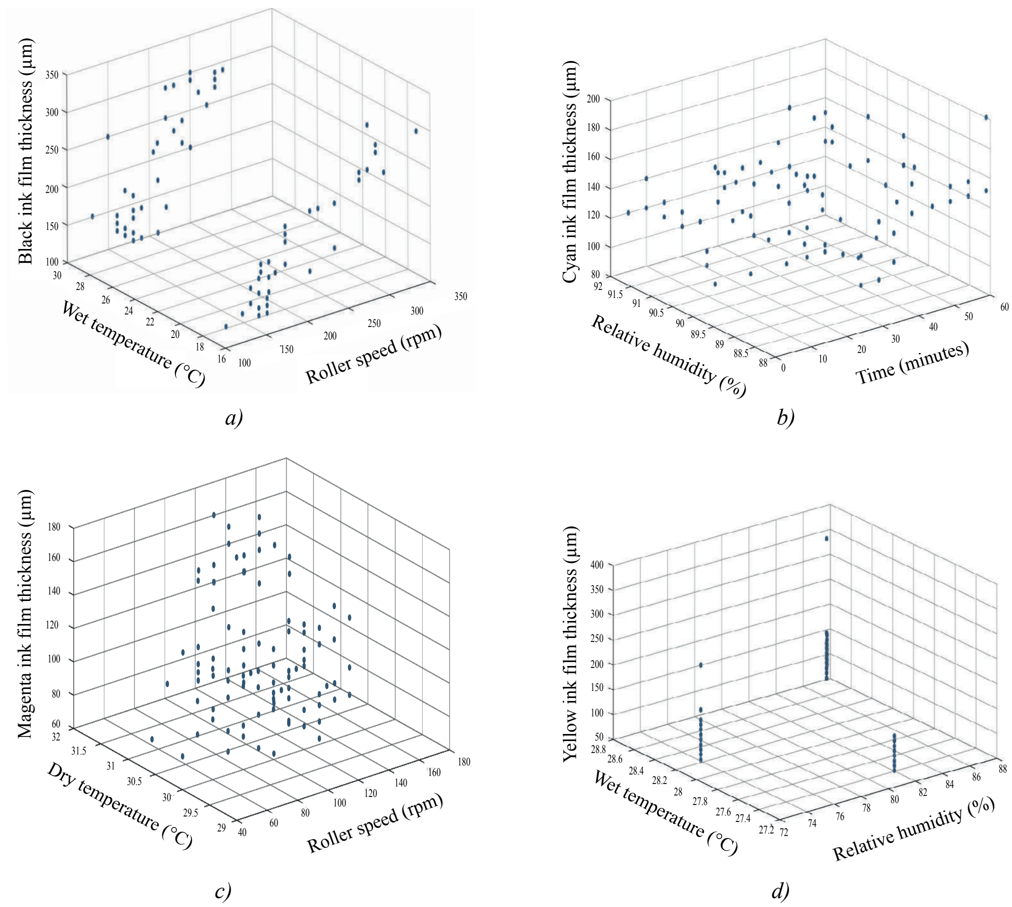


Figure 3: Examples of scatter plots of varying pattern for (a) black ink thicknesses with roller speed and wet temperature of environment, (b) cyan ink thicknesses with roller moving time and relative humidity of environment, (c) magenta ink film thicknesses with roller speed and dry temperature of environment, and (d) yellow ink thicknesses with relative humidity and wet temperature of environment

which folds the data in a way that at every run 90 % of the validation data is subjected as a training set and the rest 10 % as the test set. In this way, every data gets included in the train and test set at least once.

Table 3: The cross validation and overall accuracy of the regressors

Test	SVR	RFR
Fold 1	87.93	82.87
Fold 2	82.87	89.59
Fold 3	89.59	95.53
Fold 4	95.36	96.19
Fold 5	96.19	93.02
Fold 6	93.02	92.87
Fold 7	82.87	94.27
Fold 8	94.27	98.80
Fold 9	88.80	88.20
Fold 10	91.20	97.32
Average accuracy	90.21	92.87
Standard deviation	±4.78	±4.80

As it can be seen RFR provides improved consistency than SVR. However, in both cases, the average overall accuracy is in the tune of more than 90 %.

Hence, the prediction model can be considered as a potential addition to the existing manual and time-consuming systems of ink film thickness measurement techniques.

Table 4 provides the R^2 and MSE values for the predictors under consideration. These two are also important metrics to access the potential of the prediction models. Higher R^2 values and lower MSE values reflect better prediction possibilities.

Table 4: Comparison of prediction models in terms of R^2 and MSE

Metric	SVR	RFR
R^2	0.8923	0.9474
MSE	0.0971	0.0836

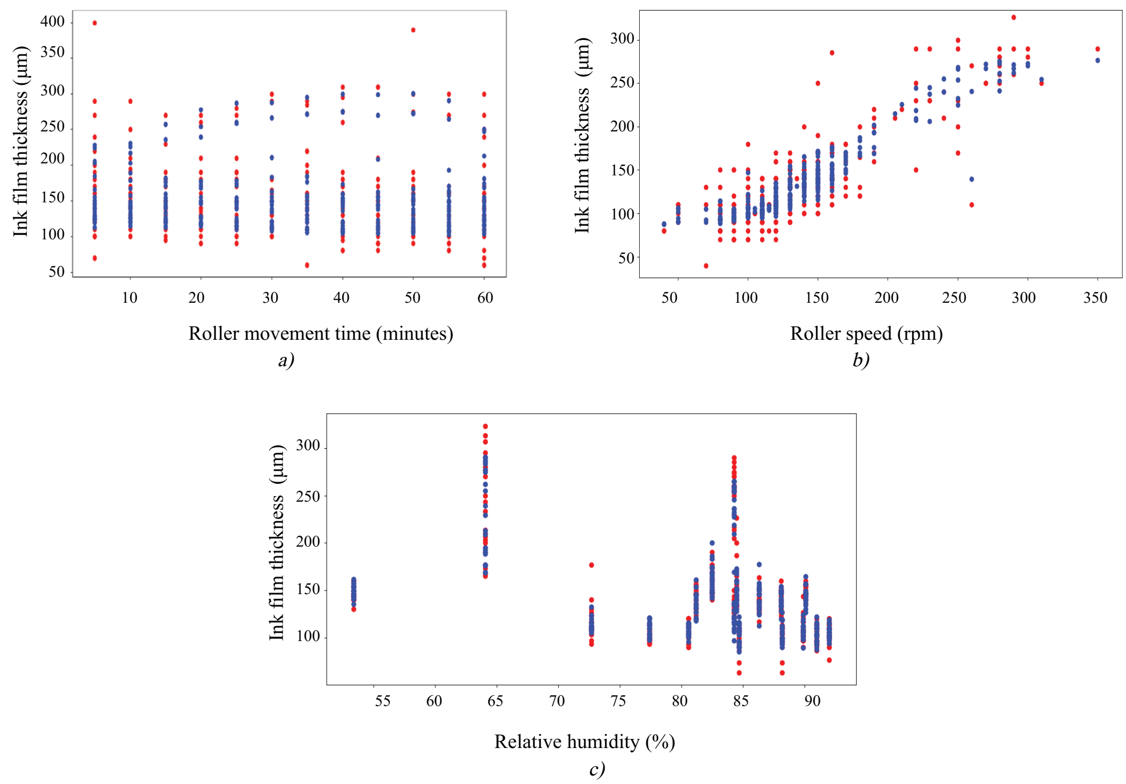


Figure 4: Prediction vs. actual ink film thickness against (a) roller movement time, (b) against roller speed, and (c) relative humidity using SVR; blue and red points represent actual and predicted values, respectively

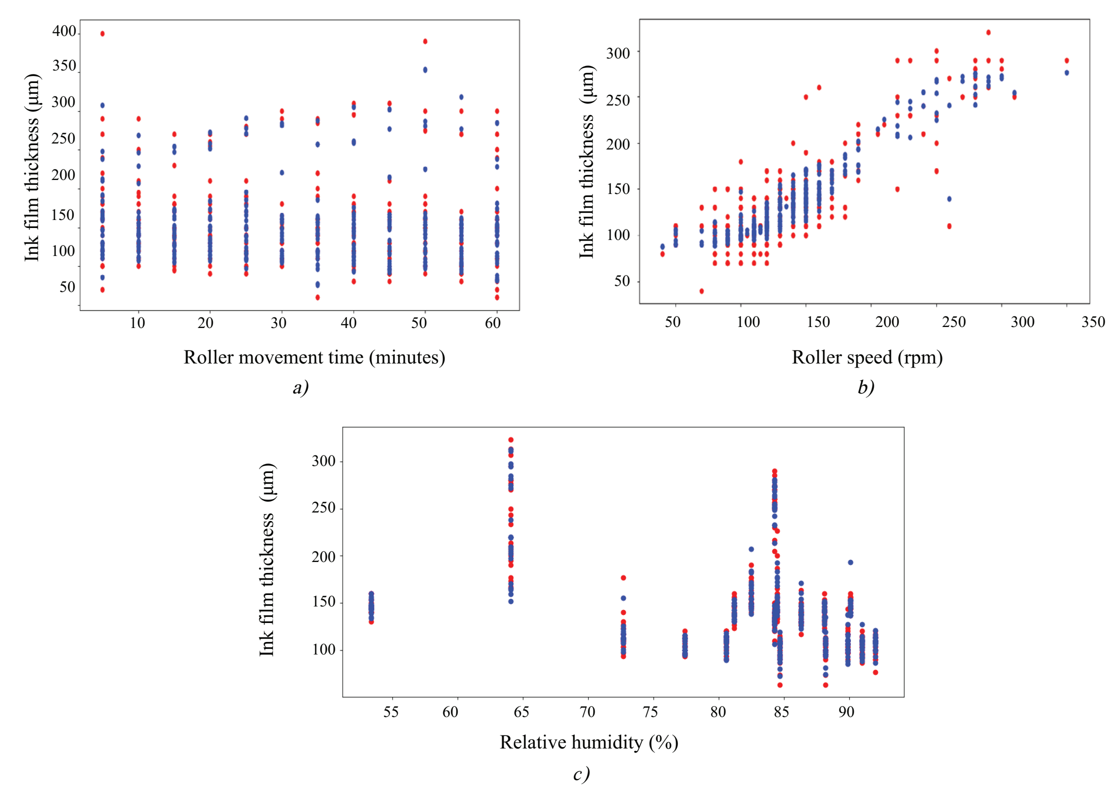


Figure 5: Prediction vs. actual ink film thickness against (a) roller movement time, (b) against roller speed, and (c) relative humidity using RFR; blue and red points represent actual and predicted values, respectively

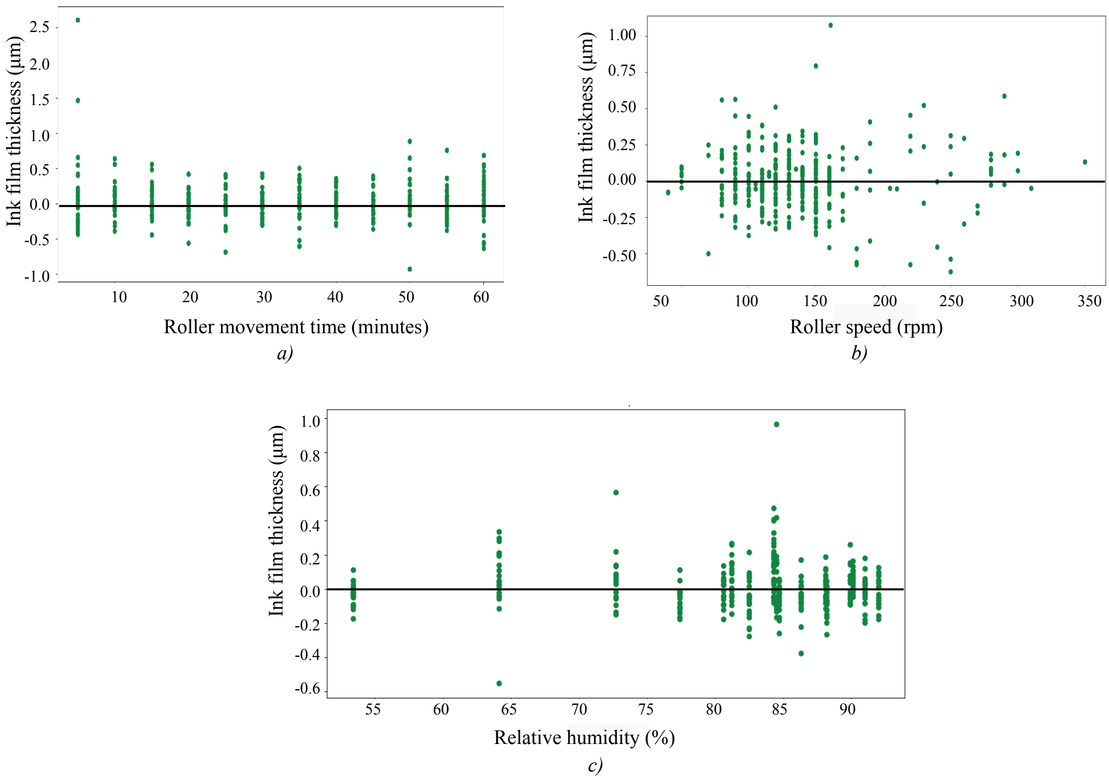


Figure 6: Residual plots for prediction results using SVR in the case of ink film thickness against (a) roller movement time, (b) against roller speed, and (c) relative humidity

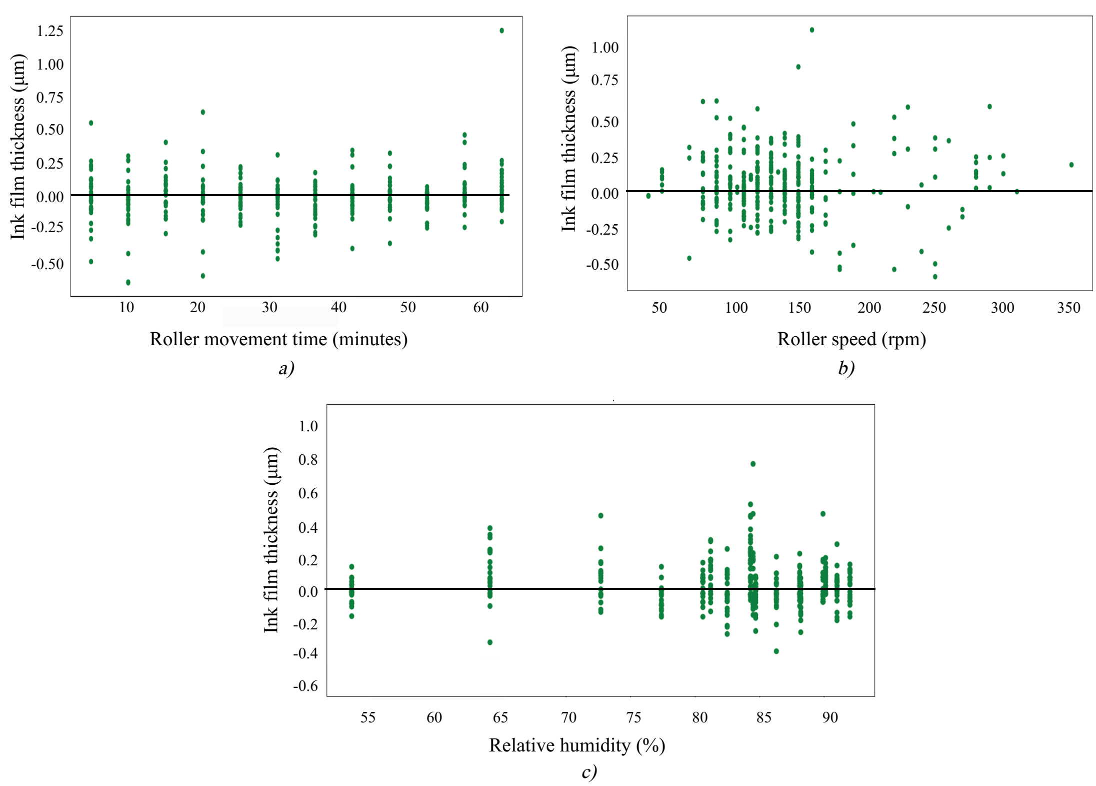


Figure 7: Residual plots for prediction results using RFR in the case of ink film thickness against (a) roller movement time, (b) against roller speed, and (c) relative humidity

4. Discussions

Figure 3 clearly shows that wet ink film thickness is well dependent on the factors under consideration. Even if the conditions remain consistent the ink film thickness changes with the ink color as well. The plots have also revealed a considerable degree of non-linearity. This motivates towards development of the regression model which can predict the ink film thickness in the rollers of the experimental model. The plots also show that RFR can predict more accurately compared to SVR. As in most of the cases the actual and predicted values (blue and red points) are overlapping in case RFR.

The residual plots in Figures 6 and 7 show that SVR can predict closely to the actual data points in most of the cases and also in terms of residual plots the points are closer to the value 0 (as shown by the black line in the plots). Also, the data spread across both sides of the zero line shows the unbiased of the data. The total number of outliers in all the residual plots is also considerably low to the tune of 2 % of the entire test dataset. The residual plots also indicate better prediction by RFR in terms of closeness to the reference line and a lower number of outliers compared to SVR. It can be also noted that the performance of SVR and RFR are similar for most of the samples hence the plot characteristics are quite the same. However residual plots show smaller deviations from the reference line and lower degrees of outliers in the case of RFR. Hence RFR can be considered as a better predictor than SVR in this study which is further reflected in Tables 3 and 4.

In terms of 10-fold cross-validation results it can be inferred that both models show considerable consistency with low standard deviation values. The parameter settings for such fold have been used in the presented results. The average accuracy in both cases is more than 90 % while RFR has shown better accuracy. It can also be observed that in some folds for both the regression models, the accuracy has crossed 95 %.

Finally, it can be seen that in terms of R^2 both the predictors result in nearly 90 % accuracy while the accuracy with RFR is higher. The same is reflected with MSE values where RFR has resulted in less. Considering the lower MSE values both the models have shown promising prediction potential in our case. Nevertheless, considering both R^2 and MSE, RFR is a better predictor for the presented work.

5. Conclusion

In this study, experiments have been carried out simulating real production conditions. The experimental results demonstrate that there is a correlation between ink film thickness and machine run time and speed for different ambient conditions. The analytics of the results obtained show some significant aspects, which may be useful for standardization. The analysis of the regression model shows that at a constant speed, as the relative humidity decreased and temperature increased, the ink film thickness increased. The ink film thickness decreased when the relative humidity increased and temperature decreased. When speed was varied, the ink film thickness increased up to a point with the rise in relative humidity and thereafter decreased with a further increase in relative humidity. It is concluded that by adopting the proposed regression model for assessing the wet ink film thickness at varying machine run time and speed, proper standardization of ink film thickness can be implemented in the offset printing process.

The study also reveals that both SVR and RFR regression models can perform competitively for accurate prediction of ink film thickness. The present investigation undoubtedly confirms that this regression model for effective measurement of ink thickness works accurately well in offset printing.

From this study, it is evident that offset printing process has a scope of mechanism to adjust the ink film thickness at varying time and speed for different ambient conditions. This approach can also be extended to find out the correlation between ink film thickness and roller contact pressure along with ink film thickness (i.e. the gap between rollers) and the size of the rollers. Also, the effect of the damping solution along with the proper ink deposition on the impression cylinder needs to be studied further for optimum ink-water balance as in real offset printing conditions. The experimentations with different other prediction models can also be performed in future research.

This work can as well be extended toward the hardware implementation of automated controls in printing machines. Considering the findings and future scopes the proposed approach may be considered as an important dimension to the emerging area of optimization and prediction of ink thickness in offset printing process.

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Two-dimensional register error

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Abstract

On contemporary web printing machines, longitudinal and lateral register control of high precision is a crucial requirement for successful use in the roll-to-roll production of multi-layer electronic components. In the present study, an overview of mathematical models of two-dimensional register errors is shown. Simulation of the register errors is enabled by the use of a multi-layer model. Representation of the influencing variables on the lateral and longitudinal register errors and the mass flow chain is given in a joint block diagram that can be further used for simulation purposes.

Keywords: block diagram, moving web, mass flow, transfer function, web deflection

1. Introduction

In the development of rotary presses, two lines of development can be identified. The first line is very fast-running machines. These must have only very small longitudinal register errors and must not show doubling under any circumstances (Brandenburg, 2000). The lateral register errors, however, are of secondary importance. These requirements were met by each printing unit being driven by a single drive that is digitally controlled. Numerous tests and simulations were necessary to master such a system with "electronic shaft" in practice (Brandenburg, et al., 1999). The simulations required mathematical models of the moving web and the individual electric drives. These tools only became available after the development of powerful computers. The second line of development is much newer. This involves the production of multi-layer printed circuit boards for later assembly with electronic components. In addition to the longitudinal register error, the lateral register error is also of utmost importance for these slow-running machines. The lateral register error must be smaller by a factor of 10 than for the former machines. The moving elastic web can be represented by the well-known mathematical model of the so-called mass flow (Kang 2010; Kang, Lee and Shin, 2011).

1.1 State of the art

The treatment of the register error in the longitudinal direction of the web, the so-called longitudinal register error, has been completed theoretically and to a large extent experimentally, as exemplified by the publications of Brandenburg (1976a; 1976b; 1976c; 2011; 2015), Brandenburg and Tröndle (1976a; 1976b), and Tröndle (1973).

Concerning the lateral register error, H. K. Kang has made a comprehensive contribution (Kang, 2010; Kang, Lee and Shin, 2011). He has investigated a rotogravure press that can be used to produce printed circuits "from roll to roll." He developed a mathematical model of lateral register error and verified it experimentally, showed the coupling between longitudinal and lateral register error, and investigated numerous variants for controls.

In the present paper, however, the model from Brandenburg and Klemm (2019) is used, which was originally derived only for constant web velocity. This is extended by linearization to variable web velocities. From this, a calculation rule for the lateral register error is derived for the first time. Further theory is restricted to a Bernoulli web, i.e. narrow webs with the ratio $L/b \geq 10$ (with the length L and the width b). For these, it can be shown that the web equations for lateral motion and those for mass flow (continuity equation) are only slightly coupled. Furthermore, it can be stated that there is hardly any difference between the continuity equation in longitudinal transport direction x, and in lateral transport direction, y. This makes it possible for the first time to represent the lateral and longitudinal register errors with the longitudinal mass flow equations in a joint block diagram, thus providing a comprehensive plan of the system for simulation purposes.

2. Lateral register error at constant web speed

Let the three-roller system with rollers 1, 2, and 3 as shown in Figure 1 be given. These are three printing units that are in synchronism and print three colors or layers on a substrate congruently on top of each other. The travelling web is a Bernoulli web and is at first assumed to be transported at the constant web speed v. It is assumed at roller 1 that the web experiences an input disturbance in the form of an input displacement $y_{E1}(t)$ or/and a change in the input angle $\theta_{E1}(t)$.

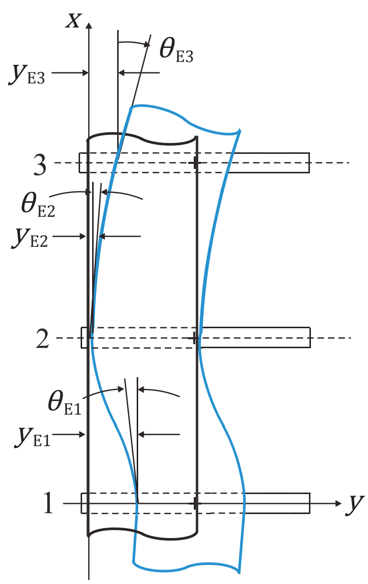

Figure 1: Three-roller system with input offset and input angle change at roller 1 (Brandenburg and Klemm, 2019, Figure 5.5)

2.1 Definition of the lateral register error

If a lateral web deflection y_{E2}(t) is caused at roller 2 as a result of a disturbance at roller 1, then, since the synchronism of the printing units is maintained, and the longitudinal change in web elongation is negligibly small, the lateral register error (LRF) $Y_{y,E2}(t)$ is directly given by this web deflection. Thus, the definition equation is

$$Y_{y,E2}(t) = y_{E2}(t) \quad [1]$$

In the s-domain it reads

$$Y_{y,E2}(s) = y_{E2}(s) \quad [2]$$

To calculate the LRF, the time $t_{L,12}$ is important, which a point needs to travel the length L_{12}. As is known, this is the time constant

$$t_{L,12} = T_{12} = L_{12}/v \quad [3]$$

An important tool for the mathematical description of the lateral motion of the web is the block diagram of Figure 2, which was first developed in Brandenburg and Klemm (2019).

2.2 Register error at input displacement and input angle change

The input displacement y_{E1} is assumed to be a step function at the time $t = t_{p1}$, the printing time of printing unit 1 (DW 1). This means that there is a lateral register error which is transported with the web and reaches roller 2 after the run time T_{12}

$$Y_{y,E2}(t) = y_{E1}(t - T_{12}) \quad [4]$$

In the s-domain, this equation reads as follows

$$Y_{y,E2}(s) = e^{-T_{12}s} y_{E1}(s) \quad [5]$$

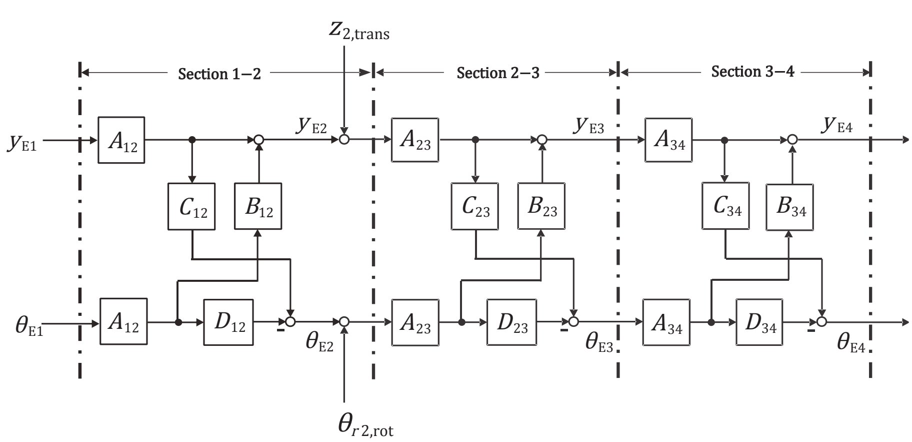

Figure 2: Block diagram of the lateral web motion at constant velocity according to Brandenburg and Klemm (2019, Figure 5.12)

However, the input displacement also triggers an immediate lateral transient $f^{(1)}[y_{E1}(t)]$, which leads to an additional LRF at roller 2. Then the total LRF at roller 2 is given by

$$Y_{y,E2}^{(1)}(t) = y_{E1}(t - T_{12}) + f^{(1)}[y_{E1}(t)] \quad [6]$$

In the s-domain this equation is

$$Y_{y,E2}^{(1)}(s) = e^{-T_{12}s} y_{E1}(s) + \phi^{(1)}[y_{E1}(s)] \quad [7]$$

Since the Bernoulli web obeys the block diagram of Figure 2, the following relationship is valid

$$\phi^{(1)}[y_{E1}(s)] = A_{12}(s) y_{E1}(s) \quad [8]$$

If a change of the input angle $\theta_{E1}(t)$ simultaneously occurs, this triggers a transient

$$Y_{y,E2}^{(2)}(s) = e^{-T_{12}s} \theta_{E1}(s) + \phi^{(2)}[\theta_{E1}(s)] \quad [9]$$

which is to be added to Equation [7]

$$Y_{y,E2}^{(1+2)}(s) = e^{-T_{12}s} y_{E1}(s) + \phi^{(1)}[y_{E1}(s)] + e^{-T_{12}s} \theta_{E1}(s) + \phi^{(2)}[\theta_{E1}(s)] \quad [10]$$

The result is

$$Y_{y,E2}^{(1+2)}(s) = \phi^{(1)}[y_{E1}(s)] + \phi^{(2)}[\theta_{E1}(s)] + [y_{E1}(s) + \theta_{E1}(s)] e^{-T_{12}s} \quad [11]$$

From the block diagram of Figure 2, *the complete lateral register error at constant web speed* then follows to be

$$Y_{y,E2}^{(1+2)}(s) = A_{12}(s) y_{E1}(s) + A_{12}(s) B_{12}(s) \theta_{E1}(s) + [y_{E1}(s) + \theta_{E1}(s)] e^{-T_{12}s} \quad [12]$$

This entire register error is simply called $Y_{y,E2}$

$$Y_{y,E2}(s) = A_{12}(s) y_{E1}(s) + A_{12}(s) B_{12}(s) \theta_{E1}(s) + [y_{E1}(s) + \theta_{E1}(s)] e^{-T_{12}s} \quad [13]$$

This Equation [13] reads in words: Both input variables, $y_{E1}(s)$ and/or $\theta_{E1}(s)$ immediately result in a lateral register error at roller 2 for $t > t_{p1}$. At the same time, however, they are also printed by printing unit 1 at the time $t = t_{p1}$, transported by the web and do not reach roller 2 until the transport time T_{12} has elapsed.

According to Brandenburg and Klemm (2019, section 5.2.6), the transfer functions $A_{12}(s)$ and $B_{12}(s)$ are generally given by

$$A_{i,i+1} = \frac{1}{\frac{T_{(i,i+1)}^2}{f_{B(i,i+1)}} s^2 + K_{CB(i,i+1)} T_{(i,i+1)} s + 1} \quad [14]$$

$$B_{(i,i+1)} = \frac{u_{(i,i+1)} - \sinh(u_{(i,i+1)})}{S_{(i,i+1)}} K_{CB(i,i+1)} L_{(i,i+1)} \quad [15]$$

and are specifically for $i = 1$ and $i + 1 = 2$ in system 1–2

$$A_{12} = \frac{1}{\frac{T_{12}^2}{f_{B12}} s^2 + K_{CB,12} T_{12} s + 1} \quad [16]$$

$$B_{12} = \frac{u_{12} - \sinh(u_{12})}{S_{12}} K_{CB,12} L_{12} \quad [17]$$

From Equation [17] it can be seen that B_{12} contains the factor L_{12} which provides dimensional correctness. It would have been more clever to use a function

$$B_{12}^* = \frac{B_{12}}{L_{12}} = \frac{u_{12} - \sinh(u_{12})}{S_{12}} K_{CB,12} \quad [18]$$

in order to make the dimensional correctness visible by the term $B_{12}^* L_{12}$. But Equation [13] is maintained in the above form because of earlier publications.

3. Lateral and longitudinal register error at variable web strain and web speed as well as at input changes

3.1 Lateral register error

In order to treat variable web velocities and web strain, the system equations have to be linearized. Since Equation [13] is a linear relation, it is also valid for small deflections from the steady state (marked by a tilde)

$$\tilde{Y}_{y,E2}(s) = A_{12}(s) \tilde{y}_{E1}(s) + A_{12}(s) B_{12}(s) \tilde{\theta}_{E1}(s) + [\tilde{y}_{E1}(s) + \theta_{E1}(s)] e^{-T_{12}s} \quad [19]$$

the time constant of the web can be assumed to be constant because of the only small changes in web velocity. That a steady state with stationary deflection and stationary angle exists is proved for the Bernoulli web using the equations of the two-mass system in Brandenburg and Klemm (2019, Equation [4.38]), for $y_0 = \hat{y}_0 = \hat{y}_{E1}$. The stationary deflection is

$$\lim_{t\to\infty} y_{E2}(t) = \lim_{s\to 0} y_{E2}(s) = \hat{y}_{E1} \quad [20]$$

From Brandenburg and Klemm (2019, Equations [4.61] and [4.65]) the stationary web angle is calculated to be

$$\lim_{t\to\infty} y_{\mathrm{E2}}(t) = \lim_{s\to 0} y_{\mathrm{E2}}(s) = \frac{u-\sin h(u)}{\sin h(u) - u\cos h(u)} K_{\mathrm{CB}} L\hat{\theta}_{E1} = \frac{u-\sin h(u)}{u[\cos h(u)-1]} L\hat{\theta}_{\mathrm{E1}} \quad [21]$$

Thus, the linearization is justified. Then the equations for further systems 2–3 and 3–4 read

$$\tilde{Y}_{y,\mathrm{E3}}(s) = A_{23}(s)\tilde{y}_{\mathrm{E2}}(s) + A_{23}(s)B_{23}(s)\tilde{\theta}_{\mathrm{E2}}(s) \cdot + [\tilde{y}_{\mathrm{E2}}(s) + \tilde{\theta}_{\mathrm{E2}}(s)]e^{-T_{23}s} \quad [22]$$

and

$$\tilde{Y}_{y,\mathrm{E4}}(s) = A_{34}(s)\tilde{y}_{\mathrm{E3}}(s) + A_{34}(s)B_{34}(s)\tilde{\theta}_{\mathrm{E3}}(s) + [\tilde{y}_{\mathrm{E3}}(s) + \tilde{\theta}_{\mathrm{E3}}(s)]e^{-T_{34}s} \quad [23]$$

3.2 Longitudinal and lateral register error due to input displacement

The question is now whether there is a relationship between lateral and longitudinal register error. For this purpose, Figure 3 is discussed.

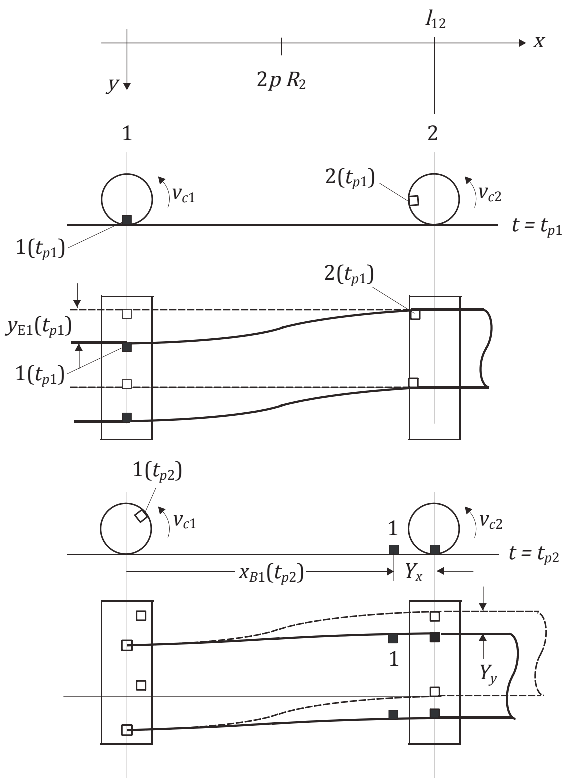

Figure 3: Part of three-roller system with input offset and input angle change at roller 1, from Brandenburg and Klemm (2019, Figure 5.5)

At the printing time $t = t_{p1}$, a step function of the input displacement $y_{E1}(t_{p1})$ is assumed. With this lateral register error (LRF), the first print unit DW 1 prints the point "1", symbolically written in the form $1(t_{p1})$ in Figure 3. In the top view of Figure 3, two points at the edge of the web are chosen: A black point means that this one will be printed, a white one means that this one will not be printed. It is now arbitrarily assumed that point 1 at the printing time $t = t_{p2} = t_{p1} + T_{12}$ of DW 2, does not exactly reach the assigned point of DW 2, but lies somewhat behind or in front of it (as is drawn in Figure 3). So at the time $t = T_{12}$ there is also a longitudinal register error $Y_{x,\mathrm{E2}}$. Now, however, the described lateral dynamic process was triggered at the same time by the input displacement, which at the time $t_{p2} = t_{p1} + T_{12}$ causes the lateral register error $Y_{y,\mathrm{E2}}$. Thus, the longitudinal and lateral register errors are coupled with each other at any time. Of course, this does not mean that a lateral register error will cause a longitudinal one. A longitudinal register error can be added at some time during an "ongoing" lateral dynamic process.

3.3 Mathematical formulations

The linearized *longitudinal* register error obeys in the *s*-domain the long-known relation

$$\tilde{Y}_{x,\mathrm{E2}}(s) = \frac{\bar{v}}{s}[-\tilde{\varepsilon}_{12}(s) + e^{-T_{12}s}\tilde{\varepsilon}_{01}(s)] \quad [24]$$

In Equation [24], the first term in the square brackets describes all points (1) that are already located in the web section 1–2 when the transient starts, while the term $e^{-T_{12}s}\tilde{\varepsilon}_{01}(s)$ describes those points (2) that enter at DW 1 for $t \geq 0$ and arrive at DW 2 after the transport time T_{12} has elapsed. For the linearized lateral register error $\tilde{Y}_{y,\mathrm{E2}}$ the above given Equation [19] is valid.

In order to mathematically describe the coupling of longitudinal and lateral register error, the following assumptions are made:

- The longitudinal web deflection, which occurs in *x*-direction, and the lateral web deflection, which occurs in *y*-direction, are treated separately.
- The lateral movement caused by the input displacement does not cause any strain in the *x*-direction.

If both simultaneously occurring register errors were present in the time domain, then both expressions would have to be added in the entire time domain for the same point in time, respectively. The corresponding mathematical formulation is:

Given $Y_{x,12} = f(t)$ and $Y_{y,12}(t)$. The inverse function of $Y_{x,12}$ is: $t = g(Y_{x,12})$. This time is inserted into $Y_{y,12}(t)$. Then the total function, i.e. the total register error, follows to be

$$Y_{y,12}(t) = Y_{y,12}[g(Y_{x,12}(t))] \quad [25]$$

By this transformation the same time was determined for both parts. This requires that the functions can be reversed analytically. When assessing the significance of this number, it must be taken into account that both errors lie in the same plane, namely the web plane, but are perpendicular to each other.

In the *s*-domain, the function pair of Equation [19]

$$\tilde{Y}_{y,\mathrm{E}2}(s) = A_{12}(s)\tilde{y}_{\mathrm{E}1}(s) + A_{12}(s)B_{12}(s)\tilde{\theta}_{\mathrm{E}1}(s) + [\tilde{y}_{\mathrm{E}1}(s) + \theta_{\mathrm{E}1}(s)]e^{-T_{12}s} \quad [26]$$

and Equation [24]

$$\tilde{Y}_{x,\mathrm{E}2}(s) = \frac{\bar{v}}{s}[-\tilde{\varepsilon}_{12}(s) + e^{-T_{12}s}\tilde{\varepsilon}_{01}(s)] \quad [27]$$

describes both register errors in parameter representation. Parameter is the operator *s*.

In Figure 4, the block diagram is drawn, which illustrates the interaction of lateral and longitudinal register error according to Equations [29] and [28] for a three-roller system. The upper chain shows the lateral register error $\tilde{Y}_{y,\mathrm{E}i}$, the lower chain the longitudinal register error $\tilde{Y}_{x,\mathrm{E}i}$. It can be seen that both register errors are linked to the mass flow chain. The name “multi-layer model” is introduced for this system plan.

The upper system for lateral motion and the lower one for longitudinal motion can be excited and simulated completely independently of each other, i.e. for any time points $\tilde{y}_{\mathrm{E}1}(t = t_1), \tilde{\theta}_{\mathrm{E}1}(t = t_2)$ and $T_{01}^*(t = t_3)$. However, to illustrate the two-dimensional register errors $\tilde{Y}_{(Si,i+1)}$, one time point $t_1 = t_2 = t_3$ has to be chosen. Since both register errors are perpendicular to each other, it is proposed to represent the quantities $\tilde{Y}_{x,\mathrm{E}i}$ and $\tilde{Y}_{y,\mathrm{E}i}$ as components of vectors

$$\vec{\tilde{Y}}_{x,\mathrm{E}i} = \tilde{Y}_{x,\mathrm{E}i}\vec{e}_x \quad [28]$$

and

$$\vec{\tilde{Y}}_{y,\mathrm{E}i} = \tilde{Y}_{y,\mathrm{E}i}\vec{e}_y \quad [29]$$

Where $\vec{e}_x$ and $\vec{e}_y$ are the unit vectors in *x*- and *y*-directions. The sum vector, i.e. the vector of the total register error, is then given by

$$\vec{\tilde{Y}}_{s,\mathrm{E}i} = \vec{\tilde{Y}}_{x,\mathrm{E}i} + \vec{\tilde{Y}}_{y,\mathrm{E}i} = \tilde{Y}_{x,\mathrm{E}i}\vec{e}_x + \tilde{Y}_{y,\mathrm{E}i}\vec{e}_y \quad [30]$$

During a dynamic process, this vector changes its magnitude and angle while the web is running.

In the block diagram of Figure 4, the following three variables appear as independent input variables: the input displacement and the input angle of the web as well as

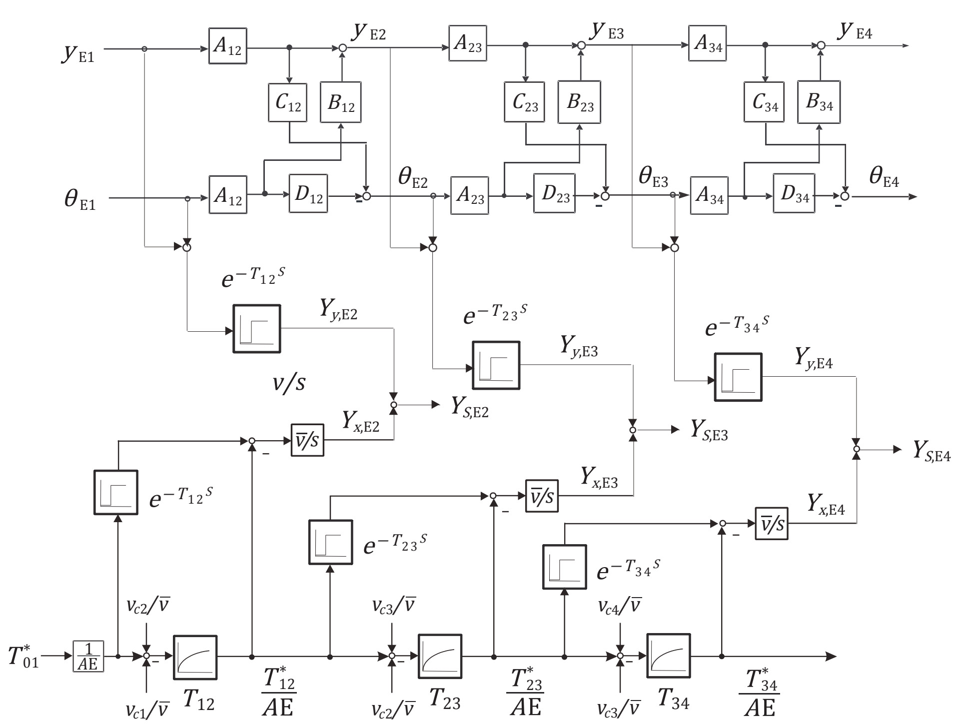

Figure 4: Total system diagram: interaction of lateral and longitudinal register errors (multi-layer model); all variables are small deviations from steady state

the change in tensile force at the input of the mass flow chain. They are defined to be “main input variables”, because they can excite all three layers. The circumferential speeds of the rollers, however, are assigned to the corresponding time lags of the mass flow chain.

Thus, this multi-layer model, together with corresponding simulations, allows quantitative predictions about the dynamics of all system variables. The retroactive effect of forces on lateral web motion and the lateral register errors was neglected. If this simplification is admissible must be justified in the specific case (Brandenburg and Klemm, 2017).

4. Conclusion

The multi-layer model in Figure 4 represents the overall system of lateral and longitudinal register errors and the mass flow chain. This study clearly shows the interaction of important influencing variables that make visible the behavior of the information printed on the web and the associated errors. From the point of view of control technology, this system representation offers the possibility of using simulations to test and quantitatively assess the control performance and in particular the behavior in relation to numerous disturbances.

Acknowledgment

I want to express my sincere thanks to Dr. Andreas Klemm for fruitful discussions and carrying out formatting guidelines.

List of symbols

If x is a variable, $\bar{x}$ denotes the steady state and $\tilde{x}$ a small deviation of this variable from the steady state. Some of the chosen formula symbols follow directly from the context and explain themselves.

A_{12}	Transfer function according to Equations [14] and [16]
B_{12}	Transfer function according to Equations [15] and [17]
e	Base of the natural logarithm
$\vec{e}_x$	Unit vector in x-direction (longitudinal direction), Eq. [28]
$\vec{e}_y$	Unit vector in y-direction (lateral direction), Equation [29]
$g(Y_{x,12}(t))$	Inverse function of $Y_{x,12}(t)$ according to Equation [25]
s	Operator of Laplace transform
T_{12}	Time constant of web section 1–2 according to Equation [3]
$T_{(i,i+1)}$	Time constant of section $i, i+1$
$T^*_{(i,i+1)}$	Web force of section $i, i+1$
v	Speed of the web in x-direction
v_{ci}	Circumferential speed of a roller (= substitute quantity for the transport speed of a printing unit acting on the web i)
$\bar{v}$	Average transport velocity according to Equation [24]
$\vec{\tilde{Y}}_{x,\mathrm{E}i}$	Longitudinal register error in vector notation, Equations [28] and [29]
$\vec{\tilde{Y}}_{y,\mathrm{E}i}$	Lateral register error in vector notation, Equation [29]
$Y_{S,\mathrm{E}i}$	Sum of lateral and longitudinal register error (see Equation [30] and Figure 4)
$Y_{x,\mathrm{E}i}$	Longitudinal register error at the input roller i according to Equation [24]
$Y_{y,\mathrm{E}i}$	Lateral register error at the input roller i according to Equation [1]
$y_{\mathrm{E}i}$	Input displacement at roller i (cf. Figure 1)
$\varepsilon_{(i,i+1)}$	Strain in the free web section $i, i+1$
$\theta_{\mathrm{E}i}$	Input angle at roller i (cf. Figure 1)

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What about the surphase?

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Abstract

We talk glibly of the *surface* of paper, even when we are talking e.g. of paper strength, where we should more correctly talk of the s*urphase* strength. The strength is related to a material layer not to a geometrical surface.

Keywords: paper science, terminology, surface properties, bulk layer properties

This brief contribution is a plea for the recognition and use of the term “surphase” rather than the more familiar “surface” when the intention is to refer not to the mathematically defined surface but rather to a layer of material in the surface region.

Dr Mladen Lovreček, a former Secretary General of the IARIGAI, used to enjoy talking of how his friendship with me as Technical Editor of the Conference Proceedings had developed from an initial debate and disagreement as to whether in one of his conference papers he should refer to the “*interface*” or to the “*interphase*”. He has indeed referred to this debate with humour and a certain degree of imaginative speculation in his contribution to the IARIGAI memoirs published a few years ago (Lovreček, 2018). Our discussion was stimulating and we reached an amicable conclusion, but the details of the discussion are unimportant. The important fact, which I wish here to document, is that both these words exist and that their different geometrical interpretations are well understood. A spontaneous *interface* may arise between two immiscible phases, but miscible liquids may intersperse and interact or an adhesive may be applied to create what is recognised as an *interphase.*

I have therefore wondered for years why we do not with the same enthusiasm and with the same desire for accuracy distinguish between the “*surface*” and the “*surphase*” of a medium or an object, particularly in the field of paper science. A *surface* is essentially a mathematical concept which can be defined in geometrical or trigonometrical terms, whereas a material layer capable of possessing physical properties surely deserves instead to be called the *surphase*.

I must perhaps emphasize that I wish to restrict the use of the term “*surface*”, using it not as a synonym for the material layer which constitutes the *skin*, but to describe a topological two-dimensional region with no thickness and no volume, a linguistic and mathematical difference which has apparently not always been recognised in the discipline of surface science. According to my definition, surface science is a discipline which is strictly limited to the study of the interface between an object and the surrounding ambient medium and not to the properties of any surface layer with a finite thickness.

We are perhaps not offended by references to the *surface tension* of a liquid for we realise that this is indeed a property which can be related to the surface and not to the bulk liquid, but I have never really liked the way in which we calmly talk of the *surface strength* of paper.

When considering the behaviour of a web of paper or of sheets of paper in a printing press and the need to keep the press clean of dust and fibre particles, we are conscious of the fact that there is a measurable strength associated with the surface and that we expect the papermaker to take the necessary steps to ensure that the strength is sufficient for our purposes.

This has led to much work in many countries and in many institutes to define, measure and ultimately improve what has become known as the *surface strength*, but this is the strength not of a mathematical concept but the strength of a thin layer of material – often a multi-component layer – which forms the paper *surphase*, and we should surely refer to it instead as the *surphase strength*.

Although the word has not been used in the field of paper physics, the word "*surphase*" is not in fact unknown to the scientific community. A group working in Vietnam, for example, has used the term when reporting the use of *surphase resonance* to study the properties of a gold nanoshell deposited on a nanoparticle core (Lien, et al., 2018). These authors realise that a gold nanoshell deposited on the *surface* creates a *surphase.*

At an early stage in the development of paper physics as a scientific discipline, there was a lot of interest in measuring the *surface roughness* and various methods were developed to measure this property, of which the Bendtsen method using air-flow across the surface became the most frequently used, although it felt counter-intuitive to express roughness in *ml/min*. In the 1960s, however, John Parker advanced this idea to produce the Parker Print Surface (PPS) instrument (Parker, 1971) where an important development was the consideration of the relationship between the air flow and the gap size so that the air flow data could be converted to and presented in μm, which could be interpreted as the mean distance between the surface and a reference plane tangent to the surface.

Consideration of what actually happens in a printing press led to the concept of compressibility and to the need to distinguish between the bulk compressibility of the paper sheet and the compressibility of the surface region, and I believe that I was one of the first to publish data on a property which I referred to as the *surface compressibility* (Bristow, 1982a; 1982b) where I used a modified PPS-instrument with an attachment so that I could adjust the pressure applied to the surface when the air-flow measurement was being made.

With increasing pressure, the surface roughness diminished, but I did not then state clearly that, when considering this to be a compressibility measurement, I was in fact no longer interpreting the PPS-value as the mean distance between the paper surface and a reference plane but rather as the mean thickness of the layer between the reference plane tangent to the surface and a reference plane defined by the bottoms of the depressions in the surface, i.e. as a measure of the thickness of a surface layer and I should therefore have referred to the compressibility of this surface layer as the *surphase compression.*

This manner of thinking can be applied to other properties. We measure the *surphase abrasion* and a *surphase puncture factor*, but we refer correctly to a *surface indentation* where the surface is deformed but where there is no physical damage.

Optical properties such as brightness, whiteness and opacity may be independent of the surface, but printability properties such as *print density* and especially *print through* are the result of an interaction which involves the *surphase* rather than merely the *surface.*

When studying printability and the interaction between ink and paper, I became involved in the field of perceptual psychology and there I learned that it is often necessary to distinguish between body colour and surface colour but, without entering into a deep discussion of the phenomenon of colour and its perception, we can here note that the two main types of colour, structural colour and pigment colour, involve material structure and that it may thus be argued that *surface colour* should, according to my current thesis, properly be called *surphase colour.*

An understanding of this is evident in a paper by Vega et al. published in the American Journal of Analytical Chemistry (Vega, et al., 2011) where the authors refer to the use of *solid surphase fluorescence.* Fluorescence involves an interaction which is, of course, a *surphase* phenomenon not a *surface* phenomenon.

The discussion can be extended to other properties, and I am, of course, interested to see what the response to this plea may be. I hope that the discussion will not be merely superficial, or should I perhaps say "superphisial"?

Dedicated to the memory of Prof Pierre Lepoutre (1933–2020) Montreal, expert in paper properties.
Many years ago, I promissed him that I would one day write this article.

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Analysis of the visual language of design of sustainable packaging manufactured from biomaterials

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Abstract

In the context of the environmental problems caused by product packaging, sustainability is becoming one of the main goals of designers. Designers are no longer content to highlight the environmental friendliness of packaging through 'green symbols', 'recycled symbols' or 'renewable symbols'. Instead, designers have opted for bio-materials such as plant fibers, waste from other materials and mycelium to form the bulk of the eco-packaging. The materials themselves are used to create a new design language, which directly reflects the eco-friendly features of the packaging. This paper analyses existing examples of sustainable packaging design and explores the new visual language of sustainable packaging design, mainly by means of literature and questionnaire research.

Keywords: eco-friendly packaging, biomaterials, sustainable design, packaging applications, circular packaging

1. Introduction and background

The evidence is now overwhelming that the depletion of the Earth's finite natural resources is attributable to human behavior (Krausmann, et al., 2009). From the perspective of product packaging, the problem of wasted resources and pollution caused by packaging is the background basis for the research in this article. In the latest packaging bill, until 2030, packaging produced in the EU, should be fully recyclable or reusable and disposable plastic products such as cutlery, straws and beverage containers should be phased out (Matthews, Moran and Jaiswal, 2021). This article will focus on the current state of packaging pollution and new packaging designs in response to sustainable design.

1.1 The environmental problems associated with product packaging recycling

The environmental problems associated with the difficulty of recycling and the low recycling rate of packaging waste are clearly known, and Rokka and Uusitalo (2008) argue that the increase in packaging waste brought about by the food retail industry has led to the greatest environmental problems in the global consumer sector. The packaging waste discussed in this paper is mainly paper, cardboard, wood, plastic, glass and metal. In France, for example, the Statista Research Department (2022) estimates that the amount of packaging waste in France in 2020 was below 12.7 million tonnes. In a survey of recycling rates for packaging waste, there are significant differences in recycling rates across Europe (Tallentire and Steubing, 2020). In 2019, the packaging recycling rate for paper and board packaging is the highest in the European Union (EU-27) at 82 %. Plastic packaging has the lowest average recycling rate at 40.6 %, but recycling rates vary greatly from country to country (Statista Research Department, 2022). The same is true in the UK, where recycling of packaging waste still fails to reach more than half of the recycling rate. According to UK statistics on waste (2022), the two main materials least recycled of all packaging waste between 2019 and 2021 are plastic and wood, both with recycling rates of 42 % to 47 %. However, when viewed globally, the waste and pollution problems associated with plastic packaging are even more significant, with the UN environment programme (2022) showing that of the 7 billion tonnes of plastic waste produced globally, 36 % is contained in packaging uses and less than 10 % is recycled.

1.2 The environmental problems associated with product packaging production

In addition to the packaging waste pollution mentioned above, which is difficult to recycle, the process of making packaging is also one of the main causes of packaging pollution. Given the current environmental situation, in addition to the known polluting nature of the production process of packaging made from petroleum-based materials, packaging made from paper and board is not entirely environmentally friendly. Some theories that paper comes from wood, and that the pollution caused by deforestation, the transport of wood, the pulp bleaching process and the packaging printing of paper boxes should all be taken into account as to whether it is environmentally friendly. Due to the non-waterproof and fickle nature of paper, laminating and varnishing are important aspects of paper-based packaging, and Wang, Hou and Lin (2013) found that laminating and varnishing added 239 kg of greenhouse gas emissions to the production of 20 000 color-box packages printed using the lithographic offset printing process.

It follows that, from an environmental point of view, the use of large amounts of non-renewable resources in packaging design and the large carbon emissions generated by the manufacturing process and the low recycling rate of packaging waste do pose a significant threat to the existing environment-in terms of wasted resources, greenhouse gases and environmental pollution.

1.3 Sustainable packaging design and two eco-friendly visual languages

Against the backdrop of global climate issues caused by human behavior, it is easy to see that designers have long turned to designing for the environment with the 3Rs of green design, sustainable design concepts and low carbon design concepts that have been developing since the 20th century. In many regions, attempts have been made to change eco-consumption behavior by raising social and individual awareness and highlighting the benefits that come from choosing eco-friendly products. Since the 1980s, many companies have done this by developing 'greener' formulations of their products, i.e. by developing packaging that is less harmful to the environment than traditional petroleum-based packaging materials, particularly plastics (Bech-Larsen, 1996).

Benson (2007) suggests that to achieve sustainable design, designers should reduce carbon emissions at source by selecting materials that are local or can be manufactured locally to reduce carbon emissions in transit. As the concept of sustainable design evolves, Sustainable Packaging Coalition (2011) put forward some rules on sustainable packaging. Sustainable packaging is purchased in a responsible way, is effective and safe in the whole life cycle, conforms to the performance and cost standards of the market, is manufactured entirely using renewable energy, and once used, it can be effectively recycled.

In the actual use and sale of environmentally friendly packaging materials, there are two main types of design available to show the environmental friendliness of the packaging itself; one is to post a 'green symbol' and the other is to use the characteristics of the packaging material as a visual symbol. The most common approach is for designers to respond to green packaging requirements by posting 'green symbols', 'recycled symbols' or 'renewable symbols' (Figure 1) on the packaging, and there is no denying what Koenig-Lewis, et al. (2014) argue that emotions are an important driver of eco-friendly purchasing decisions, with consumers creating or reinforcing a 'greener self-identity' through product choice. Duckworth, et al. (2022) confirm that consumers are heavily influenced in their consumption choices by 'green-labelled' packaging, particularly in favor of 'sustainable' and 'local materials', and are willing to pay a 'premium' for their products. And without the 'green label', it is difficult for consumers to associate their purchasing decisions with their environmental impact (Rokka and Uusitalo, 2008).

Figure 1: Moebius Loop-sign of recycling material content

However, the use of simple 'green symbols' does not satisfy consumers' understanding of the need to update environmentally friendly materials. Nguyen, et al. (2020) believe that consumers are still unaware of eco-friendly packaging in emerging markets. Consumer anxiety about new technologies for eco-friendly packaging, such as packaging made from organic or edible materials and plastic bottles containing chemicals such as bisphenol A, can lead to a direct reduction in consumer desire to buy (Grunert, 2002). The most salient aspect of eco-friendly packaging as perceived by consumers relates to the packaging material, and the most effective way for them to judge whether packaging is eco-friendly is 'what they see is what they get' (Nguyen, et al., 2020).

2. Method and results

In practice, designers and brands are already applying the 'what you see is what you get' theory, using local biomaterials as the main material for packaging and visually retaining the original material texture. In existing research, the main non-petroleum-based packaging materials used for sustainable design are beeswaxes, pineapple leaves, mycelium, seaweeds, cocoa beans, starch, rice husks, coconut husks, wheats, sawdusts, seeds and bamboos. There are two main ways of making packaging from biological materials. One is the direct use of a single material for turning or pressing, such as the use of beeswax for honey jars, which does not require the mixing of other materials, and can be completed with beeswax alone. The other is to mix two or more biological materials in order to increase the resilience, compensate for the lack of a single material or to plant it after use, for example by mixing pineapple leaves with seeds, which act as a biodegradable material and provide nutrients for the seeds after use, thus completing the planting.

After the packaging has completed its mission, there are two main types of end-of-life disposal – recycling and composting. In order to discuss the use of sustainable materials in packaging design from different dimensions, five different types of eco-friendly packaging designs are examined in this paper. Case 1, a honey jar using a single material – beeswax (recyclable). Case 2, a plantable snack packaging design that mixes seeds with pineapple leaves (compostable planting). Case 3, compostable mycelium and hull mix – fragile packaging design (compostable) Case 4, an alternative to cardboard packaging design – seaweed paper (compostable). Case 5, a durable takeaway box based on discarded cocoa beans (recyclable). The following are specific interpretations and visual characterisations.

2.1 Visual characterization of sustainable packaging based on biomaterials

Case 1: Bee Loop (Figure 2), a Lithuanian honey brand, uses beeswax, a waste product from local honey production, as a raw material for its packaging, thus reducing the use of environmentally unfriendly plastic bottles, glass bottles and plastic stickers. 'When honey is harvested from the honeycomb and made ready for consumption, we put the honey back where it belongs – into the beeswax. Alternatively, beeswax honey pots can be returned to us or your local beekeeper. When the beekeeper returns beeswax to the hive the circle of honey-making continues' (Bee Loop, 2022). From the visual point of view, the color of the jars is not bleached, printed or colored, but rather the color of the honeycomb itself. These three types of honey pot are made from their own honeycomb beeswax: with the *Linden Honey Pot* appearing light yellow, the *Buckwheat Honey Pot* amber and the *Forest Honey Pot* brown due to the difference in color of the honey. The honey pots have a rough, unpolished, frosted surface and are wrapped in unbleached wood sourced twine and corrugated paper, revealing the yellow beeswax bottle through its own holes, visually creating a rough dotted symbol.

Figure 2: Bee Loop (2022) honey pot made of beeswax in a box made from corrugated cardboard

Case 2: In the Philippines, one of the world's largest producers of pineapples, Pat Mangulabnan has made pineapple leaves and seeds into 'Pinyapel Paper' (Figure 3) for food packaging, which is printed using organic soy inks (Nagal, 2021). The packaging reuses pure, natural pineapple leaves, which are buried in the soil after use and act as a natural composting material to help the seeds germinate. Visually, the unbleached and uncolored coarse fiber paper has a low-saturation yellow-grey and grey-green color, with a rough and grainy surface due to the lack of further processing of the plant fibers and the addition of plant seeds as a mixture.

Figure 3: A snack packaging box made of 'pinyapel paper' printed using natural soy ink (Nagal, 2021)

Case 3: The London-based packaging design company Magical Mushroom (n.d.) has worked with a number of UK beauty, fragrance and skincare brands using the new biomaterial mushroom mycelium to create packaging that naturally degrades in around 45 days (Figure 4). Magical Mushroom claims the mycelium has the unique quality to produce a hard-wearing, cost-effective and fully sustainable alternative to polystyrene packaging. Mushroom packaging is a mixture of mushroom mycelium and various local agricultural waste products – wheat and sawdust, etc. The 3D printed packaging takes just seven days to complete, so visually, the fibrous properties of mushroom mycelium and other agricultural by-products are retained, with a creamy, rough, grainy surface.

Figure 4: Mushroom mycelium based packaging for Evolve, British skincare brand (Magical Mushroom n.d.)

Case 4: To prevent deforestation, reduce the pressure on forests and the environmental impact of the paper industry, minimize the use of virgin wood and use no synthetic additives, Notpla has partnered with Canopy to launch *Notpla Paper* (Figure 5), an eponymous product made from seaweed and wood pulp for packaging, labels and envelopes (Englefield, 2022). Notpla Paper is based on fibers and biomass left over from the company's extraction of seaweed gum for other products, in order to achieve a new way of recycling whole seaweed. Thanks to the mix of wood pulp and seaweed fibers, Notpla Paper has a smooth surface to the touch but visually has spots and particles of broken seaweed fibers, with the color varying according to the algae species, e.g. brown algae appearing reddish-brown and green algae dark blue-green.

Figure 5: Wrap packaging made of seaweed and wood pulp based Notpla Paper (Englefield, 2022)

Case 5: The *Zero Takeaway Packaging COCOA* (Figure 6), made from cocoa, is an experiment in circular economy principles by PriestmanGoode (2023). *Zero Takeaway Packaging* uses natural materials wherever possible. In addition to the local industrial chocolate production leftovers used in the main body, mycelium is used for insulation, natural rubber is used for the handle section, the outer bag is made from biodegradable and renewable materials, the lid section is made from pineapple leaf fibers and algae extract is used as an alternative to cling film. The takeaway box follows the original dark brown color of the cocoa beans and is not finely polished, retaining the uneven dotted texture caused by the difference in color of the granular material itself. Paula Nerlich, the designer of *COCOA*, said in an interview (Savaton, 2022) that the aesthetic impetus for the work was her passion for the texture and color of the material.

Figure 6: Food-safe takeaway boxes made of cocoa and other sustainable material (PriestmanGoode, 2023)

Through the analysis of the production process and visual characteristics of the above sustainably designed packaging, it is easy to see that the designers retain the plant fibers of the material and reduce the bleaching, coloring, fine grinding and highly purified aspects of the production process, reducing time costs, labor costs and the carbon emissions generated during the production process. The original color and rough graininess of the material is a relatively unified choice by the designers, as seen in the designers' and brands' statements, and it can be assumed that the texture of this renewable raw material or biomaterial itself has become a visual design language. It is worth discussing that Nguyen, et al. (2020) point out the importance of the aesthetics of packaging in actual sales, and that designers should balance the aesthetics of packaging design and brand design while being environmentally friendly when dealing with consumers. In a traditional study of packaging design and consumer psychology, Silayoi and Speece (2004) found that the main factors influencing consumers' purchasing decisions were packaging color and graphics. In terms of visual appeal, Magnier and Crié (2015) found that this type of less colorful and simple eco-friendly packaging was not advantageous for consumers. However, designers have not abandoned the practice of retaining plant fibers and original colors, and from a more recent study, Magnier and Schoormans (2017) conclude experimentally that white packaging has a greater environmental bias compared to red packaging in the proposition of eco-friendly packaging, while fiber-based packaging materials trigger higher product environmental friendliness ratings than plastic packaging materials. Therefore, reducing the inks in the production and manufacturing process of eco-friendly packaging and retaining the original fibers and colors will not only not reduce the visual appeal, but will instead highlight its own environmental value through this simple and effective method.

2.2 Audience perception of environmentally friendly visual symbols for sustainable packaging

In order to further explore the perspectives from which audiences get their eco-feelings from eco-packaging, a simple web-based questionnaire was conducted on the above examples of eco-design from the last two years. The questionnaire explores two aspects: on the one hand, which visual features consumers perceive as environmentally friendly in packaging, and on the other hand, whether consumers can rely on visual judgement alone to dispose of waste packaging. This is a general study of the visual perspective that consumers have on eco-friendly packaging, and the questionnaire was not strictly limited to the audience, ensuring that the product was placed in front of them in a random way. Of the 524 questionnaires returned, 49.4 % were female, 26.3 % were male and 24.2 % were transgender (Table 1). In terms of the age of the respondents (Table 2), 25–30 years old was the largest group, with 27.1 %. This was followed by 18–24 and 31–35 years old. The remaining age groups all accounted for around 10 %. Regarding the educational level of the respondents (Table 3), more than half of them had a bachelor's degree.

Table 1: Gender of respondent

Gender	Number	Proportion
Male	138	26.3 %
Female	259	49.4 %
Transgender	127	24.2 %
Intersex	0	0.0 %
Undetermined	0	0.0 %
Prefer not to say	0	0.0 %

Table 2: Age of respondent

Age	Number	Proportion
Under 18	53	10.1 %
18–24	97	18.5 %
25–30	142	27.1 %
31–35	92	17.6 %
36–40	45	8.6 %
45–50	45	8.6 %
Over 50	50	9.5 %

Table 3: Education level of respondent

Level	Number	Proportion
Below high school	102	19.5 %
High school	88	16.8 %
Undergraduate	277	52.9 %
Master	55	10.5 %
PhD	2	0.4 %

To ensure that the audience could think about the packaging in a multi-dimensional way, five multiple choice questions were created on the materials and characteristics of the packaging, including:

- Its color makes me feel environmentally friendly,
- Its shape makes me feel environmentally friendly,
- Its roughness makes me feel environmentally friendly,
- Its graininess makes me feel environmentally friendly, and
- I can't visually perceive its environmental friendliness.

There were also 4–5 options for how the packaging can be disposed of: 'landfill for composting or planting', 'incinerate', 'put it in the recyclable bin', 'clean it and reuse it', and Bee Loop (2022) offering a 'send it back to the manufacturer' service. The questionnaire received 789 views and the data return reached 524; a return rate of 66.4 % can prove that the results can be used as a reference for this study. In the overall analysis of the data, for each of the five eco-packages, less than 1.0 % of the audience could not intuitively perceive the eco-friendliness of the packaging. Under the assumption that environmentally friendly packaging is used, only 3.1 % to 5.7 % of respondents chose to use the non-environmentally friendly disposal method – incineration.

From the Bee Loop survey, it is evident that the different visual elements provide similar environmental perceptions (Table 4), with 47.3 % to 60.5 % of respondents being able to perceive the eco-friendliness of the Bee Loop product in its unpolished yellow bottle and unbleached corrugated packaging. The most notable of these was the 'graininess'. In the survey on the 'disposal method' of Bee Loop (Table 5), a majority of respondents (42.7 %) said that 'throwing it in the recyclable bin' was the most appropriate way to dispose of it, based on visual judgement alone. However, only 11.8 % of respondents opted for the brand's call to 'send it back to the manufacturer'.

In the Pinyapel Paper survey, the most evocative of respondents' environmental feelings was the roughness caused by the fibers of the pineapple leaves and

Table 4: What are the visual aspects of this five packages that consumers can perceive as environmentally friendly (multiple choice questions; N for number, and P for proportion)

Options	Bee Loop		Pinyapel Paper		Magical Mushroom		Notpla Paper		COCOA	
	N	P	N	P	N	P	N	P	N	P
Color	248	47.3 %	284	54.2 %	198	37.8 %	240	45.8 %	291	55.5 %
Shape	276	52.7 %	259	49.4 %	303	57.8 %	275	52.5 %	235	44.8 %
Roughness	237	45.2 %	297	56.7 %	236	45.0 %	214	40.8 %	300	57.3 %
Graininess	317	60.5 %	215	41.0 %	283	54.0 %	308	58.8 %	231	44.1 %
Can not	4	0.8 %	3	0.6 %	2	0.4 %	3	0.6 %	4	0.8 %

Table 5: Consumers judge the treatment of these five packages only from a visual point of view (single choice questions; N for number, and P for proportion)

Options	Bee Loop		Pinyapel Paper		Magical Mushroom		Notpla Paper		COCOA	
	N	P	N	P	N	P	N	P	N	P
Landfill for composting or planting	139	26.5 %	118	22.5 %	179	34.2 %	56	10.7 %	127	24.2 %
Incinerate	16	3.1 %	17	3.2 %	23	4.4 %	25	4.8 %	30	5.7 %
Put it in the recyclable bin	224	42.7 %	203	38.7 %	170	32.4 %	216	41.2 %	198	37.8 %
Clean it and reuse it	83	15.8 %	186	35.5 %	152	29.0 %	227	43.3 %	169	32.3 %
Send it back to the manufacturer	62	11.8 %								

the mix of plant seeds, with a percentage of 56.7 %. It was followed by its yellow-grey and grey-green color, which differed from the highest percentage by only 2.5 %. The remaining two areas were below 50.0 % (Table 4). In terms of recycling (Table 5), apart from the non-environmentally friendly method of incineration, 'landfill for composting or planting', which is the most responsive to the design of the packaging, is the lowest of all the recycling options, with only 22.5 %. The proportion of respondents who chose to put it in the recyclable bin or reuse it was above 35.0 %.

In Magical Mushroom's eco-friendly packaging design, the granular surface and soft shape of the packaging, made up of mushroom mycelium and by-product waste, gave more than half of the respondents a sense of eco-friendliness (Table 4), while the seemingly bleached or colored cream color was less eco-competitive than the other aspects, with only 37.8 % of respondents considering its cream color to be eco-friendly. In the end-of-life survey (Table 5), the visual sense of mycelium was more likely to suggest 'landfill for composting/growing' to consumers, followed by disposal in a convenient way – in the recyclable bin.

In the question on the source of environmental feelings about Notpla Paper (Table 4), the graininess due to the mixture of seaweed and pulp took the top spot, with more than three hundred people having environmental feelings about it, followed by the simplicity of the shape giving 52.5 % of the audience an environmental feeling. The other two options – color and roughness – were chosen by more than 40.0 % of the audience. In terms of subsequent disposal (Table 5), using visual judgement alone, the highest number of people felt that it could be cleaned and reused, 1.1 % more than 'put it in the recyclable bin'.

In the questionnaire on COCOA packaging design (Table 4), retaining the original color of the cocoa was as environmentally attractive to respondents as retaining the coarseness of the cocoa beans' impurities, with over 55.0 % of the audience choosing both aspects. Both shape and graininess were chosen by around 44.0 % of respondents, a difference of over 11.0 % compared to the first two. In terms of end-of-life options (Table 5), disposal in the recyclable bin and reuse after cleaning were the majority of choices.

The above tables show that the roughness of the material due to fiber residue or the reduction in detail and the color of the material itself, left unbleached or recolored, can evoke a feeling of environmental protection to varying degrees. However, when it comes to the disposal of waste based on visual judgement alone, the easiest option of 'throwing it in the recyclable bin' still dominates, being the first choice three times out of five and the second choice twice.

3. Conclusion

Due to the climate problems caused by pollution in the production of packaging and the low recycling rate of packaging waste, and in response to some policy or action designers are increasingly turning to the use of biomaterials such as plant fibers, waste from other materials and mycelium to produce environmentally friendly packaging in the interests of sustainability. This approach is certainly effective, as designers and producers start by choosing the materials for the packaging, selecting locally produced raw materials to reduce unnecessary carbon emissions due to transportation and other issues, and reducing bleaching, coloring, fine grinding and high purification during the production process to reduce production pollution and labor costs in many ways. The resulting packaging visually retains the original color of the material and the roughness of the fibers, creating a unique design language and visual symbol for environmentally friendly packaging. The audience is equally satisfied with the product packaging and can feel the environmental friendliness of the packaging through the special colors and textures of the visual symbols. However, in subsequent end-of-life disposal, relying solely on visual judgement, the above visual symbols can only serve the purpose of suggesting to the consumer that the waste should be disposed of in the recyclable bin or cleaned and reused. The choice of composting the waste or sending it back to the producer in response to the call of the design concept is hardly reinforced by visual cues. In all cases, it is easy to see that the more plant fibers are retained in the eco-friendly packaging, the easier it is to direct the consumer towards landfill composting or planting behavior when the waste is subsequently disposed of. In conclusion, existing eco-friendly packaging designs have developed a unique visual language for environmental protection, and the use of plant fiber in subsequent design development can further enhance consumer response to the design concept.

Authors statement

The author reports there are no competing interests to declare.

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TOPICALITIES

Edited by Markéta Držková

CONTENTS

News & more

A yearly update on ISO standards for graphic technology

This time, the regular overview of the standards developed under the direct responsibility of the technical committee ISO/TC 130 is somewhat longer than usual; therefore, 14 standards that remain current based on the systematic review are listed in the side column. At present, 15 standards are under development. These include four new documents, two of which were registered in 2023. One deals with image technology colour management based on ICC.1:2022, and the other with measurement and one-parameter representation of translucency. The remaining 11 documents revise or build on existing standards, in one case on the withdrawn publicly available specification ISO/PAS 15339-1:2015 defining the principles of printing from digital data across multiple technologies. Seven documents published during the past 12 months are presented below.

ISO 2834-2:2022
Graphic technology – Laboratory preparation of test prints
Part 2: Liquid printing inks

Two years after the revision of Part 1, which is dedicated to paste inks, see JPMTR Vol. 10, No. 3 (2021), the technically revised third edition of this part, which specifies a method for preparation of test prints produced with liquid printing inks as used in gravure and flexography, but not inkjet printing, is also available; it was published in December 2022 and replaced the second edition from 2015, see also JPMTR Vol. 4, No. 3 (2015). The test prints of water-based, solvent-based or radiation-cured inks are intended for reflection measurements and testing of light fastness and mechanical and chemical resistance. In the current version, the ink transfer data of particular settings of laboratory proofer, printing forme, ink and substrate need to be acquired.

ISO 5776:2022
Graphic technology – Symbols for text proof correction

After the more substantial changes introduced in the previous edition of this standard in 2016, extending its applicability to any orthography and adding several new symbols, see JPMTR Vol. 5, No. 3 (2016), its current third edition from December 2022 adds correction symbols in the Korean language and the corresponding alphabetic and syllabary examples in an annex.

ISO/TS 18621-21:2023
Graphic technology – Image quality evaluation methods for printed matter
Part 21: Measurement of 1D distortions of macroscopic uniformity utilizing scanning spectrophotometers

This second edition, published in March 2023, brings formulae corrections and bibliography updates to a recent standard that specifies a method quantifying the non-uniformity of toner-based or inkjet digital prints due to banding or streakiness oriented in the horizontal and vertical direction by a Macro-Uniformity-Score on a scale from 100 to 0 (decreasing uniformity), see also JPMTR Vol. 10, No. 3 (2021).

The ISO standards for graphic technology confirmed for the next period

The standards confirmed for the first time include ISO 2846-1:2017 Graphic technology – Colour and transparency of printing ink sets for four-colour printing – Part 1: Sheet-fed and heat-set web offset lithographic printing, ISO 12634:2017 Graphic technology – Determination of tack of paste inks and vehicles by a rotary tackmeter, ISO 13655:2017 Graphic technology – Spectral measurement and colorimetric computation for graphic arts images, ISO 16613-1:2017 Graphic technology – Variable content replacement – Part 1: Using PDF/X for variable content replacement (PDF/VCR-1), ISO 17972-3:2017 Graphic technology – Colour data exchange format (CxF/X) – Part 3: Output target data (CxF/X-3), and ISO 20654:2017 Graphic technology – Measurement and calculation of spot colour tone value, all presented in JPMTR Vol. 6, No. 3 (2017).

Further standards that were reviewed and confirmed are ISO 12636:2018 Graphic technology – Blankets for offset printing, ISO 17972-4:2018 Graphic technology – Colour data exchange format (CxF/X) – Part 4: Spot colour characterisation data (CxF/X-4) and ISO 20690:2018 Graphic technology – Determination of the operating power consumption of digital printing devices, see JPMTR Vol. 7, No. 3 (2018), and also one more recent document, namely ISO/TS 23564:2020 Image technology colour management – Evaluating colour transform accuracy in ICC profiles, presented in JPMTR Vol. 9, No. 3 (2020).

The last group consists of four reconfirmed standards. All were published about two decades ago and have been confirmed for the fourth time. Three of them specify data formats for exchange in a prepress stage. The oldest is ISO 15930-3:2002

Graphic technology – Prepress digital data exchange – Use of PDF – Part 3: Complete exchange suitable for colour-managed workflows (PDF/X-3). Among all current PDF/X options, this one is probably the least used but still supported. The other two are ISO 12639:2004 Graphic technology – Prepress digital data exchange – Tag image file format for image technology (TIFF/IT), including Amendment 1: Use of JBIG2-Amd2 compression in TIFF/IT, which was added in 2007, and ISO 12640-2:2004 Graphic technology – Prepress digital data exchange – Part 2: XYZ/sRGB encoded standard colour image data (XYZ/SCID) with Technical Corrigendum 1 published in 2008, which specified the special profile intended for interpretation of the D65 channel scaled XYZ image files of this part of ISO 12640 because D65 CIEXYZ profiles normally used otherwise would produce incorrect results. The last recently reconfirmed standard is ISO 15790:2004 Graphic technology and photography – Certified reference materials for reflection and transmission metrology – Documentation and procedures for use, including determination of combined standard uncertainty, which provides guidance to manufacturers and users of certified reference materials, especially within quality management systems as defined in ISO 9001.

The first certification according to PSD Colour Data

At present, Fogra offers seven digital printing certifications within its standardised FograCert test programme. The PSD Colour Data verifies the colour accuracy of a print job in line with the tolerances specified in the ProcessStandard Digital based on the Fogra MediaWedge measurement data. In May, the first PSD Colour Data certification for seven-colour printing was achieved by Landa Digital Printing on the Landa S10 press, meeting the FOGRA55 printing condition. Till now (September 2023), it is still the only one listed among the certified print service providers.

ISO 22067-1:2022
Graphic technology – Requirements for communication of environmental aspects of printed products
Part 1: General printing

This new standard was published in October 2022. The specified requirements and criteria should help effectively communicate environmental aspects and impacts of production processes and materials used within print production supply chains among material suppliers, printers, print buyers, consumers and recyclers or re-users of printed materials. The typical elements considered include paper, board, plastic and composite substrates, printing inks and varnishes, printing plates, offset blankets and other print substrates, components and consumables used during prepress and press stages when creating printing formes, preparing press, printing and cleaning. Printing on textiles and ceramics is not included; also, print finishing, converting, or other post-print processing are out of scope. This document, as such, does not provide a labelling system but has been developed in harmony with the ISO 14020 series – Environmental labels and declarations.

The standard defines general principles and describes criteria and parameters for materials and consumables data collection, supplier requirements, print production and printing methods, suppliers and third-party services, record keeping and assessment, exclusions, chemicals and materials, emissions to air and water, energy management and recovery, carbon dioxide emissions in general and in terms of raw materials procurement and printing process, waste and recycle or reuse. Finally, it specifies requirements for the environmental statement. The annexes list environmentally hazardous substances to be communicated, high-risk environmentally hazardous substances, volatile organic compounds, examples of laws related to water pollution, waste regulations and sample statements.

ISO 23498:2022
Graphic technology – Visual opacity of printed white ink

The original edition of this standard applicable to printing opaque white ink was published three years ago, see also JPMTR Vol. 9, No. 3 (2020). The main change in this second edition is the corrected formula in its annex.

ISO 24585-1:2023 and ISO 24585-2:2023
Graphic technology – Multispectral imaging measurement and colorimetric computation for graphic arts and industrial application
Part 1: Parameters and measurement methods
Part 2: Requirements for decorative surfaces

This new series deals with multispectral image capture of surfaces with spatially varying colour, which is based on sampling a contiguous band of wavelengths across the visible range, in some cases extending into the infrared or ultraviolet, and reflects the restrictions of current multispectral imaging technologies in terms of the number of spectral image channels. The first two parts were published this year in July and September, respectively. Part 1 defines the requirements for the spatially resolved spectral measurement of reflecting flat objects, computation of colorimetric parameters and comparison of multispectral images, as well as derived tristimulus images. It does not cover transmitting or self-illuminating objects and prints on a metallic or interference foil. Part 2 specifies the corresponding experimental parameters relevant to decorative lamination and introduces the image similarity index. It is not applicable to functional surfaces.

Bookshelf

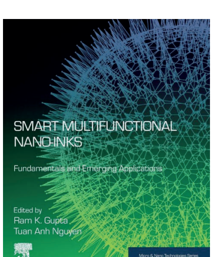
Smart Multifunctional Nano-inks
Fundamentals and Emerging Applications

This volume was contributed by over 70 experts from across the globe and covers the major types of nanomaterials used in smart inks for various applications in printed electronics and security printing. Also, it discusses the approaches based on theoretical modelling, optimised synthesis and suitable functionalisation, helping to address the issues of upscaling the production and properties of nano-inks towards their industrial use, as well as the open challenges.

The content consists of 27 chapters organised into six sections. In the first one, three chapters introduce the metal-based conductive nano-inks together with techniques for their synthesis and characterisation; the other three present aerosol-jet printing of a wide range of materials on 2D or 3D free-form substrates, 3D printing of 2D nano-inks and reactive inks, and the last chapter reviews the current knowledge on a toxicity and exposure assessment of metal, metal oxide and polymer nanoparticles.

The following parts deal with the nano-inks for the main application areas. For electronic industries, this includes the inks based on graphene, carbon nano-dots, metal oxides and solution-processed 2D nanomaterials from graphene and its derivatives to hexagonal boron nitride, black phosphorene, transition metal dichalcogenides and early-transition metal nitrides or carbides, i.e. MXenes. Regarding energy generation, the chapters cover the nano-inks for fuel and solar cells, including polymer-based inks and 3D-printable nanomaterials for flexible solar cell applications. For energy storage, the focus is on nano-ink formulations for printed supercapacitors, including polymeric inks and inks based on MXenes. Another area of interest is biomedical applications, presented in the fifth section. These include the nano-inks for tissue engineering, where nanocomposite inks are especially promising for producing complex biofunctional and stimuli-responsive environments. Also, the ink formulation for printed biosensors, mainly the optical and electrochemical ones, is discussed together with the key properties of printed layers and the performance of state-of-the-art devices. Further, one chapter reviews the emerging research on synthesis, stabilisation and studies of metallic nanostructures with unique optical properties for a range of possible applications, such as chemical and biological sensing, nonlinear optics, waveguiding, metamaterials and photothermal ablation of cancerous cells. Finally, 3D-printable nanocomposite biomaterials for bone scaffolds and grafts.

The last section is dedicated to the other applications of nano-inks. Besides one chapter dealing again with nano-inks basics and energy storage applications, the topics include novel photoactive inkjet-printable nanomaterials for solar water splitting, nano-inks for security and defence applications, and – last but not least – for food packaging.

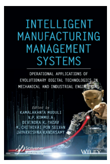


Editors: Ram K. Gupta, Tuan A. Nguyen

Publisher: Elsevier
1st ed., October 2022
ISBN: 978-0-323-91145-0
726 pages
Softcover
Available also as an eBook

Intelligent Manufacturing Management Systems
Operational Applications of Evolutionary Digital Technologies in Mechanical and Industrial Engineering

Editors: Kamalakanta Muduli, Venkata P. Kommula, Devendra K. Yadav, M. C. Pon Selvan, Jayakrishna Kandasamy

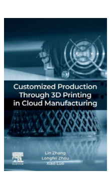


Publisher: Wiley-Scrivener
1st ed., May 2023
ISBN: 978-1119836247
400 pages
Hardcover
Also as an eBook

This book presents the approaches towards the fast and effective management, analysis and utilisation of vast amounts of a variety of data that can be collected by internet-based technologies using artificial intelligence solutions applicable in the industry. It covers the main aspects of smart manufacturing and available technologies and systems for smart design, machining, monitoring, control and scheduling, including automation, robots, 3D printing, industrial Internet of Things, smart vision-based sensing, augmented and virtual reality, digital twins, simulation, big-data analytics, cloud computing, deep learning, and other concepts. Besides opportunities, the book also identifies challenges, such as cyber-security issues, and discusses practical considerations for integrating digital technologies into operations and optimising their performance, with example case studies in different areas,

Customized Production Through 3D Printing in Cloud Manufacturing

Authors: Lin Zhang, Longfei Zhou, Luo Xiao



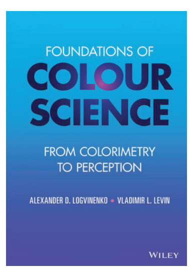
Publisher: Elsevier
1st ed., November 2022
ISBN: 978-0128235010
212 pages
Softcover
Also as an eBook

The Industry 4.0 framework made it possible to advance the idea of

Foundations of Colour Science
From Colorimetry to Perception

As explained by A. Logvinenko in the preface, “much of the book is devoted to various mathematical problems arising in colour science, and their solving”, which was motivated by realising the need to revise Grassmann’s laws and take into account the inherent fuzziness of human responses.

The book begins with the outline introducing the individual colour-related concepts and referring to the literature as well as the parts of the book where they are treated. The chapters dealing with light colour discuss the colour stimulus space and colour mechanisms, identification of Grassmann structures based on metameric matching, colour-signal cone, colour stimulus manifold, light metamerism and light metamer mismatching, light-colour perception, its typology and inter-individual differences, colour matching structures and matching metamerism, identification of Grassmann structures induced by colour matching structures, identification of indiscriminate relations, colour detection and discrimination, and colour mechanisms in the eye and the brain. The chapters in the next part are dedicated to object colour, covering the object-colour solid including the trichromatic regular one, object-colour stimulus manifold, object-colour perception in a single-illuminant scene with object metamer mismatching, object-colour perception in a multiple-illuminant scene and object-colour indeterminacy. The last chapter before the epilogue outlines an alternative approach to perception.



Authors: Alexander D. Logvinenko, Vladimir L. Levin

Publisher: Wiley
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ISBN: 978-1-119-88591-7
560 pages
Hardcover
Available also as an eBook

Digital Textile Printing
Science, Technology and Markets

This new volume in The Textile Institute Book Series is dedicated to digital textile printing, which is seen as a key technology for the development of the world’s textile printing and dyeing industry thanks to its significant benefits in terms of process speed and simplicity, design possibilities and personalisation, at the same time reducing costs and waste. All of that fosters innovations in production methods and business models. The book intends to bring an up-to-date overview of all related aspects. It covers digital printing technology, mechanisms and materials, digital textile printing machines,

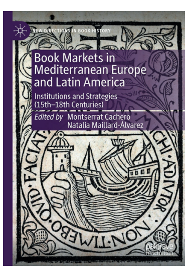
Editors: Hua Wang, Hafeezullah Memon

Publisher: Woodhead Publishing
1st ed., June 2023
ISBN: 978-0-443-15414-0
306 pages
Softcover
Available also as an eBook

colour management, management and software for textiles, digital image design and printing, developments in pretreatment processes for various types of fabrics, including the low-temperature plasma surface modification, and classes and properties of colourants and inks. Further, it discusses the technological barriers to digital printing in textiles, quality of digital textile printing, Western market overview and emerging market trends, digital textile printing innovations and the future outlook.

Book Markets in Mediterranean Europe and Latin America
Institutions and Strategies (15th–18th Centuries)

Part of the New Directions in Book History series, this book explores how books were produced, distributed and controlled in the two geographical areas that were strongly connected in the given period. The topic is treated from economic and cultural perspectives, drawing on religious, commercial and legal archive documents, including notary and court records. The text discusses the circulation of books, the role of book privileges in trade protection and promotion as well as content regulation, the use of publishing revenues by hospitals and orphanages across the Spanish Empire, the printing privilege of calendars in Castile, the Giunta publishers serving both Catholic and academic institutions, global networks in the Atlantic book market, the role of booksellers in knowledge circulation within the Portuguese Empire, publication and distribution of liturgical books in Spain, the struggles for influence between the Roman Catholic Church and the Ecumenical Patriarchate, and the regional differences in inquisitorial book control.



Editors: Montserrat Cachero, Natalia Maillard-Álvarez

Publisher: Palgrave Macmillan
1^{st} ed., January 2023
ISBN: 978-3-031-13267-4
268 pages
Hardcover
Available also as an eBook

Perspective Warps and Distorts with Adobe Tools
Volume 1: Putting a New Twist on Photoshop
Volume 2: Putting a New Twist on Illustrator

These two volumes present and explain the traditional as well as recently added advanced tools and filters available in Adobe Photoshop and Illustrator. The author demonstrates their use for correcting or creating distortion and other effects in raster images, text and vector graphics, including smart objects, content-aware scaling, 3D non-destructive effects and more.

Author: Jennifer Harder

Publisher: Apress
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1 042 & 1 131 pages, 1 631 & 1 790 images
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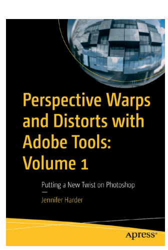
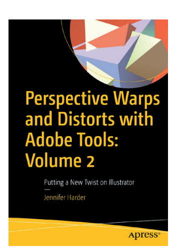




cost-effective customisation enabled by 3D printing and cloud solutions beyond small-scale studies. In this book, the authors share experience and insight in this field gained during the research and development of the cloud manufacturing platform. They present the advances in cloud manufacturing, the cloud 3D printing platform architecture, 3D model design methods, considerations for remote access to 3D printers and 3D printing process monitoring. Further, they discuss credibility evaluation, supply-demand matching, task scheduling, effective process management, security and privacy.

The Package Design Book
Volume 2

Editor: Julius Wiedemann

Publisher: Taschen
1^{st} ed., March 2023
ISBN: 978-3836590990
640 pages
Hardcover

As a highly competitive area, packaging design naturally exploits all kinds of innovative technologies. Since 2007, the excellent works have been recognised in a global Pentawards annual competition. This volume presents its winners from the past decade (the first one compiled Pentawards winners from 2008 to 2016), helping to track the evolution in the field, including new materials and emphasis on sustainability.

Logo Beginnings

Author: Jens Müller

Publisher: Taschen
1^{st} ed., January 2022
ISBN: 978-3836582285
432 pages
Hardcover

Complementing his Logo Modernism from 2015, J. Müller in this book explores and illustrates the origins of logo design based on archival materials from 1870 to 1940.

Recent Advances in Smart Self-Healing Polymers and Composites

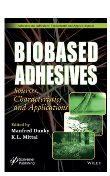
Editors: Guoqiang Li, Xiaming Feng

Publisher:
Woodhead Publishing
2nd ed., June 2022
ISBN: 978-0128234723
528 pages, Softcover
Also as an eBook

The second edition of this volume was revised and expanded to reflect the progress and new developments in the area of self-healing materials since its original publication in 2015, including their 3D and 4D printing. It brings an overview of crack self-healing, healing efficiency evaluation and modelling, the solid-state healing of polymer resins and composites and self-healing based on capsules, microvascular systems, reversible chemical bonds and supramolecular networks. Further, it describes self-healing coatings and elastomers, self-healing composites based on shape memory polymers or with embedded shape memory polymer fibres and polymeric artificial muscle wires. Finally, the book deals with additive manufacturing of self-healing materials and recyclable multifunctional thermoset polymers with self-healing ability.

Biobased Adhesives Sources, Characteristics, and Applications

Editors: Manfred Dunky, K. L. Mittal



Publisher:
Wiley-Scrivener
1st ed., May 2023
ISBN: 978-1394174638
768 pages, Hardcover
Also as an eBook

This new volume presents a comprehensive reference of biobased adhesives, reflecting their growing importance and use. The content is organised into three parts; the first deals with fundamental aspects of adhesives based on natural resources, and the other two detail their classes and a wide range of applications.

Solution-Processed Organic Light-Emitting Devices

This new book reviews the state-of-the-art technologies for low-cost, large-area organic light-emitting devices. It presents and compares the solution-processable materials and promising technologies for their deposition, as well as the related challenges and their possible solutions. After introducing the fundamental background in terms of luminescent materials, device structures, working principles and manufacturing technologies, four chapters deal with the fabrication of organic light-emitting devices by spin-coating, roll-to-roll processing using various printing and coating technologies, inkjet printing, including a description of phosphorescent and thermally activated delayed fluorescent materials and industrial research progress, and a novel approach based on transfer printing, which significantly reduces the demands on materials and device design. The next chapter is dedicated to organic electrodes, including interfacial engineering approaches to achieve desirable properties. Then, six chapters review solution-processable hole-transporting, electron-transporting, host and light-emitting materials, where oligonuclear complex emitters, dendrimeric emitters and polymeric emitters are detailed. Further, electropolymerised organic light-emitting diodes and solution-processable organic lasers are presented. The last chapter concludes with emerging solution processes and an outlook.

Editor: Guohua Xie

Publisher: Woodhead Publishing
1st ed., August 2023
ISBN: 978-0-323-95146-3
570 pages
Softcover
Available also as an eBook

Printable Mesoscopic Perovskite Solar Cells

Contributed by leading scholars in the field, this new book provides a comprehensive insight into the current knowledge of printable mesoscopic perovskite solar cells. The opening chapter introduces the principle and typical structures of perovskite solar cells. The following two describe the methods and technologies used for characterising halide perovskite materials and devices and their solution-based processing, including various coating and printing technologies. Then, three chapters deal with mesoscopic anodes and cathodes, insulating layers and perovskite materials, particularly their types, synthesis and engineering. The remaining four chapters discuss the efficiency progress in printable mesoscopic perovskite solar cells, stability issues and solutions, considerations for manufacture and module design, example applications and strategies towards commercialisation.

Editors: Hongwei Han, Michael Grätzel, Anyi Mei, Yue Hu

Publisher: Wiley-VCH
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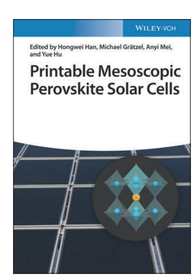
304 pages
Hardcover
Available also as an eBook



Bookshelf

Academic dissertations

Image-Based Rendering of Real Environments for Virtual Reality

This thesis contributes to developing approaches providing immersive virtual reality experiences in 360° real-world environments beyond omnidirectional stereo solutions, which can find use in various applications. The main focus was on 3D photographs, i.e. image-based scene representations with translational action spaces. The work presents novel end-to-end image-based rendering pipelines and an enhanced neural method. Input for all methods can be captured with a hand-held camera, and the time to visual feedback is short.

The introduction defines the scope and the terms virtual reality, degrees of freedom and 3D photography as used in the context of the work. The extensive second chapter provides relevant background and explains the related concepts. It specifies the assumptions made and covers the coordinate systems, pinhole camera model, camera pairs, 3D scene reconstruction and image-based rendering, including the methods utilising machine learning. Also, it reviews the research on real-world virtual reality and compares the published methods. Then, four chapters present and discuss the individual proposed approaches. The one producing depth-augmented stereo panoramas from the omnidirectional stereo panorama pair (ODS2DASP) comprises capturing the input images for reconstructing a point cloud through triangulation of the corresponding features in them and then representing and rendering the scene geometry. In the case of MegaParallax, i.e. the casual 360° panoramas with motion parallax, preprocessing of the captured video includes reconstructing camera geometry, registering cameras to the trajectory, sampling and computing bidirectional optical flow between neighbouring viewpoints. For rendering, novel-view synthesis from two cameras is described. The OmniPhotos pipeline differs by beginning with the casual capture of 360° photographs and reconstructing a scene-adaptive deformable proxy fitting alleviating vertical distortion. Finally, the extensions improving the quality of extrapolated viewpoints when using the deferred neural rendering (DNR4VE) are presented.

Doctoral thesis – Summary

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Computer Science

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Degree conferral:
14 February 2022, University of Bath, Department of Computer Science Bath, United Kingdom

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Further reading:
EThOS ID: uk.bl.ethos.852336
https://github.com/cr333/OmniPhotos

Method for Analyzing Droplet Positioning in Inkjet Printing

The aim of this thesis was to increase the inkjet print quality and its consistency by reducing the number of visible defects by analysing and controlling droplet placement with a considerably increased frequency of measurement and thus reduced waste. The approach employs small test patterns, a camera-based inspection system and a simulation model of image acquisition to enable inspection of all print nozzles during production printing without the need for special sorting in the post-processing stage. In addition to colour printing, the inspection of transparent primer is possible as well.

First, the dissertation describes the fundamentals of inkjet technology, industrial cameras and their use in inspection systems, including an overview of commercially available systems, their implementation in printing machines and the characteristics evaluated from special test patterns. Further, the limitations of current systems are identified. One chapter details the experimental setups, materials and methods. The following four chapters present the main areas of the work. For the developed simulation model,

Doctoral thesis – Summary

Author:
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Speciality field:
Printing Science and Imaging Technology

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Edgar Dörsam

Defended:
8 February 2023, Technical University of Darmstadt, Department of Mechanical Engineering, Institute of Printing Science and Technology Darmstadt, Germany

Language:
German

Original title:
Methode zur Analyse der Tropfenpositionierung im Inkjet-Druck

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the text discusses its process components, which include the object, lighting, optical imaging system and discretisation in the image sensor. Also, it deals with the measurement of the point spread function, reproduction of functional curves and verification of the simulation model by comparing simulated and captured images after adapting the simulation model to the camera system. The transferability of the simulation model to cameras and optics with different parameters is examined as well. The chapter dedicated to measuring drop positioning during printing describes the development of a reference sample for 1200 dpi, avoidance of interaction between rows of nozzles, line pattern for the area outside the trim and experiments on line shapes as well as monochromatic and multicoloured patterns. The next chapter focuses on detecting nozzle failure when applying the colourless primer material and using the same setup, which is possible by producing multi-layer test print samples. Finally, the duration between the occurrence and compensation of position errors is examined, and the trend of the position offset of lines is analysed to stabilise the compensation behaviour.

Further reading:
DOI: 10.26083/tuprints-00023438

Doctoral thesis – Summary

Printed and Templated 3D MXene Structures for Energy Storage Applications

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Defended:
8 March 2023, Trinity College Dublin, School of Chemistry Dublin, Ireland

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This thesis deals with MXenes, materials consisting of an early-transition metal (M) and carbon and/or nitrogen (X) with the general formula of $M_{n+1}X_n$. These materials are interesting thanks to their 2D layered atomic structure and many favourable electrical and physical properties. In particular, the work advances the recent research on 2D $Ti_3C_2T_x$, and its application in supercapacitors. The focus was on two main aspects: enhancing the method of $Ti_3C_2T_x$ preparation and proposing methods for creating hierarchically structured 3D electrodes to achieve optimised performance for both micro- and macroscale electrodes.

After briefly introducing nanomaterials, MXenes, their precursors, preparation and properties, and energy storage devices, the dissertation defines the objectives and describes the techniques used for deposition and characterisation. These include additive manufacturing, aerosol-jet printing, critical point drying, electron microscopy, methods for spectroscopic characterisation, X-ray diffraction, electrochemical characterisation, and four-point probe measurements. For MXene synthesis, characterisation, and ink preparation, the text describes the synthesis and size selection of $Ti_3C_2T_x$ using the minimally intensive layer delamination (MILD) method where Ti_3AlC_2 MAX phase is etched using LiF and HCl. Physical characterisation of as-synthesised $Ti_3C_2T_x$ dispersions and films confirmed the high quality of the prepared MXene material, and yield and conductivity were improved by freeze–thaw assisted delamination. This procedure, at first employed due to time restrictions during the pandemic, increased the mass of MXene flakes obtained by approx. 42 % and also significantly improved the average diameter and conductivity of nanosheets compared to the conventionally delaminated material. To produce 3D MXene structures for micro-supercapacitors, the work employed aerosol-jet printing. The text presents the successful printing of binder-free, aqueous MXene inks to fabricate a variety of 3D structures with a high aspect ratio to increase the areal capacitance of electrodes. Finally, templated MXene thin-film 3D networks enabled the fabrication of macroscopic electrodes with improved characteristics. The templating process allowed the preparation of freestanding, thin-film MXene microtube networks with tuneable structure – on the nanoscale for high-rate areal capacitance and by compression on the microscale for high-rate volumetric capacitance – and the optimisation of electrochemical performance of the resulting electrodes.

Further reading:
http://hdl.handle.net/2262/102697

Events

Printistanbul 2023
4th International Printing Technology Symposium

Istanbul, Turkey
5–6 October 2023

In 2023, this symposium, which is otherwise held biennially, takes place after four years. The opening keynote session features four invited speakers: Nadège Reverdy-Bruas on 'Sustainable printed and integrated electronics: from laboratory to training', Raša Urbas, the former JPMTR Associate Editor, presenting 'Beyond seeing: enhancing graphic technology with sensory inclusion', Zuzanna Żołek-Tryznowska on 'Novel, biodegradable, and green packaging materials' and Jalel Labidi on 'Advancement in biobased smart packaging'.

Most contributions in the following sessions deal with technology and materials, such as those with special composition, coating or other substrate treatments, their printability by different techniques, evaluation of resulting print quality and fastness, e.g. studies on rub resistance on papers produced with alternative fibre sources and photodegradation of thermochromic UV curable prints, recycling, biodegradability and waste treatment considerations, and more. Other topics include, for example, new opportunities using artificial intelligence and machine learning in the graphic arts sector, face processing techniques, evaluation of blind embossing quality based on image processing, and the role of typography in social media.

American Printing History Association's 48th Annual Conference

Austin, Texas, USA
12–14 October 2023

This annual event is organised for the first time as a hybrid conference to offer the attendees the opportunity to access all keynote speakers and presentations live online. Those attending in person can join the pre-conference tours of local art centres, libraries and cultural institutions, including the exhibit 'The Long Lives of Very Old Books' presenting books published by Europeans between the mid-15th and late-17th centuries and tracing their stories, with more than 150 volumes on display.

The theme for this year is 'The Printed Weird: Book History from the Margins'. The programme begins with the keynote by Sarah Horowitz, presenting the creation of her 'Baba Yaga' artist's book. The papers presented in the following two days explore, among others, unusual loose type in the margins of 'Orthographiae ratio' (Aldus Manutius, 1564) published by Christophe Plantin, the use of printers' ornaments in 18th-century Spanish plays, over a hundred years of collecting ephemera at the Newberry Library in Chicago, Art-Nouveau types used as text types, typographical humour of Henry Morris, a fine press printer, and creative use of page creep and page bleed. The closing keynote by Michael Winship draws on research examining the production of the first edition of 'Leaves of Grass' (Walt Whitman, 1855).

FTA's Fall Conference 2023

Louisville, Kentucky, USA
9–11 October 2023

This year, over twenty presentations aim to show "how to do more with less" when developing the workforce at all levels, implementing expanded gamut printing, and understanding all production steps.

Paper & Plastics Recycling Conference

Chicago, Illinois, USA
11–12 October 2023

The topics discussed this year include e.g. recovered paper in developing Asia, the outlook for transportation, the effect of new legislation on the supply of and demand for recycled materials, and foodservice packaging success stories. The European edition takes place on 7–8 November in Barcelona, Spain.

WAN-IFRA Events

The main upcoming 2023 events include the World Printers Summit (Frankfurt, Germany, 11–13 October) and two Digital Media editions: for Asia in Singapore (19–20 October) and for the Middle East in Riyadh, Saudi Arabia (8–9 November).

PRINTING United Expo 2023

Atlanta, Georgia, USA
18–20 October 2023

Besides printing technologies and applications, this show offers training zones, keynotes, and several co-located events.

ERA International Gravure Days

Oberdorf, Switzerland
18–20 October 2023

The topics of the conference held on the second day of this event include energy consumption across the entire process chain when comparing solvent- and water-based inks for printing flexible packaging, artificial intelligence in prepress, performance-based decision-making for printers and brand owners, and others.

3rd International Circular Packaging Conference

Ljubljana, Slovenia
19–20 October 2023

The keynote speakers announced for this edition are Maja Desgrées du Loû, introducing a proposal for the EU packaging and packaging waste regulation, Ulrich Leberle, identifying its critical aspects for the pulp and paper industry, Julien Bras, presenting high-performance cellulose-based materials for sustainable packaging, and Nadia Lotti, discussing furan-based polymers as an alternative to non-recyclable multilayer packaging.

Wolfram Virtual Technology Conference

https://www.wolfram.com
1–3 November 2023

Among a wide range of topics, the attendees can learn about the Wolfram plugin for ChatGPT.

Print Next 2023

Stockholm, Sweden
30 November 2023

The topics for this edition include e.g. robotisation, the benefits of artificial intelligence to marketing and sales, and essential standards.

RadTech Europe 2023

Munich, Germany
17–18 October 2023

Traditionally, the European edition of this event offers two days focused on ultraviolet and electron-beam (UV/EB) curing. The opening plenary session features an EU-market overview, the awards ceremony and a keynote on future energy systems. The following conference talks fill three parallel tracks. Their topics include, among others, new process technology for advanced adhesives, thermal frontal polymerisation of epoxides, cationic ring-opening polymerisation for 3D printing of degradable polyether-esters, printing recyclable packaging using EB-curable inks, new materials, such as reactive flame retardants, disulfide-containing monomers, photo-bleachable photoinitiator for deep free-radical photopoplymerisation and silicones for sustainable release coatings, advances in radiation sources and measurement methods, and regulation requirements. On the first day, the programme is complemented education sessions introducing the history, market, value chain, applications, end products, raw materials, radiation curing chemistry, formulation, curing equipment and conditions.

CIC31 – 31st Color and Imaging Conference

Paris, France
13–17 November 2023

Keeping the usual format, the first two days of this event are reserved for short courses and workshops, including the Appamat/IS&T International workshop on material appearance, co-located on 13 November. New courses deal with colour capture in scattering media, colour naming, material appearance measurement and characterisation, colour rendition in LED lighting and colour image analysis with deep learning. This year's conference programme features the keynotes 'Mastering light: reproduction, reality, and augmentation' by Michael J. Murdoch, 'On evaluating skin color user preferences for smartphone photography' by Sira Ferradans, and 'Colour science vs. colour engineering in high-end motion picture' by Daniele Siragusano. The papers presented in technical sessions deal, for example, with grey balance in cross-media reproductions, colour reproduction technique based on deep learning using a database of colour-converted images, and an appearance reproduction framework for printed 3D surfaces, to name a few.

Industrial Print Integration Conference 2023

Neuss, Germany
28–29 November 2023

The programme for the second edition of this event consists of three tracks each day. It features the keynotes on 'Advanced printed electronics in mass production of printed security features' by Philip Renners, 'The EU Green Deal & Chemicals Strategy for Sustainability: predicting the impact on the industrial printing sector' by Trevor Fielding, 'Scalable manufacturing process of perovskite solar cells by inkjet printing' by Barbara Wilk and the fourth one to be announced.

Journal of Print and Media Technology Research
A PEER-REVIEWED QUARTERLY

ISSN 2414-6250 (Online)
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Call for papers

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- **Premedia technology and processes**
  Colour reproduction and colour management; Image and reproduction quality; Image carriers (physical and virtual); Workflow and management

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Vol. 13, 2024

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B – Structure of the manuscript

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Title: Should be concise and unambiguous, and must reflect the contents of the article. Information given in the title does not need to be repeated in the abstract (as they are always published jointly), although some overlap is unavoidable.

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Introduction and background: Explain why it was necessary to carry out the research and the specific research question(s) you will answer. Start from more general issues and gradually focus on your research question(s). Describe relevant earlier research in the area and how your work is related to this.

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3-2023

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