**11th International Research/Expert Conference**
**"Trends in the Development of Machinery and Associated Technology"**
**TMT 2007, Hammamet, Tunisia, 5-9 September, 2007**

# NEURAL NETWORK APPLICATION FEASIBILITY IN GRAPHIC REPRODUCTION PROCESSES

**Damir Modrić, PhD Diana Milčić, PhD Dubravko Banić, PhD**
**Faculty of Graphic Arts**
**Getaldićeva 2, Zagereb**
**Croatia**

## ABSTRACT
*Complexity of graphics reproductions processes and their numerous parameters demands sophisticated approach. We present brief look of possibilities of neural network as a generation tool for solutions in wide aspect of complex problems which emerge in processes of graphics reproduction. Optimization of certain processes such as paper production, recycling or printing due to their complexness and mutual dependence of numerous parameters and fine interaction effects is ideal field for neural network application. This method can be powerful tool for mathematical solution demands on problem concerning quality monitoring and validation in graphical reproduction processes.*
**Keywords:** graphic reproduction, neutral network

## 1. INTRODACTION

In electronic and printing manufacturing, it is common to assure the quality of the final product by implementing time-consuming and expensive tests of final product. Integrated quality test strategies are becoming more important due to the multiple complex production steps and interactions in printing production and the presence of many parameters that affect the final quality of the products. The objective of our work is to see whether the application of methods such as generic algorithms and neural networks is effective approach strategy to the complex problem of printing machine spectral modeling. For better reproduction color images is essential to know spectral response of our printing machine. In our experiments on electrophtographic digital printing machine we treat this machine as RGB device where we include in our model machine driver operation. To test our characterization methods we consider different kinds of substrate (paper) and screen techniques.

The spectral based characterization of inkjet printing machine requires a mathematical description of the printing process, by means of modulated transfer function modified for conversion between digital counts and reflectance spectra. Most proposed methods are based on Neugebauer equation which is crucial equation in neural network theory [1].

Neugebauer model alone can not foresee the reflectance spectrum of a printed color with enough accuracy while it accounts not effects of interaction of ink with substrate as well interaction among inks alone. Many authors have suggested mathematical treatment of mechanical and optical dot-gain [2], [3], [4] to determine how ink deposition sequence determines final reflection spectra. Here printing machine drivers play significant role.

We intend to generate plausible description of light transfer in substrate and applied layers of ink with aid of generic algorithms and neural network approach to estimate final reflection spectra. According to our previous printing experience we were forced to pay attention on inks sequence during test printing. With this approach we expect to improve printing process of colored images.

## 2. THEORETICAL BACKGROUND

Today's measuring equipment is able to generate vast volumes of data for identification of machine process quality parameters, but most of this information is currently depreciated on the manufacturing level. Due to the fact that every process can be characterized by numerous (up to dozen) parameters it is not easy to analyze all this parameters and its possible correlations. Applying neural networks technique, many parameters can be compared, and a process model can be generated, even when using "raw" unfiltered process data. We designed different test scenarios by means of the machine-learning algorithm to identify the best-fit reference machine model, in terms of their prediction accuracy, identified model parameters, and model structure.

The light scattering within the paper substrate on which some image is printed, is a very complex process. Yule and Nielsen have stated that the optical dot gain can be well approximated by introducing the empirical factor n, in so called Murray-Davis's [5] equation, although the physical connotation of factor n was not clear. Somewhat acceptable physical explanation of the factor n is given by Ruchdeschel and Hauser in 1978 in their work. They show that the expression $1 \le n \le 2$ is valid if only the optical dot gain is involved. The values n = 1 and 2 represent two extremes for light scattering, n = 1 corresponds to the case when there is no scattering and n = 2 corresponds to the total scattering. The original intention of Yule – Nielsen's model was the including the optical dot gain. However, frequently the same model is applied in cases when the physical dot gain is also included. Unfortunately such attempts give the factor n greater than 2 (sometimes considerably greater than 2) [6]. The physical explanation of the factor n still eludes. The detailed studies of that problem are given in the work of V. Džimbeg Malčić (2005)). Arney J.S. [7] and Hübler A.C. [8] independently suggest in their works similar models based on the statistical description of light scattering.

One of general methods for solving optimization problems are genetic algorithms. Essential idea, governing genetic algorithm, is that every candidate solution for the optimization problem is represented by a sequence of binary, integer, real (complex) values, called individual. A small number n of individuals (with respect to the entire solution space) is randomly generated as an initial solution population *P*. Genetic algorithm iterates procedure which generate new population *P'* from initial population *P* until some criteria is satisfied.

The main advantages of using the genetic approach are that it allows managing simultaneously many parameters, while disadvantages are that it cannot guarantee an optimal solution.

The model of our printing machine is based on the well-known Yule-Nielsen Spectral Neugebauer equation. According to this model spectrum of N-inks halftone print is weighted sum of $2^N$ different colors, given by all possible ink overprints. The weight of every color is the area that this color covers in halftone cell and above mention model for 4-ink halftone model is:

$$R_{print,k} = \left[ \sum_{i=0}^{15} a_i R_{i,k}^{\frac{1}{n}} \right]^n \qquad k = 1 \ldots 8 \qquad (1)$$

Where: $R_{print,k}$ is the reflectance of the printed final color,

$n$ is Yule-Nielsen factor,

$R_{i,k}$ is the reflectance of k-th color,

$a_i$ is the area coverage percentage for k-th color

Reflectance spectra of printed and unprinted samples will be spectrophotometricaly sampled in range from 410 nm to 700 nm in intervals of 10 nm by means of X-Rite spcttrophotometer with software support of Color Shop 2.0.

For printing of test form we employ electrophtographic digital machine Indigo Turbo Stream 1000+ with prior calibration. Indigo Turbo Stream 1000+ is standard 4-color printing machine with printing speed of 60cm/s and resolution 812 dpi.

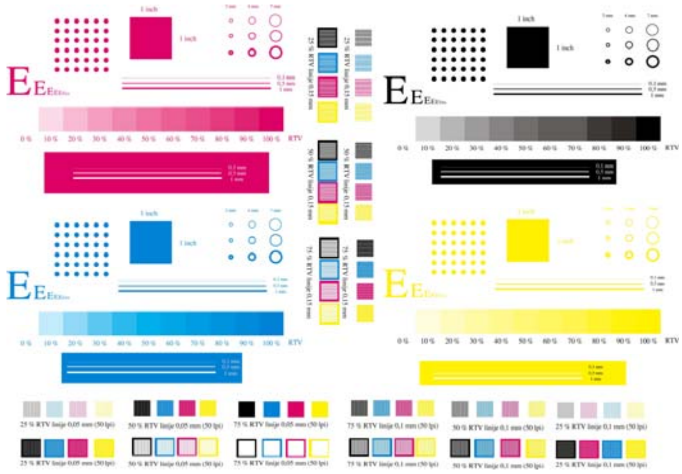

*Figure 1: Test form used in our preliminary investigations*

## 3. APPLICATION FEASIBILITY

Our aim was to present a phenomenological approach to neural modeling and control of the offset printing process. A group of neural networks should be trained to measure the printing process output (observable variables). From only one measurement the trained group should be capable of estimating the actual relative amount of each cyan, magenta, yellow, and black inks dispersed on paper in the measuring area to obtain better modeling of final reflection spectra with monitoring the order of their application. Some printing processes are poor at representing low saturation (yellow), low intensity colors and there were made efforts to expand color gamut of printing processes by increasing the amount of applied color. Some digital printing machines have already implanted software compensation for such problem. Acquired results are further used by a neural model predictive control unit for generating control signals to compensate for color deviation in offset newspaper printing or to suggest optimum printing ink sequence. Preliminary experimental analysis has shown that the system achieves higher printing process control accuracy than that usually obtained by the press operator.

## 4. CONCLUSION

In this work we reveal possibilities to improve printing process control and generate novel approach to spectral characterization of our printing machine. Our aspiration was to see if it is feasible to advance in improvement of our quality control as well as quality of final product by means of applying neural networks. If it is so, using proposed representation we would be able to characterize printing machine with less parameters and time consuming. Starting point of our investigation is Yule Nielsen Neugebauer equation with related mathematical framework. Preliminary results indicate that this characterization is possible although we deal with numerous parameters which we attempt to overcome by applying of neural networks.

Our wish is to examine the correlations between different ways of print standardizing on rotations, different print qualities on different rotations with given specific terms and then correlate that system of quality monitoring with the construction and quality and the life span of the rotation itself. It is expected that on the basis of the carried research data models will be obtained that will enable quality growth in graphic products by adjusting singular most influential parameters which would in the end enable an optimum effect of the whole graphic reproduction process.

It is our wish to develop algorithms with clear, predictable performances which can be used for a broad spectrum of problems and real models, and which will permanently be examined in a real environment.

Due to the tendency of continuing improvement and advancement of quality, the importance of the research can be seen in strive to standardize the process since quality is achieved by removing the variations in the process.

It means that the process standardization will be conducted by the implementation of the determined results, but all the results will also be evaluated from ecological aspects.

## 5. REFERENCES


[1] D. R. Wyble, R. S. Berns, A Critical Review of Spectral Models Applied to Binary Color Printing, Color Research and Application, **25**, 1, (2000).

[2] P.Emmel, *Modéles de prédiction couleur appliqués é l'impression jet d'encre*, 1998, THÉSE No 1857, École Polytechnique Fédérale de Lausanne

[3] Emmel P. and Hersch R.D., *Towards a color prediction model for printed patches*, IEEE Comp. Graphics and Appl. **19** (1999), 54–60.

[4] Yule J.A.C. and Nielsen W.J., *The penetration of light into paper and its effect on halftone reproduction*, Tech. Assoc. Graphic Proc. **3** (1951), 65–67.

[5] Murray A., *Monochrome reproduction in photoengraving*, J. Franklin Institute (Philadelphia) **221** (1936), 721

[6] Džimbeg Malčić V., PhD Thesis, (2005)

[7] Arney J.S., *A probability description of the Yule-Nielsen effect, I*, J. Imaging Sci. Technol. **41** (1997), 633–636.

[8] Hübler A.C., *The optical behaviour of screened images on paper with horizontal light diffusion*, Proc. Is&T's NIP13 Conf., pp. 506-509, Nov. 1997, Seattle, Washington.