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Estimation of Screen Density According to Different Screening Methods With Artificial Neural Network Method in Flexo Printing System

Araştırma Makalesi / Research Article

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ABSTRACT

Choice of dot shape is the most important factors that affect the printing quality in the flexographic printing system. The aim of the operations performed by the machine operator during the printing process (densitometric measurements, ink settings, etc.) is to achieve the same quality from the first printing to last printing. This study attempts to estimate screen density values obtained from the same polymer structure (DFR), 175 Lpi screening and 10 different screen structures using the Artificial Neural Networks method (ANN). Data necessary for calculations were obtained from real values as a result of experimental studies. The correlation coefficient of the data obtained from the model created with ANN for screen density values was found to be 98,902% and this value was found to be consistent with scientific values. According to the results, the neural network model used in flexographic printing systems of different screening methods predictable effect on the printing result.

Keywords: Packaging, flexo printing, screening methods, flexo plate, artificial neural networks.

Flekso Baskı Sisteminde Farklı Tramlama Yöntemlerine Göre Tram Yoğunluğunun Yapay Sinir Ağı Yöntemi ile Tahmini

ÖZ

Tram türü, flekso baskı sisteminde baskı kalitesini etkileyen en önemli faktördür. Makine operatörü tarafından baskı işlemi sırasında yapılan işlemlerin (yoğunluk ölçümü, mürekkep ayarları, vb.) amacı, ilk baskıdan son baskıya kadar aynı kaliteyi sağlamaktır. Bu çalışmada, aynı polimer yapısına sahip (DFR) 175 Lpi tram sıklığında, 10 farklı tramlama yapısından elde edilen tram yoğunluğu değerleri Yapay Sinir Ağları Yöntemi (ANN) kullanılarak tahmin edilmiştir. Deneysel çalışmalar sonucunda hesaplamalar için gerekli olan değerler; tram noktalarının densitometrik ölçümlerinden elde edilmiştir. Tram yoğunluğu değerleri için YSA ile oluşturulan modelden elde edilen verilerin korelasyon katsayısı %98,902 olarak bulunmuştur ve bu değer bilimsel değerlerle uyumlu bulunmuştur. Çıkan sonuçlara göre, YSA modelinde flekso baskı sisteminde kullanılan farklı tramlama yöntemlerinin baskı sonucuna etkisi önceden tahmin edilebilir.

Anahtar Kelimeler: Ambalaj, flekso baskı, tramlama yöntemi, flekso kalıbı, yapay sinir ağları

1. INTRODUCTION

Flexo printing system is a branch of the relief printing system. It is a printing system which relies on transferring inked images on high areas on the surface of the printing plate to the printing material with the help of pressure [1]. Plates used in flexo printing systems are polymer-based. Printing areas of plates used in the flexo printing method are positioned higher and non-printing areas are positioned lower. Flexo printing system is mostly used for packaging and label printing.

Ink consumption is one of the factors affected by the screen structure. It is possible to reduce the ink consumption by printing the same image with lower ink density, which means using less ink for the same operation. Using less ink has ecological benefits as well.

Among the most significant elements that affect the quality of printing in Flexo printing systems are selection of plate and screen [2]. Before starting the print, the plate is prepared, a test printing called "fingerprinting" is done to characterize the features of the printing for once only. Necessary adjustments in plate preparation are done in accordance with the results of this process and the plates are prepared, which means interpreting each printing variable and preparing optimal plates. To know how printing variables affect the printing process will prevent unnecessary fingerprinting and enable the preparation of plates with the correct features at a time. Plates which

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preferred for packing printing industry using Flexographic printing, by employing different screening methods in ESKO CDI Spark 4835. These screening methods are Circular, Concentric, Eliptical, HD 29px, Helio, Monet, Round FOGRA, Rugby, Samba, and Square, which are commonly used as screening methods. The values obtained from the experimental results, screening density applied to the model was estimated by using artificial neural networks[3].

This study attempts to estimate screen density values obtained from the DFR plate, 150Lpi and 175 Lpi screening and different screen structures using the Artificial Neural Networks method (ANN). The values necessary for calculations were obtained by printing on Duncote 3 Brand 75g/m^2 coated paper with Harper QD Proofing system test printing machine in the Paper Engineering Department of Western Michigan University and measurements were performed with X-rite Exact NGH spectrophotometer. The correlation coefficient of the data obtained from the model created with ANN for screen density values was found to be 98,902% and this value was found to be consistent with scientific values. It was found that the ANN model created in the study produced accurate results.

2. MATERIAL and METHOD

2.1. Materials

2.1.1. Test Page

Different Screenings to be printed were identified. Plate image to be used in the printing was formed. 1%, 2%, 3%, 4%, 5%, 10%, 20%, 30% (to see sub-tone values) 40%, 50%, 60% (to see mid-tone values) 70%, 80%, 90%, (to see top-tone values) bottom printing control strip was formed using Adobe In Design program. In order to obtain complete printing values. Bottom printing control strip were added in the side. The test scale was exposed on 1,14mm-thick Dupont CyrelFast digital plates (DFR) and the plates were prepared.

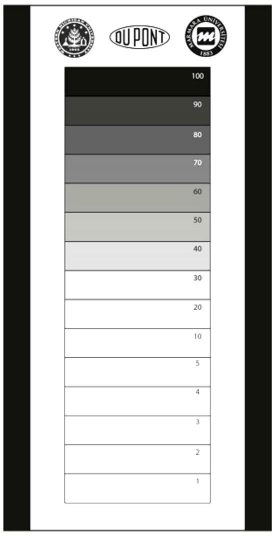

Figure 1. Printed test printing image

Duncote 3 brand 75g/m^2 coated paper was used as substrate. In the Flexo printing technique, various printing plates and ink formulations can be used depending on printed material and production technique. Water-based, solvent-based, UV-cured and electron beam-cured inks are available. In this study, a water-based ink was used, as it is ecological and its printing base is paper [4]. The main components of Flexo inks are colorant, binder and solvent. Diverse adducts can also be used for operation of printing and printability.

Screening methods were selected as Circular, Concentric, Eliptical, HD 29px, Helio, Monet, Round FOGRA, Rugby, Samba, and Square, which are commonly used screening types (Figure 2).

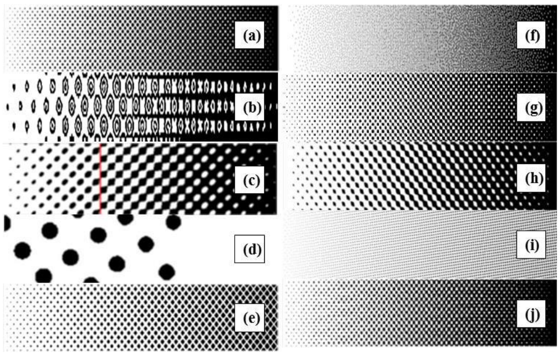

Figure 2. Screening types (a) Circular, (b) Concentric, (c) Eliptical, (d) HD 29px, (e) Helio, (f) Monet, (g) Round FOGRA, (h) Rugby, (i) Samba, (j) Square [5].

Figure 2 shows the shapes of the screen structures used in the study. In prints where details are important, screen structures with superior highlight and mid-tones are preferred. In prints where details are not significant, screen structures with better shadow are preferred. Toning is one of the important factors determining the quality of the print image.

2.1.2 Plate

Digital and analog plates are prepared by different methods. One type of plate used was manufactured by DuPont. Firstly, DupontDFR is the high durometer [6] plate for the DuPont FAST thermal platemaking process, designed to meet the needs of high quality flexo with finest halftones, linework and solids [7-8].

Plate is selected, which preferred in labels, flexible packaging carrier bags, beverage cartons and pre-print liner printings and were exposed providing 175Lpi dot tonal value. The reasons behind selection of the digital plates are that it is formed rapidly in preparation, it obtains a sharper dot and it has less dot swellings (Figure 3).

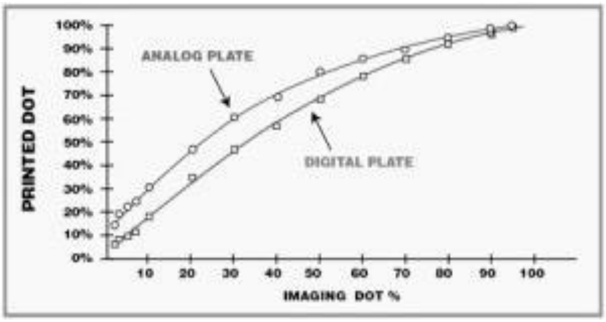

Figure 3. Graphic of dot swelling difference between digital plate and analog plate(http://caltapeandlabel.net/?page_id=2444 2016).

2.1.3.1 Preparing Plate

All plates were exposed in a controlled atmosphere (1,3% O_2, 98,7% N_2). The controlled atmosphere used to create the flat top dot during the main exposure of a plate also produces an exact 1:1 reproduction of image elements for improved solid ink density. The minimum dot was exposed as 1% for HD plates. For other plates, the minimum dot exposed was 2%. DFR plates were pulled down after a total of 9 cycles.

2.1.4 Test Printing Machine

Prints were made on the QD™ Proofing System test printing device. When a Flexo printing press is used, at least 100-150 m printing is required for settlement of the printing. However, a print can be achieved using this printing device in a laboratory environment with the same results.

2.1.4.1 Anilox Selection

Harper brand anilox, which is 1200 cells/inch 4,8 µm, has been used in the printing of the prepared plates.

2.1.5 Mounting Tape

SA 2315MS was used as a mounting tape. Mounting tape's thickness is 0,35mm. Rogers Coporation R/bak® Cushion Mounting Tapes are advanced, open-cell urethanes that provide the most consistent, resilient cushioning for flexographic printing. SA 2315 tape should be used for combination jobs including screen, line and solid work.

2.1.6 Measurements

The tests conducted to determine printability were: Tone Value Increase (dot gain), tone reproduction, optical/reflective density, and dot shape. The Tone Value Increase and tone reproduction curves of the printed materials were determined with Microsoft Excel. The density patches on each test print were measured in increments, from one to a hundred. The X-rite Exact NGH Spectrophotometer was used to measure the densities of a solid black area and the all other patches on test print. The ImageXpert system was used to determine the roundness of the 1% and 90% dots on each sheet. The dot roundness was defined by the ratio of the circumference of a circle with the same average radius to the perimeter length of the dot. A digital image was captured of the one percent and ninety percent dots using a SonyXC-003 video camera and the roundness was calculated by the ImageXpert system.

2.1.7 Ink

Fluid Sciences, Inc. brand black water-based FSI-40124 Accu Extra PC Black flexo ink was used as the ink. The ink was diluted with 15% water. The viscosity was measured with Brookfield DV-III brand rheometer and adjusted such that it will be 18s/DIN4/25°C (70 Centipoise), required value of water-based flexo ink. The pH value of the ink was measured with Denver Instrument AP5 brand pHmeter as 9,23.

The desired level is between 9-9,3 for flexographic press. However, the average range for water-based inks is between 8-9,5 therefore, the pH was within the tolerance level.

2.1.8 Printing

In these tests performed on the Harper QD Proofing test device, printing was done with water-based black flexo ink in optimum physical printing works on Duncote brand coated paper having 75 g/m^2 basis weight with a total of 20 plate of DuPont DFR 045 type in a thickness of 1,14 mm screened at 175Lpi resolution prepared with 10 different screening methods.

Ink type and viscosity, anilox roll, printing pressure and printing speed were all of the same. Print image was taken as 4 repeats on the sheet. Measurements were taken from the image formed on the third print from the plate. Printing measurements were made with X-rite Exact NGH brand spectrophotometer and ImageXpert.

2.1.9 Dot gain

Dot gain is known to increase the size of the half-tone dots over the period between the pre-press and printing processes. A low dot gain demonstrates high print quality[9].

In this study, two different plates were used belonging to the DuPont Company. Thicknesses of both plates were 1.14 mm. Hardness of DFR (Dupont Fast Robust) plates was 79 ShA. Printing of plates was made in appropriate conditions in accordance with TAPPI T402 SP-13 standards and measurements there of were made in the same environment throughout a day[10].

The X-rite Exact NGH Spectrophotometer was used to measure the densities of solid black area and the all other patches on test print.

3. MODELLING WITH ANN

Artificial Neural Network (ANN) is an information-processing archetype or exemplar that is inspired by the biological nervous system, i.e., the human brain [11].

Artificial neural network is a flexible mathematical structure which is capable of identifying complex nonlinear relationships between input and output data sets [12]. Neurally inspired models, also known as parallel distributed processing (PDP) or connectionist systems, de-emphasize the explicit use of symbols in problem solving [13]. Processing in these systems is distributed across collections or layers of neurons. Problem solving is parallel in the sense that all the neurons within the collection or layer process their inputs simultaneously and independently [14].

The origin of the ANN is the artificial intelligence. It consists of massively interconnected processing elements arranged in a layered structure. The input neurons are connected to the output neurons through layers of hidden nodes. Each neuron processes information through an activation function; hidden units with nonlinear activation function result in non-linear mapping [15].

Neurons consist of large number of processing elements are interconnected by weights. Input layer and output layer and at least one hidden layer create a simplified ANN model. The weight at the final iteration is assigned to the input parameters of the model, and the output is obtained. The difference between the observed and predicted concentrations denotes the accuracy of the model.

Artificial neural network method fast, simple and high learning capacity is an important problem-solving tool used in many scientific fields.

What this study aims using the ANN method is to train the neural network model with two different plates and 10 different screen methods and estimate screen density values obtained at the end of printing. In order to increase the accuracy of the estimation, the training was supported with standard screen density values. Different operations performed by the machine operator (densitometric measurements, ink settings, etc.) machine performance and knowledge and skills of the staff engaged in manufacturing are affective in the process from the beginning to the end of the flexo printing operation [16]. Since it is quite difficult to define such a problem as a mathematical model, the ANN method was used to contribute to the Flexo Printing Technology. The selected ANN structure is shown in Figure 4.

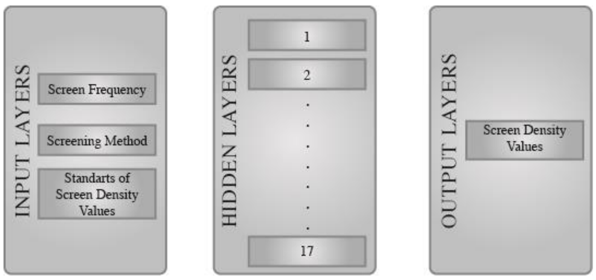

Figure 4. Artificial Neural Network structure

The data used in this study determines the print quality. The data were collected in Western Michigan University Paper Engineering Department in USA 2015. The data consists of 493 data points, and were recorded between 2014 and 2015(TUBITAK PROJECT NO. B.14.2.TBT.0.06.01-219-6040).

Neural Network model were performed using MATLAB 9.0.0 (R2016a) program. Data selection was made from 495 values. In the ANN model by using Matlab Toolbox programme (Figure 5), the input layer corresponds to the three experimental parameters including the initial screen frequency, screen method and standart of screen density values. A 17 hidden layer ANN with a tangent sigmoid transfer sunction (tansig) at hidden layer, a linear function (purelin) at output layer and Levenberg-Marquardt back-propagation algorithm with 1000 iterations were implemented [17]. 1-17 neurons in the hidden give one output signal as their removal percentage. All inputs and output are normalized within a uniform range of according to Equation 1. After establishing the ANN model, the next step was to divide the values into three parts by randomly: the values were being used to make training and validationing and testing (70% training, 15% validation, 15% test).

$$X_{norm} = \frac{X_i - X_{min}}{X_{mix} - X_{min}} \quad (1)$$

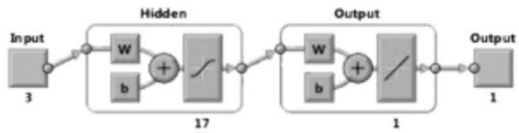

Figure 5. The Designed ANN Model

Performance criteria as RMSE (root mean square of error) is selected and optimized in terms of reflecting the network model of the system. The activation function was assessed by testing performance. (Table 1)

Table 1 Values of The Design ANN Model

The Design ANN Model		
Input Number	3 Neurons	Screen Frequency
		Screening Method
		Standart of halftone values
Hidden Layer Number	17 Neurons	
Output Layer Number	1 Neuron	Halftone values
Data Division	Random	
Training Method	Levenberg-Marquardt	
Performance	RMS	
Epochs	67 Iterations	
Regression R	Training	0.99036
	Validation	0.98248
	Test	0.99035
	All	0.98902
Gradient	20.152 at 67 epoch	
Validation checks	6 at 67 epochs	
Mu	0.01 at 67 epoch	
Best Validation Performance	42.1296 at epochs 61	

5. RESULTS AND DISCUSSION

Figure 6 and Table 1 show the model's ability to predict the percentage of screen density values at 175 Lpi plate in flexographics printing. As seen from the results

(Figure 7), ANN can be use for the determination screen density values. From this correlation and statistical test, it is evident that the model was successful in predicting the actual data of percent of screen density. This shows the importance of the artificial neural network to determine the screen density. The estimated of screen density values are obtained using results of ANN application as Figure 5 modelling.

Figures (Figure 7) show estimation of result percentages of training, validation and test regression of the ANN model which is created by using the same polymer structure (DFR), 175 Lpi screen frequency and 10 different screen structures.

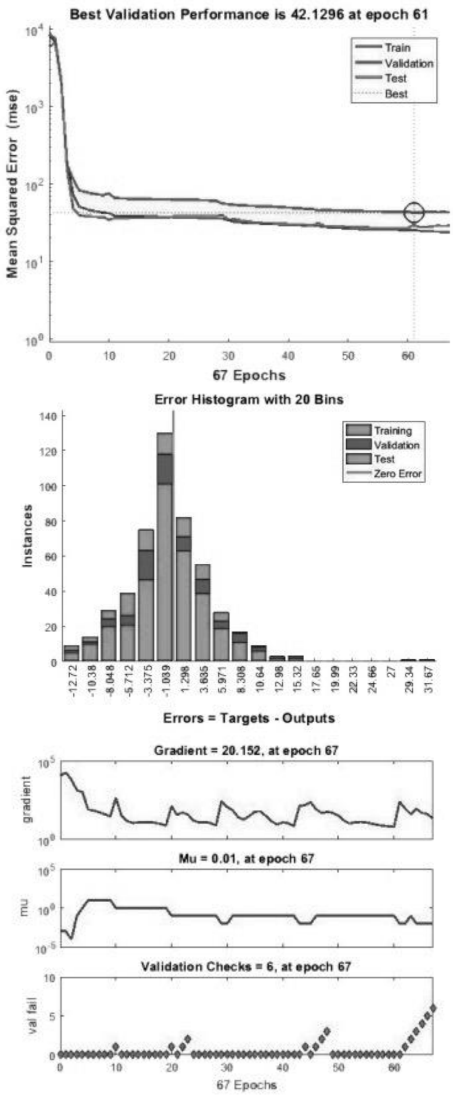

Fig 6. Performance graph obtained using linear activation function.

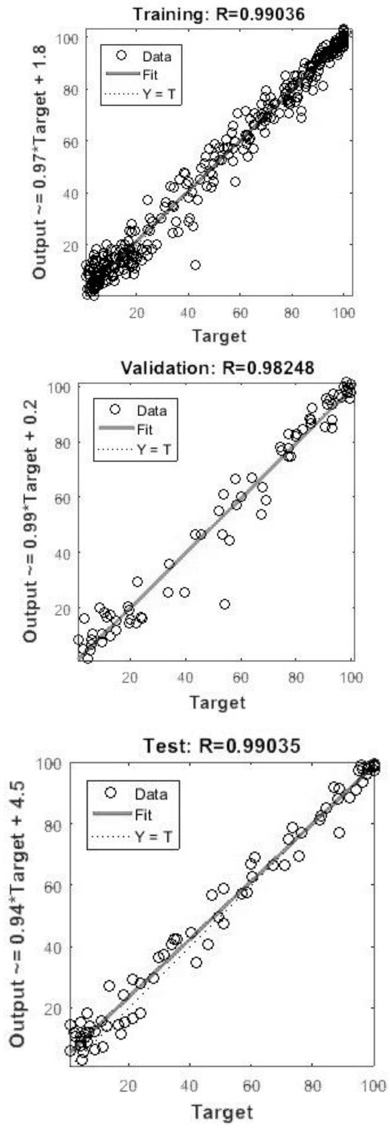

Fig 7. Regression values of ANN model (a) Training, (b) Validation, (c) Testing

6. CONCLUSION

According to satisfying results of ANN model can be use determination screen density values. From this result, it is revealed that the ANN model was successful in predicting the actual data of screen density values.

This ANN implementation in the field of printing was found to be faster compared to classical methods. It is an advantageous method which can be trained with examples and does not require a mathematical model. This study shows that it is also useful in estimation of screen density in particular.

Results from neural network model will allow to improve determination of the screen density values and to understand in a short time the behavior of the predicted analysis.

INDUSTRY PRACTICE

Print shops use conventional screen types when preparing plates without considering any standard rules. They do not use a different screen for each task.

This category is highly under- represented in the literature, also evident by the absence of any such papers in this special issue.

REFERENCES

[1] Kurt, M.B., "Determination of The Under Press Substances and The Pressing Surface Height of The Plate Used in Flexo Printing System", ***PhD Thesis***, Istanbul, TURKEY, (2012).

[2] Crouch, J.P., ***"Flexography Primer"***, Graphic Arts Technical Foundation Press,Pittsburgh, PA, (1998).

[3] Sonmez S., "Development of Printability of Bio-Composite Materials Using Luffa cylindrica Fiber", ***BioREsources*** 12(1): 760 –773, (2017).

[4] Laurent GL., "Prediction of the substrate printing in flexography by using a new established Printing Coefficient", ***PhD thesis, Royal Institute of Technology***, Stockholm, Sweden, (2002).

[5] http://esraprint.ir/wp-content/uploads/2016/06/expert_guide_screening_tech.pdf, (2016).

[6] http://www.dupont.com/content/dam/assets/products-and-services/printing-package-printing/PG/assets/NA/PDS-NA0031-EN-Cyrel-DFR-Data-Sheet-i.pdf, (2016).

[7] Olsson R., Yang L., Stam, J., and Magnus L., "Effects on ink setting in flexographic printing: coating polarity and dot gain" ,***Nordic Pulp & Paper Research Journal***, 21(5): 569–574, (2006).

[8] Ural, E., "The Applied Observation Of The Relationship Between Printing Pressure And The Amount Of Ink Printed And Solid Tone Density In Offset Printing On Coated And Uncoated Papers" ***İstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi,*** 9(17): 61–71, (2010)

[9] Youssef K.T., "The Impact of FM-AM Hybrid Screening and Am Screening on Flexographic Printing Quality", ***International Design Journal***, 5(4): 1471–1476, (2015).

[10] TAPPI T402, "Standard conditioning and testing atmospheres for paper, board, pulp handsheets, and related products", ***TAPPI Press***, Atlanta, GA, USA, (2013).

[11] Farhana K., and Aishwarya P., "Artificial Neural Network: Framework for Fault Tolerance and Future.", ***International Conference on Electrical, Electronics, and Optimization Techniques*** (ICEEOT), 648– 651, (2016).

[12] Ghaedi M., Ansari A., Assefi Nejad P., Ghaedi A., Vafaei A., and Habibi M.H., "Artificial neural network and Bees Algorithm for removal of Eosin B using Cobalt Oxide Nanoparticle-activated carbon: Isotherm and Kinetics study", ***Environ. Prog. Sustainable Energy,*** 34: 155–168, (2015).

[13] Ham F.M., and Kostanic I., "Principles of Neurocomputing for Science and Engineering", ***McGraw-Hill Higher Education,*** (2001).

[14] Ozel Y. , Guney I., and Arca E. "Neural Network Solution to the Cogeneration System by Using Coal", ***12th WSEAS International Conference on CIRCUITS***, Heraklion, Greece, 279–283, (2008).

[15] Lenzi G.G., Evangelista R.F., Duarte E.R., Colpini L.M.S., Fornari A.C., Menechini Neto R., and Jorge L.M.M. & Santos O.A.A., "Photocatalytic degradation of textile reactive dye using artificial neural network modeling approach", ***Desalination and Water Treatment***, 57: 14132–14144, (2016).

[16] Bates I., Zjakic I., and Budimir I., "Assessment of the print quality parameters' impact on the high-quality flexographic print visual experience", ***The Imaging Science Journal***, 63(2): 103–110,(2015).

[17] Cengiz C., and Kose E., "Modelling of color perception of different eye colors using artificial neural networks", ***Neural Computing and Applications***, 23(7): 2323–2332, (2013).

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