Modeling of the Braille Font Elements Creation Process

Volodymyr Mayik, Kseniya Bazylyuk, Lyudmyla Mayik and Marian Khariv

October 5, 2022

Modeling of the Braille font elements creation process

***Abstract*— Braille is widely used in almost all countries of the world, which confirms the perspective of technology research for the creation of information space for people with vision impairments. The improvement of technological processes, materials, and equipment for the product manufacture for people with vision impairments was carried out through the years of Braille system usage. Based on the analysis of scientific works, patent documentation, and Braille printing technologies, it was concluded that a large thickness of the print layer can be achieved in the stencil printing method. Therefore, it is one of the most promising methods from the perspective of tactile communicative media manufacturing for people with visual impairments. For the standardization of the stencil printing process, it is important to describe mathematically the influence of the main parameters of the stencil printing form and the process of printing relief-dotted images to ensure the necessary height of Braille font elements.**

Keywords*— modeling, regression analysis, correlation analysis, Braille, stencil form, spreading coefficient, absorption coefficient, element height.

I. Introduction

When producing publications and other products for people with vision impairments, it is necessary to receive the appropriate thickness of the ink layer, which is determined by regulatory documents (technological instructions, technical conditions, state standards, etc.) to ensure the reliability of information reading by people with vision impairments.

The conducted analysis of scientific and technical sources and patent information showed that lots of different technologies are applied during the use of the Braille system, but one of the most promising technologies is the stencil printing method, which allows scientists to receive thick image layers. Also, the advantages of the stencil method are the ability to print on a wide range of materials with different configurations and the ability to ensure significant resistance of relief elements to mechanical impact during reading by people with vision impairments [1-9].

The thickness of the raw ink layer of the print depends primarily on the grid geometry (ruler (lin/cm) and wire diameter thickness) on the printing form, so the grid is a method for the ink layer thickness adjusting. As the diameter of the wire decreases and the ruler of the grid increases for the same diameter of the wire, the thickness of the ink layer decreases. When the diameter of the wire increases and the ruler of the grid decreases, the thickness of the ink layer increases. With an increase in the wire diameter under a single ruler, the ink capacity increases, and after reaching a certain value, it decreases, which is a result of a change in the size of the free volume between the wires of the stencil grid.

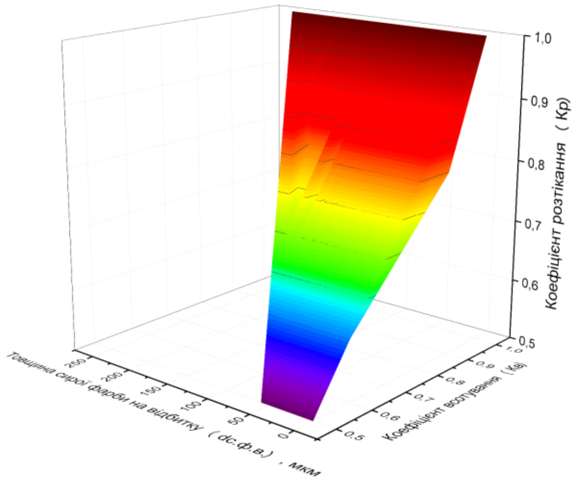
II. Modeling of the Relief and Dot Images Elements Creating Process in the Stencil Printing

Prints with relief dot images created with a stencil grid with a minimum thickness of the copying layer ensure readability for people with vision impairments if the ink capacity value of such a grid is estimated in the range of 125.4-294 cm3/m2.

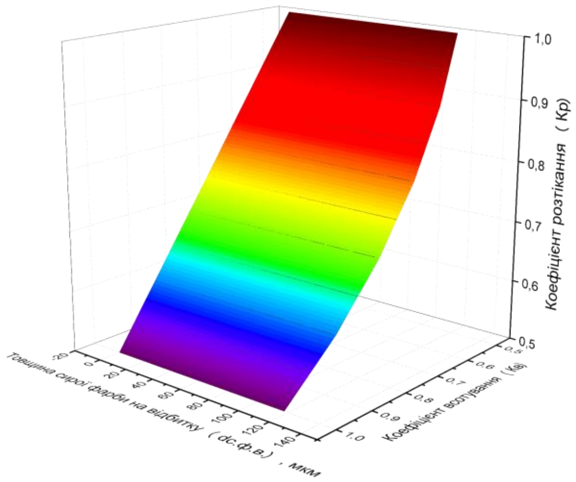
The ink capacity of the printing form and the ink transfer coefficient influence the thickness of the raw ink layer, which quantitatively characterizes the share of ink transferred to the print. While researching, it was determined that the color transfer coefficient is equal to the 0.3-0.8 value range. To ensure the necessary range of ink capacity of the stencil grid, the theoretical thickness of raw ink should be equal to 100-235.2 microns, and the color transfer coefficient should be equal to 0.4-0.8.

Also, the thickness of the raw ink on the print depends on the coefficient of the ink spreading, which is equal to 0.5-1.0, and on the coefficient of absorption, which is equal to 0.5-1.0 [13, 14]. The thickness of the raw ink on the print is calculated in two ways: when the coefficients coincide in ascending order, and when they are placed in opposite directions.

To provide the necessary range of theoretical raw ink thickness for the stencil grid with a minimum thickness of the copying layer, the raw ink thickness on the print should be 100-235.2 μm with a spreading coefficient of 0.8-1.0 and an absorption coefficient of 0.8-1.0, if the corresponding coefficients coincide in ascending order (Fig. 1, a) and 100-131.71 μm with a spreading coefficient of 0.8-1.0 and an absorption coefficient of 0.5-0.7, and if the coefficients are placed in opposite directions (Fig. 1, b).



a)



b)

Fig. 1. Dependence of the thickness of the raw ink on the print from the spreading coefficient and the absorption coefficient: a) – the coefficients coincide in magnitude; b) - coefficients are placed in opposite directions.

Regression analysis (Fig. 2), according to the information from the stencil form with the minimum thickness of the copying layer (part I), shows that the dependence of the theoretical thickness of the raw ink on the print (TRIP) on the thickness of raw ink (TRI) and coefficients of spreading (Ks) and absorption (Ka) can be considered linear since the coefficient of determination R2 = 0.86 is high (> 0.7).

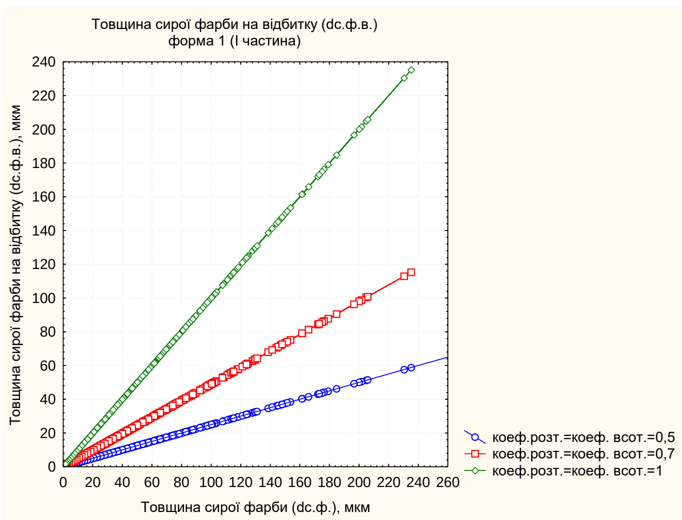


Fig. 2. Regression dependence of the thickness of the raw ink on the print from the thickness of the raw ink (the spreading and absorption coefficients coincide).

The corresponding regression dependence (1) will be calculated in the following formula (Fig. 3):

$$TRIP_{form1\ (p.I)} = -51{,}9330 + 0{,}6037 \cdot TRI + 48{,}3664 \cdot Ks + 19{,}7900 \cdot Ka \pm 11{,}867 \qquad (1)$$

N=3096	Regression Summary for Dependent Variable: Товщина сирої фарби на відбитку (дс.ф.в.) R= ,92891290 R?= ,86287917 Adjusted R?= ,86274613 F(3,3092)=6485,8 p<0,0000 Std.Error of estimate: 11,867					
	Beta	Std.Err. of Beta	B	Std.Err. of B	t(3092)	p-level
Intercept			-51,4142	0,984237	-52,2376	0,000000
Товщина сирої фарби (дс.ф.), мкм	0,853454	0,006659	0,6037	0,004710	128,1587	0,000000
Коефіцієнт розтікання (Кр)	0,257916	0,035708	48,3664	6,696258	7,2229	0,000000
Коефіцієнт всотування (Кв)	0,110178	0,035708	19,7900	6,413852	3,0855	0,002050

Fig. 3. Screenshot of the program for determining the regression coefficients (the coefficients of spreading and absorption coincide).

The correlation analysis (Fig. 4), according to the information from the stencil form with the minimum thickness of the copying layer (part I), indicates the existence of a reliable direct linear dependence of TRIP from TRI (partial correlation coefficient r = 0.92), but not from spreading coefficient (partial correlation coefficient r = 0.13) and absorption (partial correlation coefficient r = 0.05). At the same time, TRIP is more significantly affected by TRI (0.85) and less by spreading coefficient (0.26) and absorption coefficient (0.11).

Variable	Variables currently in the Equation; DV: Товщина сирої фарби на відбитку (дс.ф.в.) Beta in	Partial Cor.	Semipart Cor.	Tolerance	R-square	t(3092)	p-level
Товщина сирої фарби (дс.ф.), мкм	0,853454	0,917372	0,853454	1,000000	0,000000	128,1587	0,000000
Коефіцієнт розтікання (Кр)	0,257916	0,128813	0,048100	0,034780	0,965220	7,2229	0,000000
Коефіцієнт всотування (Кв)	0,110178	0,055404	0,020547	0,034780	0,965220	3,0855	0,002050

Fig.4. Screenshot of the program for determining correlation coefficients (the coefficients of spreading and absorption coincide).

Regression analysis (Fig. 5), according to the information from the stencil form with the minimum thickness of the copying layer (part II), did not reveal a linear dependence of TRIP from the coefficients of spreading and absorption, but only the dependence of TRIP from the thickness of the raw ink (TRI), the coefficient of determination R2 = 0.99 is very high (> 0.7).

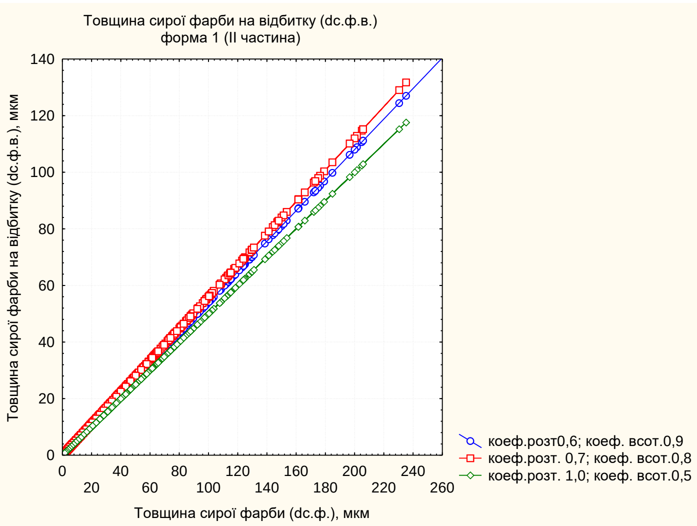


Fig. 5. Regression dependence of the thickness of the raw ink on the print from the thickness of the raw ink (spreading and absorption coefficients are located in opposite directions).

The corresponding regression dependence (Fig. 6) will be calculated in the following formula (2):

$$TRIP_{form1\ (p.II)} = 0{,}5333 \cdot TRI \pm 1{,}5959 \qquad (2)$$

N=3096	Regression Summary for Dependent Variable: Т сирої фарби на відбитку (дс.ф.в.) R= ,99782544 R?= ,99565562 Adjusted R?= ,99565281 F(2,3093)=3544E2 p<0,0000 Std.Error of estimate: 1,5959					
	Beta	Std.Err. of Beta	B	Std.Err. of B	t(3093)	p-level
Intercept			-0,000000	0,132312	-0,0000	1,000000
Товщина сирої фарби (дс.ф.), мкм	0,997825	0,001185	0,533333	0,000633	841,9388	0,000000
Коефіцієнт розтікання (Кр)	0,000000	0,001185	0,000000	0,167945	0,0000	1,000000

Fig. 6. Screenshot of the program for determining the regression coefficients (the coefficients of spreading and absorption are located in opposite directions).

The correlation analysis (Fig. 7), according to the information from the stencil form with the minimum thickness of the copying layer (part II), testifies the existence of a reliable direct linear dependence of TRIP from TRI (partial correlation coefficient r = 0.998), but no dependence from coefficients of spreading and absorption was found. At the same time, the influence of TRI on TRIP is estimated as 0.998.

	Variables currently in the Equation; DV: T сирої фарби на відбитку (dc.ф.в.), мкм						
Variable	**Beta in**	Partial Cor.	Semipart Cor.	Tolerance	R-square	t(3093)	p-level
Товщина сирої фарби (dc.ф.), мкм	0,997825	0,997825	0,997825	1,000000	0,00	841,9388	0,000000
Коефіцієнт розтікання (Кр)	0,000000	0,000000	0,000000	1,000000	0,00	0,0000	1,000000

Fig. 7. Screenshot of the program for determining correlation coefficients (the coefficients of spreading and absorption are located in opposite directions).

III. CONCLUSIONS

According to many scientists' opinions, the research of most parameters of stencil printing processes is not connected with the adjusting the thickness of the ink layer on the print, but with possible deviations of these parameters from the standardized technological process. Hence, if the stencil printing process is standardized, the thickness of the ink layer on the print is mainly influenced by the geometry of the printing form (grid ruler, wire diameter), as well as the properties of the printing ink, in particular the coefficient of spreading and the coefficient of absorption of the ink. That fact was taken into consideration in our theoretical calculations.

Based on the conducted regression and correlation analysis, the relationship between the main parameters of the printing form and the printing process (coefficients of ink spreading and absorption) was determined, which provides the necessary height in the range of 100 microns and more for the Braille element on the print.

REFERENCES

[1] R. M. Sheffield, F. M. D'Andrea, V. Morash†and Sarah Chatfield, "How Many Braille Readers? Policy, Politics, and Perception Show less" Journal of Visual Impairment & Blindness Volume: 116 issue: 1, First Published February 21, pp: 14–25, 2022.

[2] T. Parthiban, D. Reshmika, N. Lakshmi and A. Ponraj, "Handwritten Text to Braille for Deaf-Blinded People Using Deep Neural Networks and Python." Lecture Notes in Networks and Systems, 339, 2022, pp. 379–393.

[3] S. Tiendee, Ch. Lerdsudwichai, S. Thainimit and Ch. Sinthanayothin. "The Method of Braille Embossed Dots Segmentation for Braille." Document Images Produced on Reusable Paper // (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 13, No. 2, 2022, pp. 163–170.

[4] P. Renganathan, C. J.Schwartz, "Investigation of human perception of tactile graphics and its dependence on fundamental friction mechanisms." Wear 476: 203729, 2021.

[5] A. Martos, G. Kouroupetroglou, V. Argyropoulos and K. Papadopoulos, "Tactile identification of embossed lines and square areas in diverse dot heights by blind individuals." // Universal Access in the Information SocietyVolume 20, Issue 2, June 2021, pp. 333–342.

[6] G. Kouroupetroglou, A. Martos, "Tactile detection by blind people of embossed lines and squares with selected dot elevation." J. Technol. Pers. Disabil. 5, 2017, pp. 285–293.

[7] P. Ackland, Serge Resnikoff and R. Bourne, "World blindness and visual impairment: Despite many successes, the problem is growing" // Community Eye Health JournalVolume 30, Issue 100, 2018, pp. 71–73.

[8] Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis // "The Lancet Global HealthOpen AccessVolume 5", Issue 9, 1 September 2017, pp. 888–897.

[9] S. Milos, D. Vujčič, I. Majnaric, "Use and analysis of UV varnish printed braille information on commercial packaging products "// Journal of Graphic Engineering and Design Open Access Volume 12, Issue 4 2021, pp. 5–15.

[10] V. Maik, M. Khariv, "The process of forming relief-dotted images by screen printing." Qualilogy of the book: materials of the VIII international science and practice Internet Conf. Ukraine, Lviv: Ukrainian Academy of Printing, 2015, pp. 128–130.