3-D Convex Outputs for the Blind - Image Quality Analysis

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Abstract

One of the means by which the blind communicate with the environment is text information in the Braille system and convex graphical images printed on the paper. Printing and reading 3-D images is of a special significance in the process of educating the blind. It is also used in any contact of the blind with the literature, in every-day life (e.g. convex guidebooks) and professional life (letters, documents, etc.).

Because of a high diversification of the perception abilities of the blind as well as widespread application of the convex printings, the role of evaluating their quality becomes more significant. Quantitative measurements of the image quality of the convex printouts may be also used for evaluation of printing and copying devices.

In the paper one analysed the main techniques of making 3-D printouts and copies for the blind.[1,5,6,7,9,12] In the paper one proposed parameters for evaluating the quality of convex images[1,6] and methodology of measuring them. One provided also preliminary results of measurements of these parameters.[10,13] Results of the works carried out can be a basis for developing design of devices for printing in the Braille system and for convex copying.

Introduction

Data written down on a paper both as written signs Braille's and copies of 3-D images are very important source of information for the blind. The printouts and convex copies have got a special meaning in education of the blind children,[2] are commonly used as teaching aids in their education. Also the blind uses the periodicals and books written in Braille's system. In work and in everyday life of the blind find application in Braille's text, convex maps, convex score etc.

Due to very different perception abilities of the blind quality of the 3-D printouts are of great importance. Objective, quantitative assessment of the quality of this printouts has got also commercial meaning and can be used for comparison of working results of the different Braille's printers and copiers.

Since few years in Institute of Micromechanics & Photonics of Warsaw University of Technology the attempting at objective assessment of the quality of the convex printouts and copies have been undertaken.

A determination of the parameters of the 3-D printout quality designed for the blind is connected with analysis of the technology of the convex printout and the possibilities of their measurement, analysis of the construction of the printing and cooping equipment. The purpose of the conducting in Institute of Micromechanics & Photonics research is to simplify the construction of this devices and methods of their production.

The Brief Analysis of the Making Technologies of the Braille's Printouts And Convex Copies for the Blind

Convex Printouts Technologies

There are different technologies of the making convex printouts for the blind:

- *Embossing process* - it is a mechanical imprinting of the points in Braille's system on paper.[1,7,8] This technology is applied to hand Braille's typewriters (destined first of all for preliminary writing teaching in Braille's system), in Braille's printers (at a low speed of record – up to 20 characters/second), electric machines with an electromechanical drive and in very fast computer Braille's printers (with a speed of record at a 80 – 120 signs per second), in full-page printers (old type equipment, imprinting whole pages with a previously made metal, tin matrix) used in publications.
- *Thermal swell-tauch process* – swelling of the microcapsule papers under the influence of local effecting of high temperature.[10,11,13] Microcapsule papers include multimolecule polymers compounds. This process is commonly applied in thermal copiers for the blind.
- *Thermoform process* - the process of the thermal shaping of the plastic foil on the previously made matrix, applied in copying devices.
- *Ink Jet process* – ink jet or manual record on paper with special swelling ink.[5,9]

Embossing process is the most often applied technology of making convex printouts for the blind. Is used both as impressing letters and other marks in Braille's system on paper (paper of 120 – 160 grams per square meter) and on tape made of plastic (on Braille emboser on foil made of polyvinyl chloride).

Due to economic reasons reversible Braille's printout is more often realized – graphic characters are embossed on both sides of the paper; horizontal characters of both sides are slipped through half of the scale – Fig. 1.

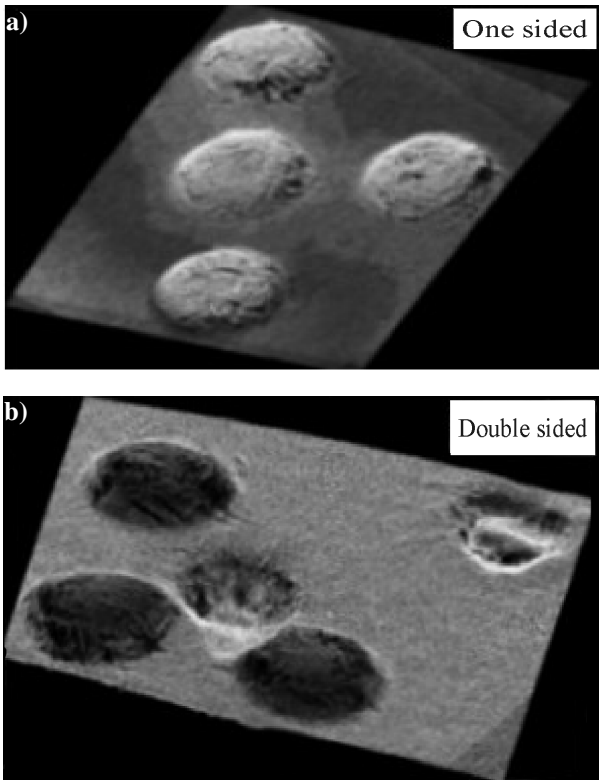

Figure 1. Examples of the printouts in Braille's system – a) one-sided and b) double-sided (scans obtained during A3-D objects' analysis – straight net projection method in Institute of Micro-mechanics & Photonics of Warsaw University of Technology.

Characteristics of embossed Braille's printouts depend first of all on the features of the paper used (tearing resistance, elasticity, stiffness, abrasion-resistance, smoothness) and features of emboser and other printer's devices (for example striking force of tangs, shape of the tangs, speed of the paper's deformation, working of the paper pass and embossing head). These characteristics determine resulting operating features of the printer (first of all printing speed), quality and durability of embossed graphic characters. Unfavorable feature of all Braille's embossing devices is their noisiness (for example in some models of fast computer printers up to 120dB).

Convex Images Copying

Copying on microcapsule paper consist of two phases: black and white flat copy (made on traditional laser or in some cases on LED printers or traditional xerograph, what depend on the characteristic of used microcapsule paper) and phase of thermal copy on special thermal copier.[10,11,13]

During heating of flat copy blacken areas absorb more heat, what results in swelling of polymer molecules (they increase their volume even 80 times) and creating convex copy.

As I proved in my research[10] the quality of convex copy depend on the degree of the blackening of the flat copy, on the temperature and time of heating in the process of copying. These parameters result from the features of capsule paper, flat copy and first and foremost on mechanism of thermal copier. New construction solutions in this copier (in US made copier new lighting system of delivery of heat energy) reduced by 30% energy used and noticeably simplify copier's construction.[2,10] These changes are submitted to be patented.[2]

The basic problem facing during convex thermal copying is relatively high price of the paper used (in Poland A4 cost 1$).

To form convex copies there are previously made matrixes of the copying image (usually made of plaster, but also of wood or metal). Special thermoplastic foil is used for doing a copy. The foil is putted on the matrix (placed in special device) and guarded against the movement. Heating cause melting of the foil. Due to vacuum under the matrix the foil stick precisely to the matrix. Then the foil is being cooled and its shape precisely imitates the matrix.

The technology of the thermal shaping of the plastic foil on the previously made matrix is mainly used for making maps for the blind, different emblems rather than high-volume Braille's editions. A disadvantage of this technology is necessity of making of the matrix.

Technology of spraying swelling ink on an ordinary paper[5,9] or manual applying the ink on the paper are currently being tested and hasn't been yet used in mass-produced devices for the convex printouts.

Obtained printouts out of worked out in Poland swelling ink[5] have got proper height of the printouts and images but did not fulfill the blind's requirements due to roughness which was too intense and caused scratches on the fingers. Therefore this ink hasn't been mass-produced. Due to above analysis the basic technologies of the making convex printouts and images for the blind are imprinting on the paper and thermal copying on capsule swelling paper.

The Convex Text Properties

The basic parameters of the convex images are their geometrical features and the quality of the surfaces of the convex graphic characters. The most important characteristics are height and shape of the Braille's points.

Many tests of reading the convex Braille's letters proved that the height of the printouts shouldn't be less than 0,5 mm. The tips of the convex graphic characters ought to

have a hemisphere shape. The smooth surface of the embossed points is very important. It is unacceptable to break the curvature of the embossed points (it happens when tangs are exerting too big pressure on the paper, tear apart it and punch convex points. Sharp edges of the Braille's points cut then the blind's fingers that can not be acceptable.

The points which form the Braille's graphic characters are ordered in 2 x 3 matrix (two columns, three rows) or 2 x 4 and are recorded in rows (usually 42 marks per row).

The distance between the columns and rows of the points in mark, diameter of the point, IntelliType space, interline space are the characteristics of the Braille's printouts.

In practice, the different values of the geometric parameters of the Braille's points and marks are used in different countries. In Europe German measurements are applied, in America and Australia – a little bit different American measurements – Tab.1.

Table 1. Braille's Marks Geometric Measurements.

	Marburger			*US* **Standard**	*Meteo*
	Large	Medium	Small		
a [mm]	2.7	2.5	2.3	2.3	3.0
z [mm]	6.6	6.2	6.4	6.4	7.5
d [mm]	1.6	1.5	1.4	1.4	1.2/1.6
Swelling's height [mm]	0.5 - 0.8				

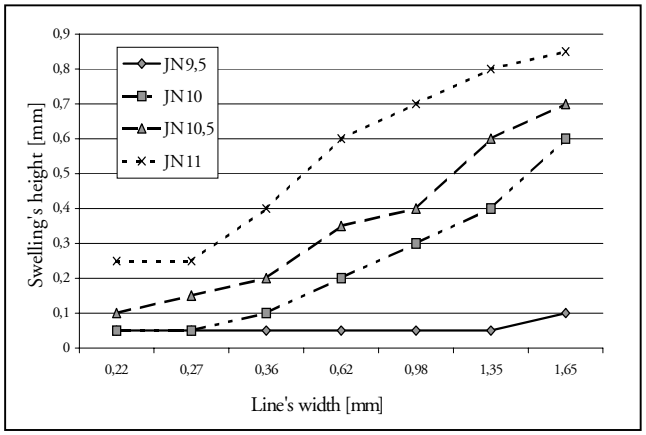

Figure 2. Examples of the research's results of the width of copying line influence on the height of the swelling 3D copy (research's conditions: English copier, capsule paper made in Japan).

Swelling's Height

The convex images are characterized mainly by the height of the swelling.

There are many factors influencing the height of the swelling in copying on capsule paper: the width of the copied line (on flat copy) – Fig. 2, degree of the blackening of the copy and the measurements of the blackening area – Fig. 3.

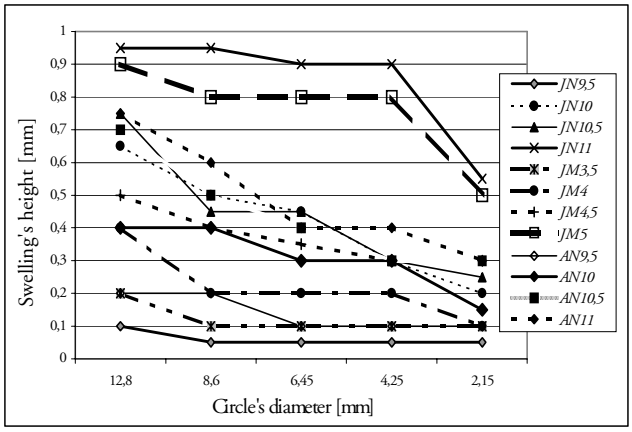

Figure 3. Examples of the research's results of the influence of blacken areas' measurements on the height of the swelling 3D copy (research's conditions: American copier, paper made in America).

These parameters determine the amount of the absorbed heat energy and height of the swelling. During the convex copying of the line drawings (very important type of the images due to wide application in the blind children education) the width of the imitated line of the flat copy is very important. The convex lines technology determine (as proved research[4]) that in order to obtain requested height of the swelling (min 0,5 mm) copying line should have the width of 1 mm.

The height of the swelling depends very strongly on the operation temperature of the copier.

Swelling's Shape

The next parameter of the quality of the convex printouts is the shape of the swelling.

It is very important in text Braille's printouts. The convex Braille's point (part of the mark) should have a hemisphere shaped tip.

This is an optimal shape for the fingers of the blind (based on the statements of the many blind readers from different social classes, persons with various education). This shape is pleasant to the touch and easy to read. By analogy to the parameter "irregularity of the contour of the mark" – described in the international standard ISO 13660 and concerning the quality of monochromatic, flat, written on the paper graphic characteristics for measuring the shape of the Braille's point one proposed parameter R_b-(raggedness blind). This parameter is defined as the average value of the deviation of the tip shape of the Braille's point. Is defined from two perpendicular sections of this point as follows:

$$R_b = \sqrt{\frac{\Sigma(r_i - r_o)^2}{(n-1)}} \quad (1)$$

where:

r_i – length of the successive ("i") radius of the Braille's point tip from the perfect radius

r_o – length of the perfect radius of the Braille point's tip, defined by the value of the real radius with a smallest squares sum method,

n – number of the radiuses examined (no less than 20)

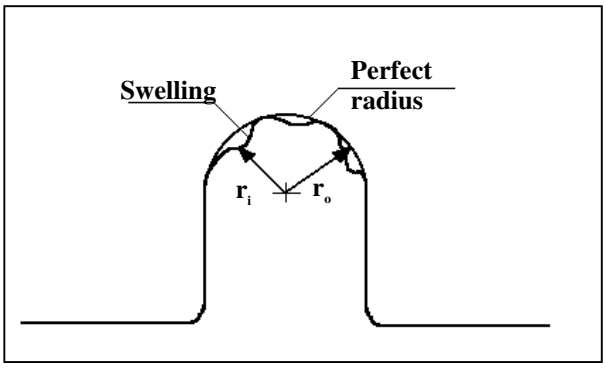

Figure 4. Swelling's shape measurement illustration

Raggedness

The contacts with the blind readers so far prove that the low raggedness of the text or convex copies is a very important feature of the convex printouts because sharp tips of the palpable marks can scratch the reader's fingers.

The measure of the raggedness can be friction's coefficient while shifting the model plate made of certain material on the model convex printout, including certain Braille's text and convex images.

Convex Image's Quality Parameters

Proposed parameters of the measurement of the convex printout's quality are defined due to reader's requirements.

Summarizing the analysis of the parameters of the convex printout's quality, we can put them together due to attributed them a priori importance weights:

1) *Highness* of Braille points - H_b (should be contained in the span 0,5 – 0,8 mm); parameter's weight – 1,6
2) *Raggedness* of the embossment - RG H_b (the value of the raggedness coefficient possibly low, maximum acceptable value will be determined in detailed tests); parameter's weight 1,4
3) *Irregularity* of the shape of Braille's tip point R_b (raggedness for blind - coefficient possibly low, maximum acceptable value will be determined in detailed tests); parameter's weight 1,2
4) *Geometrical parameters* of Braille's points G_b (average value of the deviation of the Braille points' scale "a", scale of the IntelliType space "z" and the diameter of the Braille's point "d", deviation from the recommendations in the certain geographical – see table 1); parameter's weight 0,8

It is proposed to determine collective vector of the quality swelling printouts as a sum of ratios of the values of the individual parameters of the tested model printout to the recommended value and the weights of the particular parameters.

The Measurement of the Particular Parameters Methodology

The standard printout has been prepared to measure the particular parameters – Fig. 5. It includes linear graphic elements, convex areas circle shaped, Braille's points in the form of 6 Braille's points and group of the typical graphic symbols.

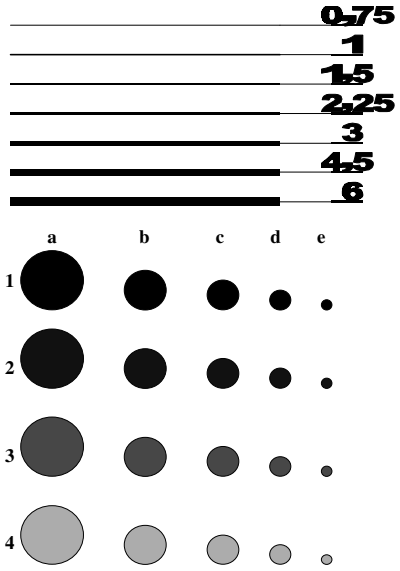

Figure 5. Printout test for the examination of the convex copies

The widths of the lines have been compiled due to adequate values of the typographic points. The differentiation of the measurements of the diameters of the convex circles enable to research an influence of geometric measurements on the height of the dwelling.

There is the same purpose of the graduation of the measurements of the Braille's points and graphic characters.

Moreover to test the printouts from Braille's printers one should print standard printouts including three lines: six Braille's points, three lines of selected Braille's graphic characters and six lines of the current text. In two-sided printers the sample two-sided printout including six lines of the complete six Braille's points should be prepared.

To measure the height of the Braille's points and raggedness of their shapes one proposed straight net projection method and optical scan with the CCD camera on the position for 3-D measurements worked out in Institute of Micromechanics & Photonics of Warsaw University of

Technology.[12] In this method – Fig. 6 – one light tested convex sample printout by the projector including the sample plate with becoming more and more frequent groups of the lines. This net of the lines is projected on rotating object at a certain angle. The CCD camera then scans reflection image.

Arising electric signals are the function of three dimensions x,y,z of the tested object. They are memorized in the computer and analyzed with a special application program.

To the certain values of the "z" dimension are attached appropriate colors of the sample image.

Application program enables to prepare and present graphic cross-sections of the examined objet at any angle and to tabular display of the values of the height of the Braille's points. Straight net projection method also enables to specify the geometric measurements of Braille's points and convex images. In order to achieve this one can use very easy but laborious measurements on a workshop microscope.

Raggedness of the embossments will be specified through an analysis of the shapes of the Braille's points' tips placed in line on the position to 3-D images measurements.[12]

Conclusions

The analysis of the technologies of the convex printouts for the blind, proposals of the definitions and methods of the measurement of the parameters of the quality of the convex printouts for the blind proved that:

- The basic methods of the convex printouts making are: embossing process and thermal swell-touch process,
- It is possible and purposeful to identify parameters and test the quality of the printouts for the blind,
- Following basic parameters has been proposed: height of the swelling, raggedness of the Braille's point's tip, raggedness of the swellings and geometric measurements of the marks,
- Proposed collective vector of the quality of the convex printouts will be tested in the detailed study,
- Used for measurement of the parameters of the quality of the convex printouts net projection method is very successful, touchless method, giving the possibility of the computer analysis of the measurements.

References

1. Buczynski L., Ocena jakosci drukow wykonanych w systemie Braille'a (Estimating of Image Quality of Braille Printouts) *Int. Conf. Poligraf Expo 96*, Warsaw Poland 1996 (Polish)
2. Buczynski L., Lesniewski M., Olobry M., Urzadzenie do kopiowania wypuklego (Device for convex copying) patents annoucement No P.338 025 Polish Patent Office, 2000 (Polish)
3. Buczynski L., Krupowicz M., Urzadzenie do wytlaczania punktow Braille'a (Emboser device for Braille prints), patent annoucement No P.338465 Polish Patent Office 2000 (Polish)
4. Buczynski L., Krupowicz M., Urzadzenie do wytlaczania punktow Braille'a (Emboser device for Braille points), patent annoucement No P.338466, Polish Patent Office 2000 (Polish)
5. Goralski Z., Prot T., Metody powielania informacji dla niewidomych z zastosowaniem standardowych urządzen poligraficznych, (Copying methods for blind using standard polygraph devices) work of PREBOT 1998 (Polish)
6. Halousek J., Embossed Braille Advancements: Automatic Reading by a New Optical Braille Recognition System OBR and Objective Dot and Paper Quality Evaluation, white paper, Merit , Czech Republic,2000 (English)
7. Harres H., Herrstellung von Buchern und Zeitschriften in Blindenschrift (Manufacturing of books and journals on Braille print), paper from Blista Brailletec Marburg Germany 1998 (German)
8. Krupowicz M., Konstrukcja modelu zespolu wytlaczającego do szybkiej drukarki brajlowskiej (Design of Model of computer Braille printer), diploma work of Institute of Micromechanics and Photonics, Warsaw University of Technology, Poland 2000 (Polish)
9. Lange O., PRINT – Non-Impact Printer and Plotter for Braille/Moon and tactile Graphics, Conference of CSUN Center on Disabilities, Los Angeles, 1998 (English)
10. Olobry M., Konstrukcja kopiarki druków wypuklych (Design of convex copying device) diploma work in Institute of Micromechanics and Photonics Warsaw University of Technology, Poland, 2000 (Polish)
11. Partner Vision 2051 – a copying device for blind, paper from R&D Center MINOLTA Toyokawa Japan 1999 (Japan)
12. Pawlowski M., Pat. No 08192 576 –Thermal transfer sheet for forming relief image and image forming method using the same Japanese Patent Office 1996 (English)

Biography

Ludwik Buczynski received his PH Dr degree in micromechanics from Warsaw University of Technology in 1972. Since 1963 he worked in Micromechanics and Photonics Institute of Warsaw University of Technology and since 1986 in R&D Center Office Technoque PREBOT Radom Poland. He is member of IS&T. Since 1990 his main area of interests are computer peripheral's devices and image quality investigations.