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Article

Creation of Braille plates using 3D printing technology

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Abstract: This article describes a program for the printing Braille tables using 3D printer. A basic function is creation the STL file containing Braille tables geometrical characteristics which representing input text. The received out-put file can print on the 3D printer.

Keywords: Braille plates; 3D printing

1. Introduction

Braille is named after its creator, Frenchman Louis Braille, who lost his eyesight due to a childhood accident. In 1824, at the age of 15, Braille developed his code for the French alphabet as an improvement on night writing. He published his system, which subsequently included musical notation, in 1829. The second revision, pub-lished in 1837, was the first binary form of writing developed in the modern era[1]. Braille characters are small rectangular blocks called cells that contain tiny pal-pable bumps called raised dots. The number and arrangement of these dots distin-guish one character from another. Since the various braille alphabets originated as transcription codes of printed writing systems, the mappings (sets of character des-ignations) vary from language to language. Braille is derived from the Latin alphabet, albeit indirectly. In Braille's original system, the dot patterns were assigned to letters according to their position within the alphabetic order of the French alphabet. The first ten letters of the alphabet, a–j, use the upper four dot positions. These stand for the ten digits 1–9 and 0 in a system parallel to Hebrew gematria and Greek isopsephy. (Though the dots are assigned in no obvious order, the cells with the fewest dots are assigned to the first three letters (and lowest digits), a-b-c = 1-2-3, and to the three vowels in this part of the alphabet, a-e-i, whereas the even digits, 4, 6, 8, 0 are corners/right angles.) The next ten letters, k–t, are identical to a–j, respectively, apart from the addition of a dot at position 3 (red dots in the table). Figure 1 represents a braille alphabet.

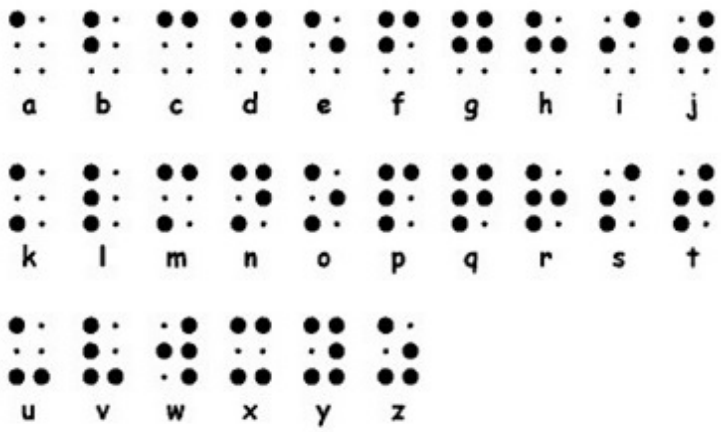

Figure 1. Braille alphabet showing arrangement of dots that make up each letter. Note: the little dots are placeholders and are not to be printed.

2. Description of the building STL file method

For the printing of the Braille book, consisting of tables on the 3D printer it is necessary to create at first the file containing spatial characteristics of this table. As the technology of the printing by a fusing method is at the moment most developed and available (Fused deposition modeling, FDM) in which an object is created by layerwise laying down of the melted thread of melting working material (plastic, metal, wax), we will save spatial characteristics in the STL file. The description of each edge begins with the keyword of "facet". Further there is a description of a normal to this edge in the form of a vector with three coordinates. The description of a normal begins with the word "normal". Further there is a unit of the description of peaks of the edge. This unit is framed with the words "outer loop" and "endloop". In the unit each peak of a triangular edge is described by three spatial coordinates. The unit of the description of an edge comes to an end with the word "endfacet"[3]. Thus, it is possible to select the principal function of the program for the printing of tables of Braille – creation of the STL file containing characteristics of a table of Braille in the input text. Generally, the analysis of the input text comes down to symbol-by-symbol analysis. However, for example, in the English Braille language some words and combinations of words can have special abbreviations. For example, the word "afternoon" in the Braille representation registers as a string of "AFN". At this stage we won't consider these features. Also, we will consider only 6-and a 8-dot font of Braille[2]. Figure 2 shows a Braille dots dimensions schema in the plate.

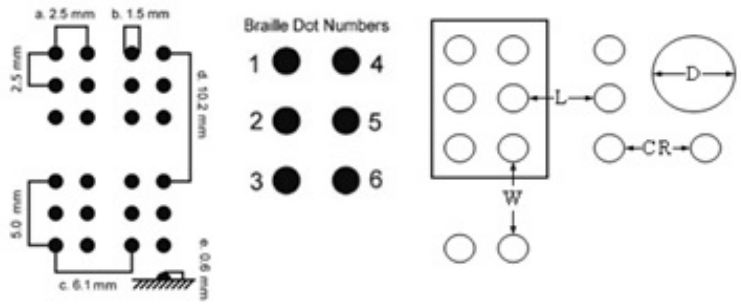

Figure 2. Braille dots dimensions schema

The general diagram of a method::

1. Symbol-by-symbol analysis of the input text (characters of the Russian and English alphabet, digits, separators);
2. Search of compliance of the selected characters with 6-dot glyphs (Braille's characters);
3. Division of glyphs into tables (25 glyphs down and 30 across);
4. Computation of spatial characteristics (coordinates of X, Y, Z, normals) of glyphs in a table;
5. Saving the calculated characteristics in the STL file.

As a result of these steps the file which can be viewed also any three-dimensional packet, for example, in MeshLab will be received.

3. Description of a braille plate building method

This section describes a braille plate building method. Method contains 2 steps: processing the input text and calculation of Braille plates parameters; generating a Braille table 3D representation.

3.1. Module of processing the input text and calculation of Braille plates parameters

We will consider process calculation of characteristics of a glyph in the plate. The Glyph model geometrically consists of 2 types of figures: one parallelepiped and 6 cylinders presenting to camber. But as a result of formation of the plate parallelepipeds of the basis of glyphs will coincide with a parallelepiped of the basis of all plate, for definition of her spatial characteristics the X and Y centers of the bases of cylinders of cambers are enough to calculate coordinates. For calculation of horizontal coordinate of the center of a circle C_x of the basis of cambers (points) both on six - and on an eight-fine-molded glyph the following formula is used: For calculation of vertical coordinate in a six-dot glyph the following formulas are used:

$$C_x = i(L + 2D + CR) + (x - 1)(CR + D) \tag{1}$$

For calculation of vertical coordinate in a six-dot glyph the following formulas are used:

$$C_y = j(W + 3D + 2CR) + (y - 1)(CR + D) \tag{2}$$

In eight-dot similarly:

$$C_y = j(W + 4D + 3CR) + (y - 1)(CR + D) \tag{3}$$

where i, j – an index of the calculated camber of a glyph, x, y – a position of camber of a glyph, L – distance between glyphs across, W – distance between glyphs down, CR – distance between the bases glyph circles, D – diameter of the basis of a circle of a glyph. At the output of the module will create the SVG file which contains visual representation of one plate of Braille and the file with parameters of this plate. The file of parameters of the plate comprises all necessary data (length, width and height of the basis of the plate, height and radius of a circle of the basis of cambers, coordinates of the centers of circles of the bases of cambers) for creation of the STL file.

3.2. Module for generating a Braille table 3D representation

On an output the module receives a set of coordinates of centers of the bases re-ceived at the previous stage. As STL stores the description of geometry in the form of a set of edges and normals to them, in this module it is necessary to realize an algorithm of creation of edges (fig. 1). The base of a table is described by a simple parallelepiped. Cylinders of convexities are presented in the form of the correct n-square. The dimensionality of a n-square the more form of convexity is above ap-proaches cylindrical. On an output the module creates the STL file which contains complete three-dimensional idea of a table for the printing on the 3D printer.

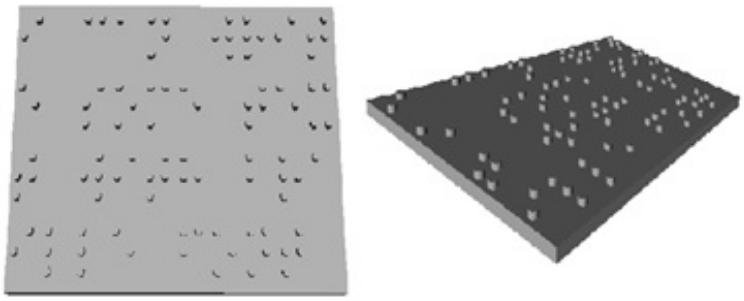

Figure 3. Generated Braille plate representation in MeshLab and printed part of Braille table

The first step is computation of peaks of a circle of the bases of convexities. The circle of the base is presented in the form of the correct n-square where 2 any adjacent peaks divide circle sector into equal angles φ. This angle is calculated the following on the following formula:

$$\varphi = \frac{2\pi}{V_{count}} \tag{4}$$

where V_{count} - quantity of peaks of a n-square.

Respectively, coordinates of peak are calculated by the following formula:

$$X = L_x + C_x + R\cos\varphi \tag{5}$$

$$Y = C_x + R\sin\varphi \tag{6}$$

$$Z = const \tag{7}$$

where R - the radius of a circle of the base of convexity, L_x – horizontal is long tables. The second step – to display peak on the upper circle of convexity. As in our representation convexity has the cylindrical form, for display of the base it is enough to increase coordinate Z peaks by convexity height. The third step is to create from the received edge peaks for formation of STL and to calculate to them normals. Edges of convexities are created as follows. Sequentially two adjacent peaks from the lower base and one, corresponding to one of lower, upper peak are selected. These three selected peaks (A, B, C) create one edge. The normal to this edge is calculated on the following formula:

$$N_{facet} = (B - A)(C - A) \tag{8}$$

Further calculated is normally normalized by the maximum component on the following formula:

$$N_{normal} = \frac{N_facet}{Max(N_x, N_y, N_z)} \tag{9}$$

The fourth step – to create table base edges. This step occurs similarly previous for convexities. As a result we will receive a complete description of geometry of a table in the STL file.

4. Results

The three-dimensional type of the plate is presented in the figure 4.

Figure 4. Printed Braille plate

The developed method of printing of plates of Braille is realized in the form of the program.

5. Discussion

All defined tasks of this work were successfully complited.

6. Materials and Methods

STL formation module (language C ++) is github.com/vlusslus/STLGenerator. The module of analysis of the entrance text is github.com/vlusslus/Braille3D.

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