RESEARCH ON THE DEVELOPMENT OF A MULTI-DEVICE TYPE DEVICE FOR PEOPLE WITH SPECIAL NEEDS

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ABSTRACT: The theme of the project "Research on the development of a multi-device type device for people with special needs" involves an intelligent haptic system that helps the blind, able to simulate the Braille alphabet and transmit user commands to an electronic device. The product resulting from this process is useful for people with special needs. Following the study carried out in this paper, a series of constructive-functional variants were analyzed for this type of product, from which the only variant was chosen, as the optimal variant. This analysis also included products competing with our device, and thus resulted in a product that has twelve components made physically with the help of additive manufacturing technology. With the help of 3D printing, we managed to have a product design model and continue its development, making it functional. The appearance of the automatic typing system is like a cropped box or a kind of miniature 3D printer, to make room for rods that help coordinate movements. The functionality of the product requires of electronic elements, but also a software that allows the recognition of the Braille alphabet.

KEYWORDS: multi-device, Braille alphabet, additive manufacturing technology.

1. Introduction

This chapter presents a history of the development of keyboard devices from the appearance of the first electromechanical product for Braille text display to the most advanced 32-cell Braille display system. Braille technology is an assistive technology, created by Louis Braille in 1825, which has been continuously developed to this day, allowing blind and partially sighted people to perform common tasks such as typing, surfing the Internet, typing in Braille, and printing. in text, chatting, downloading files, music, using e-mail, recording music, and reading documents[1].

The letters are made up of dots that can be felt with your fingers. All letters of the alphabet have corresponding signs in the Braille alphabet.

A Braille product (Braille terminal) is an electro-mechanical device for displaying text in the Braille alphabet, usually by means of rounded-pointed pins raised through holes in a flat surface. Visually impaired people who want to use a computer but can't distinguish the characters on the monitor can use a Braille display to read the displayed text. Screen readers are also frequently used for the same purpose, and a blind user can switch between the two systems or use both at the same time, depending on the circumstances. The Braille display can also be used by deafblind users [3].

The advances in Braille technology are significant and there are some examples of software and hardware components currently in use, as follows:

Fig. 1.1The example of the Braille alphabet [2]

1.1. Software component

- **Duxbury DBT** is a program that interprets the lines of a fingerprint and converts them into Braille (and vice versa) for over 100 languages;
- **JAWS** is a program that reads text on a screen and allows you to browse directories, documents, and programs under the Microsoft Windows operating system, or send text to a Braille display;

- **Kurzweil** is a device that scans texts on the computer and tells them;
- **Nvda** is an open source screen reading software with Braille supportlle.

1.2. Hardware component

Table 1.2.1 Components

 Fig. 1.2. Brailliant device Bl 32 [4]	**a) Braille keyboard** – used only with Braille typewriters. There is currently a generation of Brailliant Bl screens that incorporate state-of-the-art Braille cell technologies, clear and realistic points. The ergonomic screen fits in front of your laptop or keyboard and can be used with mobile devices.
 Fig. 1.3. The Braille printer[6]	**b) The Braille printer** renders text as touch cells. Using Braille translation software, a document can be highlighted with relative ease
 Fig. 1.4. Electronic books in Braille[7]	**c) Electronic books in Braille,** which use electroactive polymers. [5]

The first objective of the study is to create a typing system using the Braille alphabet, which helps people with special needs to communicate and navigate on a variety of devices.

Currently the 3D model of the keyboard system is almost complete, because we noticed the need for other components. This system was designed in Solidworks design software. The components have been established according to the fulfillment of the objective proposed by us.

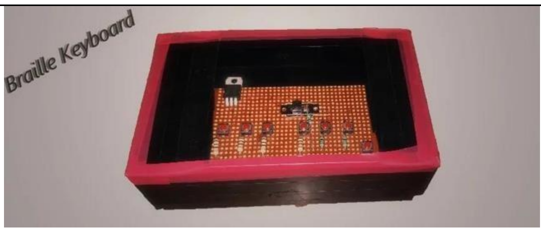
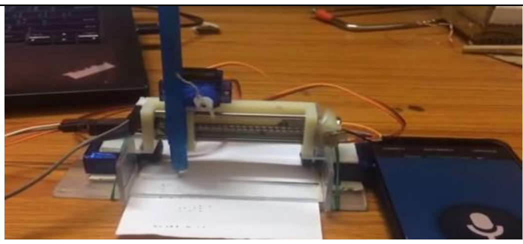
The next step is to research and demonstrate the effectiveness of the product and its commissioning. At present, only the operating principles of the components and their integrity in the system have been analyzed.

2. 3D printed variants

At present, all kinds of additive-manufactured equipment have been developed, which have the role of integrating the Braille language. These equipments are composed of both components made by additive manufacturing and components made by other means.

Table 2.3.1 3D Printed systems

 Fig. 2.1. Connecting components for the device [9]	**Option 1: Braille enabled mobile phone for the visually impaired** The project proposal is about a mobile phone design that will act as an essential device for the visually impaired, which can be used for efficient reading of SMS. [8]

 Fig. 2.2. Braille alphabet system keyboard [11]	**Option 2: Braille keyboard with voice output** This type of keyboard helps people with special needs to enter data on laptops, using Braille, and at the same time be able to hear what they are typing. With the help of the open source software "Cool Term", the typed text can also be converted into a Word document or a text document. [10]
 Fig. 2.3. Braille typewriter [13]	**Option 3: Braille writing mechanism** This type of mechanism is a paper typewriter in the Braille alphabet, connecting to a device and being voice activated.[12]

3. Functional analysis of the product Multi-device typing device

In this stage, an analysis of the product "Multi-device typing device" will be performed, in order to establish the main functions and their evaluation in fulfillment of the final purpose.

Please note that the proposed product must allow the simulation of the Braille alphabet by transmitting the commands given by the user and converting these commands to the device.[14] The functional tree for the product "Multi-device typing device" is as follows:

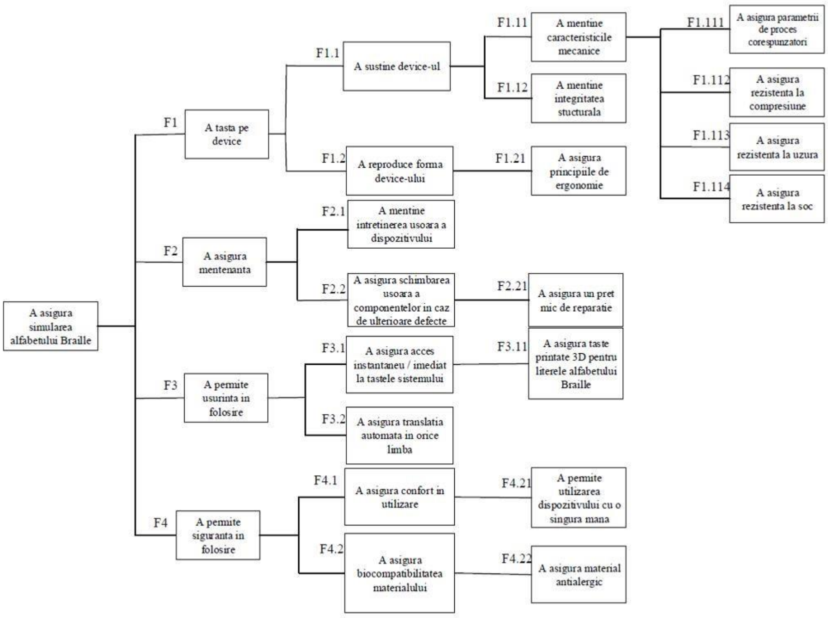


Fig. 3.1. Functional Tree for Multi-Device Keyboard Product

3.1. Hierarchy of functions and evaluation matrix

This ranking involves the determination of a final evaluation that highlights the most important functions of the product.

The evaluation will be based on the first functions of the device - F1, F2, F3 and F4. The number 1 will be placed diagonally in the evaluation matrix, following the notation of the other functions. When evaluating the functions, 2 tables will be drawn up, following to make an average of the obtained results, in order to be able to achieve the final ranking matrix.[15]

Table 3.1. Product function ranking matrix (Option 1)

Functions	F1	F2	F3	F4
F1	1	0	0	0
F2	1	1	1	1
F3	1	0	1	1
F4	1	0	0	1
Level of importance ni	4	1	2	3

Table 3.2. Product function ranking matrix (Option 2)

Functions	F1	F2	F3	F4
F1	1	0	0	1
F2	1	1	1	1
F3	1	0	1	1
F4	0	0	0	1
Level of importance ni	3	1	2	4

The final matrix of the hierarchy of functions is presented in table 3.3. This matrix highlights the final average of the importance level of the previous matrices.

Table 3.3. The final hierarchy of functions for the product

Functions	F1	F2	F3	F4
F1	1	0	0	0.5
F2	1	1	1	1
F3	1	0	1	1
F4	0.5	0	0	1
Level of importance ni	3.5	1	2	3.5

The functions weighting matrix for the multi-device typing device is shown in table 3.4. The formulas that make up the values in this table are as follows:

The importance coefficient is calculated with the relation:

$$C_i = ni/\Sigma ni ; \quad (1)$$

The weight of a product's function is determined using the relationship :

$$P_i[\%] = (ni/ \Sigma ni)*100. \quad (2)$$

Table 3.4. Matrix of general evaluation of product functions

Function	F1	F2	F3	F4	Total (Σni)
Calculated weight	3.5	1	2	3.5	10
Global impact factor	0.35	0.1	0.2	0.35%	1
Global weight	35%	10%	20%	35%	100%

By comparing the functions, it was concluded that the F1 and F4 functions obtained the same 35% score, so the support of the device, respecting the ergonomic principles are as important as the safe use of the device.

The value of the product is equal to the sum of the calculated hierarchical values, ie 10. After weighting the functions, the following percentage values result:

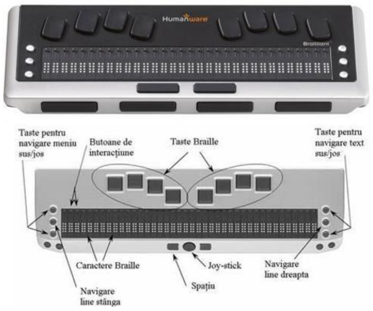
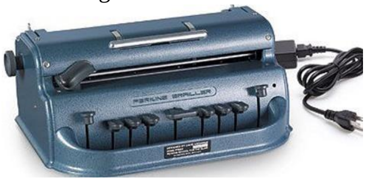
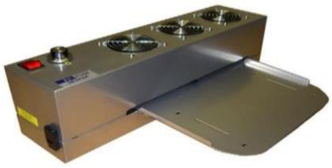
XF1 = 35%; XF2 = 10%; XF3 = 20%; XF4 = 35%.

5. Market analysis

This chapter covers the market analysis of products that fall into the category of devices that help the visually impaired. The products use the Braille alphabet.

An analysis of the existing products on the market and of the product proposed by our team will be made, highlighting the competitive advantage. 4 competing products and their specifications will be presented in Table 5.1.

Table 5.1. Competition table

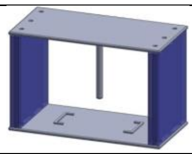
Competitive products	Product specifications
 Braille display with keyboard Competitive advantage: Low cost, low maneuverability [16].	The purpose of the Braille display is to render in Braille the descriptive and textual information that the user needs in order to interact with the applications. Technical specifications: – Keyboard with 32 Braille cells; – 4 keys for the thumb; – 6 control keys; – Extended Braille keyboard (8 keys); Total weight: 524g; Product size: 26 x 8.7 x 1.8 cm; Product price: 16,560.00 RON.
Braille writing machine Perkins Standard  Competitive advantage: High writing speed, low cost [17].	The Perkins Standard Braille Typewriter is a mechanical Braille typewriter that allows you to write the Braille alphabet on special paper, on Braille-type plastic wrap, and with a special adapter on Dymo tape. Technical specifications: – Allows you to write up to 42 characters at a time; – The text can be read while writing; – Made of metal; Dimensions: 22.5 x 15 x 39 cm; Total weight: 5,022 kg; Product price: 4849 RON.
ZY – Tactile diagram  Competitive advantage: Made of PLA, low cost [18].	The ZY- Fuse device is the simplest and fastest way to le images. al Technic pecifications: – Working rate: 4 pages / minute; – Dimensions: 150 x 520 x 500 mm; – Total weight: 7.2 kg; Voltage: 220 V; – Price: 1048 RON.
Everest-D V5 Braille Printer  Competitive advantage: The product is not bulky or heavy, low cost. [19]	Everest-D V5 is a powerful Braille printer that offers a wide variety of solutions for the blind. The unique individual sheet feeder allows embossing of documents. Technical specifications: – Print speed: 120 characters / second; – Graphic resolution: 50 dpi; – Connectivity: USB, WIFI; – Control panel: Braille tags; – Paper sheet size: 25 x 30 cm; – Paper package weight: 15 kg; – Price: 26,548.90 RON.

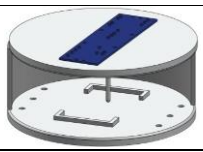
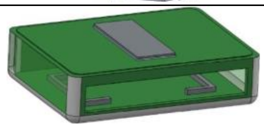
Conclusion: after analyzing the specifications of each product, we noticed that our product has the right advantages to continue its development.

5.1. Presentation of integral concepts

After analyzing the proposed problem, we had to choose from 4 concepts (constructive variants) of the product. These are presented in table 5.1. and will be accompanied by a sketch, together with a detailed description of the process performed.

Table 5.1. Presentation of the complete concepts of the product

Concepts	Sketch with description	
C1		This type of product looks like a 3D printer and has the role of typing on different devices, instead of the person who can not do it on their own. The product has a typing device, having a length and shape suitable for contact between the device and the typing instrument. The keyboard tool has a rubberized tip that helps in direct contact with the device screen.

Concepts	Sketch with description	
C2		This type of product is shaped like a sphere and is easy to integrate in different spaces, it is not difficult and it is easy to handle. The use of the product is very easy, with all the access ways at the user's fingertips. The Braille keyboard is positioned above the device and connects, using electronic components, to the component that performs typing on the device.
C3		Typing on a specific device will be done automatically, with the help of the program that will make possible the interaction between man and device. The movement of the device will be achieved by the action of 7 components that support the typing tool on the device. The system consists of 3 retaining walls, oriented on either side of it, the component that supports the Arduino control board, the top board and the base board of the system.
C4		The typing is performed with the help of a rubber dot that is positioned on top of the main test instrument, and is attached to the upper support plate. For fixing the devices, the system is provided with a portion that holds the device in place, without detaching from the table of the typewriter. The user has quick access to where the devices are placed.

The selected concept is the C3 concept, because this concept best fulfills the functions we want achievable and usable by us, those who develop the product, but also by the people who will use it, in order to make their lives easier.

6. 3D modeling and assembly of the product Multi-device typing device

The mechanical parts covered by this chapter are: device base, retaining walls (3 in number), rod and wall support component, construction rods, assembly support components, device support top, device framing component in the work environment and the supporting component of the Arduino board. At the moment, we have adapted the 3D model in such a way that the proposed study can be carried out. The 3D model was extracted from the Grabcad platform, which is an open-source platform without copyright [20].

The characteristics of the parts will be presented in table 6.1.

Table 6.1. The characteristics of the parts that make up the product

No. part	Part name	Manufacturing technology	No. pieces
1	The basis of the device	Additive Manufacturing	1
2	Retaining wall	Additive Manufacturing	3
3	Component for supporting rods and walls	Additive Manufacturing	6
4	Component that supports the device	Additive Manufacturing	1
5	Construction rod	Additive Manufacturing	6
6	Component to support the assembly in 2 holes	Additive Manufacturing	12
7	Component to support the assembly in 3 holes	Additive Manufacturing	5
8	Component to support the assembly in 4 holes	Additive Manufacturing	1
9	Top support of the device	Additive Manufacturing	1
10	Component that provides typing on the device	Additive Manufacturing	2
11	Component that supports the Arduino board	Additive Manufacturing	1
12	Support component	Additive Manufacturing	6
-	The final ensemble	Additive Manufacturing	-

The product assembly multi-device keyboard consists of the 12 parts described in Table 6.1. Connection conditions between the system components were required for the assembly. The connection conditions between the components represent the geometric position between the elements that make up the product. Next, we applied the additive manufacturing technology to make the final layout of the product.

7. Additive manufacturing of the product Multi-device typing device

This chapter includes the steps followed to carry out the additive manufacturing process, following the completion of the production process and the assembly of the designed parts.
The Z-SUITE 3D printing software was used to complete the process and the Zortrax M300 Plus printer was chosen. The material used was Z-HIPS (white).

Fused Deposition Modeling (FDM) or Fused Filament Fabrication (FFF) is an additive manufacturing process that belongs to the material extrusion family. In FDM, an object is constructed by the selective deposition of molten material in a predetermined path, layer by layer. The materials used are thermoplastic polymers.
FDM is the most widely used 3D printing technology: it is the largest installed base of 3D printers globally and is often the first technology to which people are exposed. [21]
The features of the Zortrax M300 Plus 3D printing software are shown in Table 7.1..

Tabele 7.1. Features of the 3D printing software, Zortrax M300 Plus

3D printer	Description	The software used
	Zortrax M300 Plus Technology: LDP (Layer Plastic Deposition) Layer resolution: 90-290 microns Construction volume: 300 x 300 x 300 mm Minimum wall thickness: 400 microns Material diameter: 1.75 mm Nozzle diameter: 0.4 mm Materials: Z-ULTRAT, Z-PETG, Z-GLASS, ZHIPS, Z-ASA, Pro, Z-PLA Pro, Z-ESD. [22]	Z-SUITE[23]

In order to perform the part printing operation, they were converted to STL files and added one by one to the Z-SUITE printing software. 2, 3D printers were used in the printing process.

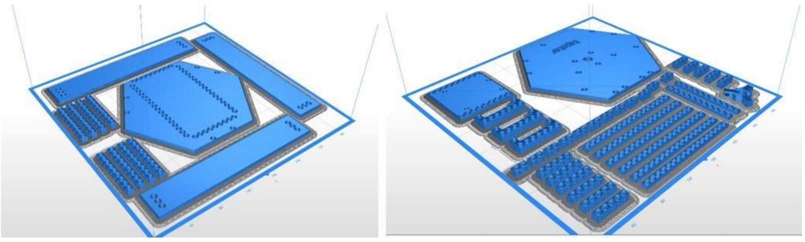


Fig. 7.1. Printer 1 (see left), Printer 2 (see right)

The following parameters have been set for making parts on printer 1:

- The material used is Z-HIPS.
- The settings for setting the media have been set to be editable.
- The nozzle diameter is 0.4 mm.
- The thickness of the print layer is 0.29 mm.
- Print quality is normal.
- The print time was set to normal and model 0, with a fill density of 50%.
- The print point starts randomly.
- Filling the thin walls is set to a maximum thickness of 2.63 mm.
- The size of the area underlying a single support pillar is set to be editable with a 7 pcs layer.
- First Layer Gab sets a gap between the cork and the first layer of a model and has been set to 0.42 mm.

After choosing the printing parameters, we decided that we do not need support structures, because the parts do not have complex shapes.
Depending on the chosen parameters, the printing time was established (17 hours and 23 minutes) and 269 grams of material were used. Printer 2 had the same printing parameters, but the resulting time was 17 hours and 53 minutes, 225 g of media were used.

Fig. 7.2. Estimated printing time

8. Conclusions

At the moment, we have assembled the 3D printed parts and noticed the need for other parts to be designed and added as a whole. Next is the purchase of control components: servo motors, controller, etc. The final product will have a control software, which will make possible the interaction between the person using the device and typing on the device.

Subsequently, tests will be made on the functionality of the parts, but also on the system that will be put into operation, and thus other improvement decisions will be made.

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