Access of visually impaired people to cultural and historical heritage using Braille visualization

D. Karastoyanov, N. Stoimenov.

***Abstract*—**The paper presents a new technology for access of visually impaired people to graphical information using Braille display. In the state of the art are shown different existing devices, realized ideas and conceptual models. The technology for graphical Braille display on the base of linear electromagnetic micro drives is shortly described. Previous experience of the team is shown, including tactile tiles representing tapestries of “Pavia Battle 1525”. Future steps for development of the described above Braille display technology are considered.

***Keywords*—** Braille display, cultural and historical heritage, digitization, tactile graphics.

I. Introduction

THE integration of people with disabilities and disadvantages, the provision of equal rights in society to these social groups, assisting them in their work, social realization, and career development is extremely important for the development of society as a whole.

A device, called Braille display can help to those people. The device visualizes Braille alphabet and graphics as well as pictures for visually impaired people. Nowadays there is no developed such device for graphical purposes. In the presented work, a prototype of the screen will be presented. It will allow blind users to "see" the screen and give feedback according to the resolution and the “pixel” density of the screen. The density is very important and helps to produce a detailed image. On the other hand, it must be compliant to the user capabilities and to the device possibilities.

This work aims to investigate and make conceptual models for future development of the technology, which will contribute to improving the quality of life of the low sighted people.

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II. State of the Art

Visual impaired people have difficulties to work with graphical computer interface (Windows icons) and to understand pictures or other 2D objects of cultural-historical heritage. The assistive interface for unsigned or blind people we divide in two groups – for text and for graphics visualization. In each of these groups they are subgroups depending on the movement method of the elements, presenting text/graphics touchable way.

Graphic environments that allow intuitive work for normal users, creates great difficulty for the blind people. Based on the fact that navigation and individual programs are presented beforehand in the form of pictograms, it is concluded: People with visual impairment need a new concept of working with computer. This disadvantage can be eliminated by using tactile displays. [1], [2], [3].

Nowadays, a number of devices have been developed to help visually impaired people. They can be divided into several major groups: Braille matrices; Braille terminals; Braille printers; Braille mice; Braille keyboards. Depending on the functions that such terminal offers, prices reach up to several thousand dollars [1].

Braille is a tactile writing system used since 1824, with symbols traditionally printed on embossed paper. In the modern era, electronic devices provide refreshable Braille displays. One of the existing on the market device [1] is a Braille terminal (fig. 1). It consists of 40 or 80 cells with 2x3 needles in each cell. The movement of each needle (pin) is electro-mechanical. The device is very expensive (12 000 USD) and can display a line of up to 80 Braille symbols.

Fig. 1. Braille terminal.

Other way of movement is by using piezo effect - crystals, which increased or reduced their size when electricity is provided on them. The resizing is transformed into mechanical vertical movement. Each pin has an own crystal, so this is very technological difficult. The device have an additional buttons for computer functions, [2], [3], [4].

Another example of Braille device is the Bulgarian Braille tablet Blitab, shown on fig. 2. It visualizes text and will be in mass production next year, with expected price about 500 euro (the available devices cost between 2,500 and 14,000 USD depending on the technology used). The Blitab consists of two main functional parts: a Braille tactile screen with 14 lines changing surface and a touch screen for navigation and application usage [5].

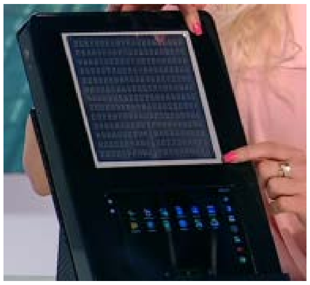


Fig. 2. Blitab.

The ZIXEL technology uses mini piezoelectric linear drive motors, to support the Zixel actuation (fig. 3). These ultrasonic motors create high force and speed with few built-in parts. The reason of employing mini piezo motors is their much smaller sizes than previously used electromagnetic and pneumatic methods to support linear actuation. A linear stack of ten miniature 2.8mm cubes is mounted over the shaft of the linear actuator, [6].

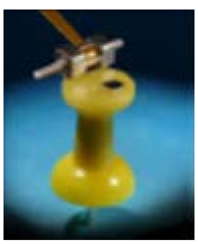


Fig. 3. Zixel element.

There are interesting conceptual models that have the idea of displaying not only Braille symbols but also graphics. These are only conceptual models that have not been realized yet. An example of such model is the DrawBraille (fig. 4) – the left side of the phone is the display; it has a series of mechanical dots in groups of 6, that can display Braille characters. There are 5 rows, each containing 7 cells of 6 dots each. The right side of the phone is the input area and contains 20 touch-sensitive squares arranged in 5 x 4 matrix. The middle 6 squares represent the 6 possible dots that form a Braille character. The user enter each character by touching the corresponding squares, that represent the Braille character [7].

Fig. 4. DrawBraille phone.

A refreshable Braille Screen was announced in 2016 (fig. 5). Researchers from the University of Michigan are working on a Braille tablet that, thanks to the use of microfluidics, could display complex information as graphs and charts, all while still being mobile. The Braille display uses air or liquid bubbles to create the raised dots on the screen. The technology also makes it possible to fit as much as 10,000 dots on the screen, which would allow for interpretation of complex data, so visually impaired persons could read scientific and mathematical information from a tablet more easily. It is expected that the microfluidic technology will help to produce much smaller and lighter devices than current Braille displays, which use motorized plastic pins that move up and down [8].

Fig. 5. Refreshable Braille Screen.

III. The New Graphical Braille Display

The patented Braille display is with simple structure and easy conversion technology with improved static, dynamic and energy performance, as well as to apply a common link between all moving parts, an extended tactile feedback and a highly efficient start up with low energy consumption [9], [10], [11], [12], [13].

The dynamic screen is a matrix with linear electromagnetic micro drives (LEMD). When a signal is processed to the device, the pixels will display on the screen the image. Paintings and artifacts from museums can be digitized and used as images, thus visually impaired users will be able to "see" these historic objects touchable way.

The display represents a matrix comprised of a base with fixed electromagnets, arranged thereon. The display element (fig. 6) includes an outer cylindrical magnetic core, in which a winding magnetic core locking up the cylindrical magnetic core at the top side and a winding magnetic core locking up the cylindrical magnetic core at the bottom side are placed, where the magnetic cores are with axial holes, and into the space between the windings a movable non-magnetic cylindrical body is placed, carrying a cylindrical permanent magnet axially magnetized and a non-magnetic needle, passing axially through the permanent magnet and the axial holes of the magnetic cores, and the top side of the permanent magnet a ferromagnetic disc is arranged having an axial hole, and on its underside a ferromagnetic disc is arranged having an axial hole wherein, the upper disc and the upper magnetic core have cylindrical poles and the lower magnetic core and the lower disc have conical poles, and above the electromagnets a lattice is placed with openings through which the needles pass [9], [10], [11], [12], [13]..

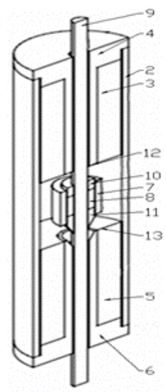


Fig. 6. Braille Display element.

Advantages of this device are the retention of the needles (elements) in their final positions does not need an external power supply, as it is provided by the permanent magnet; intermittent power supply voltage with which an extremely low power consumption is achieved (only when moving needle from one end to the other); reduced size; extremely low electric and mechanical time constants, resulting in very good velocity and dynamic characteristics; realizable tactile feedback; representing besides letters and numbers, graphic symbols (roots, integrals), images of icons, paintings in the case of larger matrix and others can be written on the tactile (Braille) matrix; positioning accuracy and stability [9], [10], [11], [12], [13]..

IV. Previous experience

It is interesting how visually impaired people touch and examine the graphics (pictures, icons, contours, etc.)

Our previous works (Restoration of historical events for Exhibition in Pavia Castle - a satellite event of EXPO 2015 – Milan, Italy), in cooperation with Pavia University – Italy, shows that digitalization of paintings, masterpieces, etc. can be produced with 3D printers (fig. 7). After digitalization is used appropriate 3D softwares for developing 3D models. The models were printed with 3D printers. The tactile tapestries were produced with three depths: base level (for bottom and inner contours), level 1 (outer contours), and level 2 (Braille letters). The different levels helps to visually impaired people for better representation of the tapestries.

This method is good and effective way to represent the static content to the visually impaired people [14].

a) Tapestry from Pavia battle.

b) 3D Tactile image of tapestry from Pavia battle.

Fig. 7. Tapestry from Pavia battle: a) Tapestry, b) Modelled and 3D Printed tactile tapestry.

V. Future steps

Now the future step after developing the Braille display, is to produce and represent dynamic pictures.

It is important to be examined the size of the pixels, density of the pixels, the refresh rate, as well as height of the pixels. A possibility of two level of pixel heights is considered.

These parameters are extremely important to the visually impaired people (users). Simulations with different images and different size, holding force and pixel density of the linear electromagnetic micro drives, of the permanent magnets and of other elements were made.

The existing device (fig, 8) is made with low-resolution, due to the fact it is used for testing.

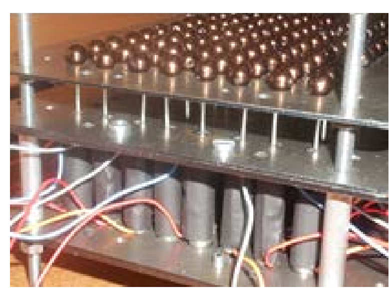
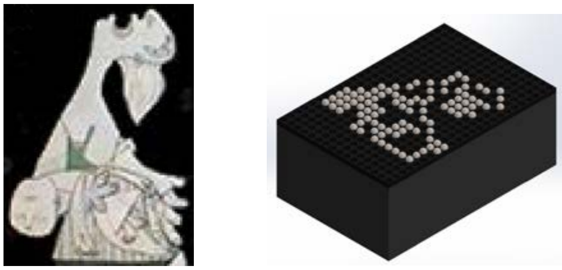


Fig. 8. Existing device.

Simulations with the existing device are provided. The aim of the simulations was to examine the pixel density.

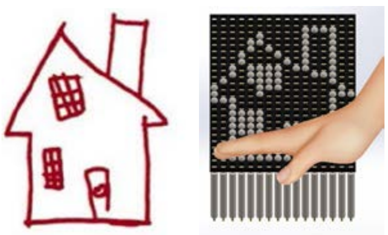
It is not appropriate for big and complex masterpieces (etc. Courage mother from Picasso), shown on fig. 9.



a) image b) simulation

Fig. 9. Simulation of complex image with low-resolution screen.

For simple simulations of draw with low-resolution it is satisfying, (fig. 10).



a) draw image b) simulation

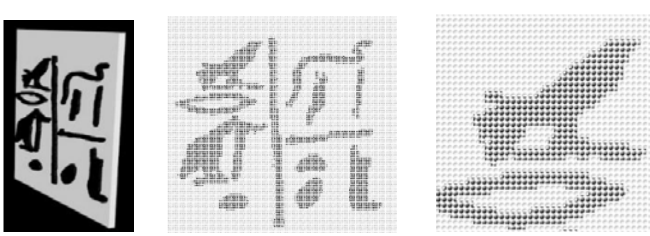
Fig. 10. Simulation of simple painting with low-resolution screen.

Fig. 11 represents an image, shown on high-resolution display. Technically, due to the technology, there is no limitation for the size of the display. The problems that may occur are mobility (due to the size), power supply, price, etc. The idea is high-resolution displays to be used from museums and other facilities, where many people can visit and explore.

a) 3D model b) tactile simulation

Fig. 11. High-resolution display.

It is considered a zooming option for better representation of images for smaller displays (fig. 12). The smaller displays will be more mobile, can be used at home, etc. Simulations show a zooming option for image and segment of the image.



a) 3D model b) image c) zoomed detail

Fig. 12. Zooming option.

VI. Conclusion

The state of the art shows that nowadays still there is no device, which can provide detailed picture or graphic for visually impaired people. Previous experience shows that 3D technology is a good and appropriate way to represent painting and masterpieces by producing 3D tactile images for low sighted or blind users. The developed testing device of Braille display on the base of synchronous and simultaneous controlled linear electromagnetic micro drives shows that the patented technology is simple, appropriate and energy efficient. Future steps for developing and optimization of the existing device are discussed. The medium size of Braille display is acceptable for an assistive computer interface, helping low sighted or blind users to work with graphical OS (Windows icons). It is extremely important to continue future developments and tests not only for Braille display but also similar devices, due to the fact that visually impaired people can have access to objects of the cultural-historical heritage using graphical Braille displays, tactile tiles etc.

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