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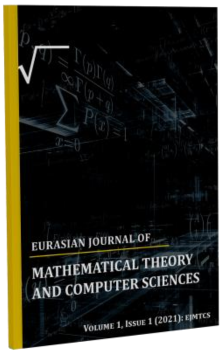

DESIGN OF A PROTOTYPE OF A SINGLE-CELL REFRESHABLE BRAILLE DISPLAY

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ABSTRACT

With the rapid development of information technology in recent years, it is imperative that modern technologies are integrated into our daily lives. Advancements in technology are transforming our daily lives, providing wide opportunities for all regardless of physical ability. Even individuals with disabilities, including the blind and visually impaired, can be literate through learning the Braille system, thanks to technological advances. Braille-based devices are crucial tools for individuals who are blind or visually impaired to learn new skills. This paper proposes a single-cell Refreshable Braille Display that is innovative and straightforward in design, making it highly beneficial for users.

Introduction.

Braille is a writing system for people with visual impairments, including those who are blind, deafblind, or have low vision. It was invented by French inventor Louis Braille.

In recent years, interest in conducting research in the development of Braille-based gadgets and devices has increased around the world, including in Uzbekistan [1-5].

One of the most common Braille-based devices is Refreshable Braille Displays. A Refreshable Braille Display (RBD) is a device that uses pins to raise braille characters on a flat surface. Computer users with visual impairments can read text output using non-standard monitors.

There are three main types of Refreshable Braille Displays (RBDs): standalone displays, notetakers, and smart display devices. Although each functions differently, they share similar characteristics [6].

Stand-alone braille displays. This type of Braille display comes in different variations, with varying numbers of braille cells and keyboard options for braille input. Some displays are solely for the purpose of showcasing braille. Other features commonly found on standalone braille displays include cursor routing buttons and navigation keys.

Notetakers. Notetakers are commonly used by students for classroom work and test-taking. They are portable and can connect to the internet.

Smart display devices. This type of RBD is a cross between stand-alone displays and notetakers, with limited functionality. They are usually small, portable, and can perform utility functions like device clocks, calendars, and e-book reading.

The rest of the paper follows this structure: The “Related work” section is dedicated to the overview of existing research on the topic. The “Modeling and Design” section proposes a design approach for single-cell refreshable braille display. The section “Conclusion” concludes this paper.

Related work.

Due to the advancement of science in recent years, various Refreshable Braille Displays based on Braille are being developed. In [7], it is developed an integrated open-source hardware and software solution based on a single Braille cell concept. The system was evaluated by blind volunteers with varying levels of Braille knowledge and computer experience. In [8], it is discussed the development of a dynamic/refreshable Braille display which presents Braille points by the up-and-down movement of pins using a Cam actuated mechanism with just two actuation points instead of a standard six used by every refreshable Braille board. In [9], it is proposed to create a display model that can show multiple lines of text simultaneously, with the ability to adjust the number of lines displayed. It is also designed a three-dimensional model of the multi-line Braille display. In [10], it is proposed a single-cell refreshable braille display with six custom-made electromechanical flapper actuators. The proposed system incorporates speech functionalities to facilitate self-learning and independent operation. The learner can adjust the cell size by moving the actuators to their preference. In [11], it is presented a flexible Braille display called BrailleRing. The BrailleRing is a rotating ring with tactile characters that refreshes Braille displays for the blind.

Another interesting found in [12]. In the study, it is presented a rationale for the actuating method and a design solution implemented in a working prototype of the mechanism. In [13], it is developed a novel refreshable Braille display based on the layered electromagnetic driving mechanism of Braille dots. In [14], a portable Braille reading system is developed based on electrotactile display technology. The proposed system consisted of a six-channel electrotactile stimulator, a flexible electrode array for Braille display, and a graphical user interface (GUI) for monitoring and control. In [15], it is reviewed the braille display technologies in various developed and developing countries. The paper proposed a concept design for an inexpensive, portable, refreshable braille generator using electromagnetic relays and solenoids. In [16], it is designed and developed a one-character refreshable braille display that is affordable and easy to use through the Internet of Things (IoT) technology. According to the study, it concluded in their future work they reduce the prototype's size and carry out tests with users to validate its usability, usefulness, and efficacy. In [17], a novel method called the linear Braille alphabet which represents Braille characters using the vibration engine of a mobile device operated via vibrotactile signal sequences is proposed. In the study, there conducted two different tests for distinguishing distinct sequences and characters over a subject group of 50 clear-sighted people. Based on the test conducted, the method used has a signal distinguishability rate of 99% and character distinguishability rate of 97%. The maximum duration for a single character is 1050 ms. Furthermore, a second test carried out on 10 visually impaired users showed a signal distinguishability rate of 90% and a character distinguishability rate of 82.5%. In [18], it is given an overview of available Refreshable Braille Displays. In the study, it is covered Refreshable Braille Displays such as BI 40, BraillePens, EDGE 40, Focus Blue Family, HIMS, insideONE, Orbit and QBraille XL. In [19], it is given an overview and compared trends in braille display where there is a deviation from the standard braille presentation. In the study, various aspects of alternate Braille designs, including relative cost, convenience, and reading speed are reviewed. In the study, there are outlined the standard braille display designs with different actuators and presented the alternate modes of displaying braille. In [20], it is introduced a new working model of a computer display board designed specifically for blind individuals. The proposed prototype aimed to transform an ordinary computer screen into a tactile braille display board. The proposed name for this device is the "Arranged Blind Computer Display Board" or ABCD for short. Finally, The design and characterization of a new cost-effective single-cell Electromagnetic Refreshable Braille Display called Readable is presented in [21].

To summarize, the overview of the previous contribution mentioned above on Refreshable Braille Displays is based on hardware approaches. However, none is based on a design presented in this work. In this study, a single-cell Refreshable Braille Display specialized for 6 Dot Braille standard is designed.

Modeling and Design.

Autodesk 3ds Max software was used to design the 3D model of the proposed display. Autodesk 3ds Max is a professional software used for 3D modeling, animation, visualization, and game design which Autodesk developed.

Initially, the micro stepper motor - one of the essential components for the proposed display was designed. A 3D model of the micro stepper motor is shown in Fig. 1.

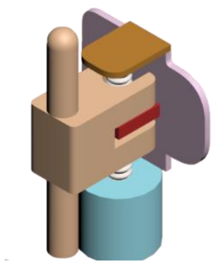

Fig. 1. 3D model of the micro stepper motor

The next step is to design an inside part shell of the proposed display for installing micro stepper motors. A 3D model of the inside part shell of the proposed display for installing micro stepper motors is shown in Fig. 2.

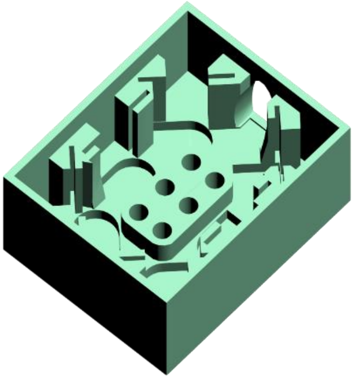

Fig. 2. 3D model of the inside part shell of the proposed display for installing micro stepper motors

The next step is to install micro stepper motors in an inside part shell of the proposed Braille display. A 3D model of the installation process of micro stepper motors in an inside part shell of the proposed Braille display is shown in Fig. 3.

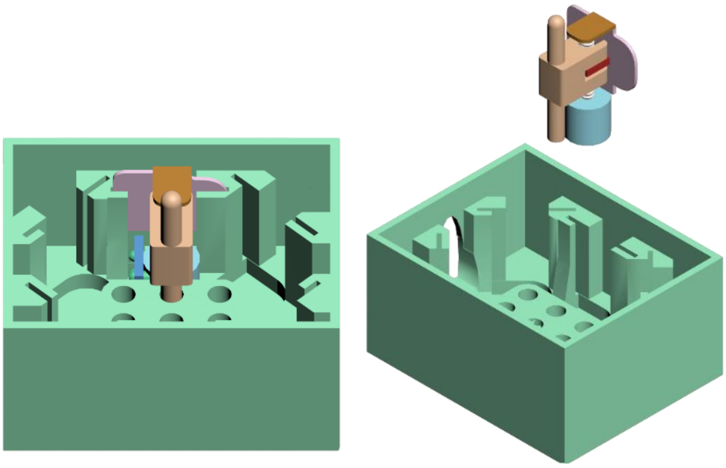

Fig. 3. 3D model of the installation process of micro stepper motors in an inside part shell of the proposed Braille display

A 3D model of all six micro stepper motors installed in an inside part shell of the proposed Braille display is shown in Fig. 4.

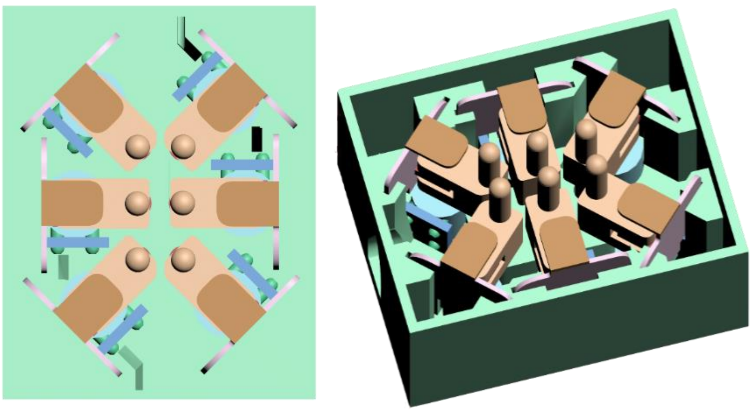

Fig. 4. 3D model of all six micro stepper motors installed in an inside part shell of the proposed Braille display

The next step is to design the top part of the shell of the proposed Braille display. A 3D model of the top part of the shell of the proposed Braille display is shown in Fig. 5.

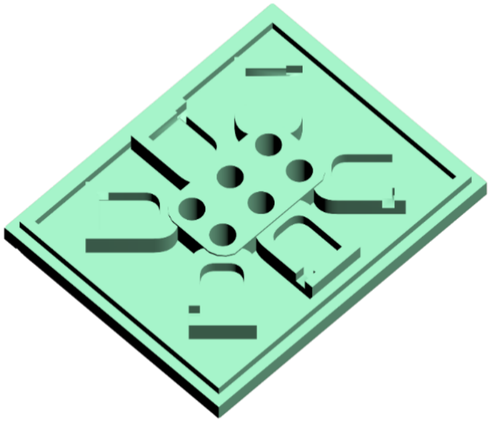

Fig. 5. 3D model of the top part of the shell of the proposed Braille display

Finally, a 3D model of the proposed Braille display is shown in Fig. 6.

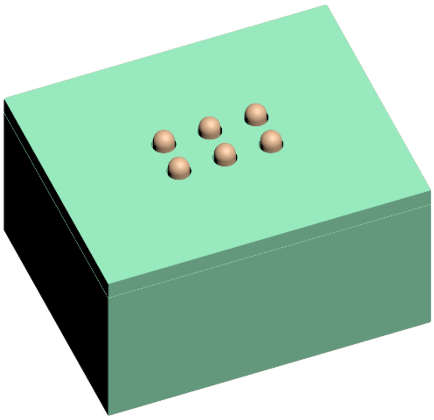

Fig. 6. 3D model of the proposed single-cell Refreshable Braille Display

Conclusion.

Due to the likely increase in the number of blind and visually impaired individuals globally, accessibility tools for daily communication and learning for the blind and visually impaired individuals have become increasingly crucial. In this paper, we propose a design of a single-cell Refreshable Braille Display that is innovative and straightforward in design, highly beneficial for users in daily communication and education.

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