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Raspbraille: Conversion to Braille Alphabet with Optical Character Recognition and Voice Recognition Algorithm

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ABSTRACT

It is quite difficult for visually impaired individuals to read a physically printed material. It is a necessity to provide information flow and communication between visually impaired individuals and other individuals. For this purpose, an alphabet has been developed for visually impaired individuals. With this alphabet, which is called the Braille alphabet, it is possible for visually impaired individuals to access written culture. There are special letters in the alphabet designed for the visually impaired. With the development of technology, studies in the field of Braille alphabet have increased. Optical character recognition (OCR) technology can convert the letters on files such as pdf, pictures, photos into understandable data by selecting and separating them. Speech recognition algorithm, computer, tablet, mobile phone, voice recorder devices, etc. It is the process of detecting and recognizing the human voice through a microphone with technological products. Within the scope of the study, a device has been developed for Braille alphabet by using optical character recognition technology and speech recognition algorithm. First, the images of each page of the books that were requested to be translated into Braille alphabet were taken. Then, a transformation was performed using a specific character set with the optical character recognition algorithm. Audiobooks, on the other hand, were first converted into text and then into Braille alphabet using speech recognition algorithm. With these converted characters, a physical hardware device has been developed to display Braille letters that visually impaired individuals can read faster.

Keywords:
Optic character recognition; Voice recognition; Braille; Raspberry; Servo motor; Servo motor driver.

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INTRODUCTION

The right to life is a basic human right and being healthy is a prerequisite [1]. Health is not only the absence of disease and infirmity, but also a state of physical, mental and social well-being [2]. Therefore, health is a fundamental right and need for every individual, but some individuals may become disabled due to congenital or later reasons [1].

The restrictions and barriers that people have are divided into four categories under the name of "disability types". Types of disabilities consist of four different types as mental disability, hearing disability, physical disability and visual disability [3]. Intellectual disability is a type of disability and deficiency that causes the individual to lag behind their peers in understanding, making sense of events, and social and practical adaptation skills [4]. Intellectual disability is also expressed as difficulty in solving problems, learning difficulties in the field of education, and a retardation in making sense of abstract situations and comprehending situations obtained through experience.

It is also the most common type of disability among children with disabilities, and its physical aspects, ability abilities, etc. They are very similar to normal children in such situations. Educable mentally retarded children comprise approximately 85% of all mentally retarded children [5].

Hearing impairment, the human ear has the ability to perceive certain sounds, and the inability to perform this ability adequately is called hearing loss [6].

The audiogram graph is a graph showing the hearing loss in both ears and is the amount of sound that a person can hear. At the beginning of the chart are numbers from 125 to 8000. These are frequencies, that is, different pitches. If a normal individual cannot hear

the sound in this value range, it means there is a hearing impairment. People who have completely or partially lost their hearing are called "hearing impaired" [7].

Individuals who have lost their physical abilities in various degrees due to physical disability, disorders in the nervous, musculoskeletal system are called physically disabled individuals.

These physically disabled individuals have difficulties in adapting to society, meeting their needs in their daily lives, etc. situations are difficult. These individuals have needs such as support, counselling, protection and care.

Diseases causing physical disability are listed as follows in [8].

- Cerebral Palsy Disease
- Mental Motor Retardation
- Congenital Arm Paralysis
- Metabolic, Degenerative and Genetic Diseases Affecting the Central Nervous System
- Spinal Cord Closure Defects
- Traumatic Nervous System Injuries
- Congenital Muscle Diseases

Today, there are some treatment methods for physical disability caused by the above-mentioned conditions.

Visual impairment, congenital or disease, accident, etc. for some reasons. People who have lost their sight as a result of not being able to fulfill the function of the organ of vision due to situations such as visually impaired individuals.

Visual impairment; They are divided into two groups as those who have never seen (blind) and those who have low vision. Individuals with a visual acuity between 20/70 and 20/200 are defined as blind, and individuals with a visual acuity between 20/70 and 20/200 are defined as low vision [9].

This type of disability affects their lives negatively, as visually impaired individuals face difficulties in their daily activities, social development, and skills such as learning and making sense [3].

Within the scope of disability types, with the development of technology, various products have been produced that can make the lives of people with disabilities a little easier. In addition to the products produced in the project work, a hardware device has been developed so that visually impaired individuals can benefit from this information, access data in electronic environments and improve themselves as a result of the information increasing with the rapidly advancing technology. Thanks to this developed device, it is aimed to make it easier for visually impaired individuals to access the resources that normal people can access

RELATED WORKS

Within the scope of the study, a system that converts written texts and audio files into Braille alphabet has been developed. After the files given as input are converted, Braille letters are seen as output on the device. Optical character recognition algorithm is used in the conversion of written texts. For audio files, text conversion was performed using the voice recognition algorithm.

Studies carried out to facilitate the lives of visually impaired individuals and the algorithms used in the current study and studies brought to the literature are explained under this title.

In 2022, Şahin et al. developed a software for converting physical business cards to digital. Within the scope of the software, there is an interface for the transactions to be made on the business card. The physical business card is uploaded to the system either as a file or photographed. The uploaded file is converted into text using the Optical Character Recognition: OCR method. The obtained texts are separated and grouped. The converted digital business card data is stored numerically in a cloud-based database. Experimental studies were carried out on 15 physical business cards with the developed software. It can parse the data on the business card by reading it with 84.76% Accuracy, 96.05% Precision, 84.88% Sensitivity, 90.12% F1 Score and an average extraction time of 1.6 seconds [10].

Bakır et al. developed applications for banking transactions. They used the optical character recognition method in the application. They presented a system for classifying banking orders from customers and determining the trading parameters of these orders using machine learning techniques. The presented system uses optical character recognition and shape detection technologies to extract texts and tables from images, namely scanned e-mail attachments and fax images. Developed in 2022, this application is used in a medium-sized bank [11].

Voice recognition studies are a subject that has been studied since 1950 and is still being studied. Voice recognition processes are applied in many areas such as speech recognition, speaker recognition, identification, gender recognition, conversion of voice to text [12].

I. Avcı and M. Yıldırım developed an application for visually impaired individuals in 2021. With the application, people are enabled to recognize the objects around them. There is also voice over in the application. In this way, visually impaired individuals both find opportunities to re-

cognize the objects around them and it becomes easier to find their way. Within the scope of the study, they used the YOLO algorithm for object detection. They used the artificial neural network method for the training of the application [13].

R. Sawant et al. In their project in 2021, they developed a device that converts text to Braille alphabet. They took the letter data from the computer keyboard and processed it with the help of source code. In order to simulate the letters in the Braille alphabet, six metal rods were connected to the rotating arms of the motors with the help of six servo motors connected to the Arduino. Servo motors made the rods move back and forth when rotated by a small angle. This back and forth movement of the rods caused a depression or elevation on the surface of the device. With the movement, they took the Braille alphabet as a printout [14].

S. Kumari et al. In 2020, they developed a Braille system to help visually impaired people read text or their content. With the project they developed, they provided access to documents not in Braille or electronic data for 37 million visually impaired citizens around the world. They took the image data with the camera and processed it with image processing techniques. In this way, the data received from the camera was converted into text, and then the characters in the text were converted to Braille code with Raspberry Pi. They showed the Braille code as output with the help of the solenoid [15].

Ilya G. Ovodov developed an optical Braille recognition method that uses an object detection convolutional neural network to detect all Braille characters at once. With the algorithm developed for the method, the deformation and perspective distortions that occur in the image are prevented. It renders all images renderable, including tilted pages and distorted images taken with a smartphone camera. Thus, conversion to Braille alphabet on the image taken as input has become more lossless and easy to do. This algorithm showed high performance and accuracy compared to existing methods. In addition, a new dataset named "Angelina Braille 21 Images" containing 240 annotated photographs of Braille texts has been brought to the literature with the study [16].

M. T. Meral and M. M. Özbilen performed the vocalization of texts such as books and magazines by using optical character recognition, sound synthesis and voice recognition processes for the visually impaired, the elderly and individuals who do not have the knowledge of reading and writing. They have developed an application for this. In addition, directions for a place you want to go are given in the application [17].

MATERIAL AND METHOD

It has been determined and realized as a goal to facilitate the lives of visually impaired individuals, thus enabling them to access resources, books, documents and texts that other individuals can access. Fig. 1. The algorithms used in the project, the steps followed and the use-case diagram of the data to be obtained as a result of these processes are included. Within the scope of this project, documents, texts, papers, etc. Written materials such as these have been translated into Braille alphabet that visually impaired individuals can read.

The conversion process into the alphabet that visually impaired individuals can read in the project was carried out in two different steps. As a first step, optical character recognition algorithms and optical scanners, documents taken with a camera, special circuit boards, etc. By transferring the documents obtained with the devices to the digital environment, it is ensured that the paragraphs, words and letters in the document are obtained as an output.
Another step, the algorithm of transforming the voice into text, has enabled the conversion of the speech voice received by people with technological devices (mobile phone, computer, voice recording devices, etc.) into a readable text. A transformation of the letters, characters or words in the texts obtained with the conversion made in two different ways was carried out with the pre-created dataset [18] for the Braille alphabet used by visually impaired individuals. As a result of this transformation, the data converted to Braille alphabet was shown on a prototype hardware device.

The area shown as Algorithm 1 in Fig. 1 represents the optical character reading algorithm, and the area shown as Algorithm 2 represents the Voice Recognition algorithm.

Dataset

In this study, a ready data set was used for the corresponding character in Braille alphabet of each character taken as input [18]. The data set used is shown in Table 1. Symbols such as characters, numbers, letters and each corresponding Braille value are in the Braille column of Table 1.

Data obtained from Optical Character Recognition and Voice Recognition algorithms are given as input to the algorithm developed within the scope of the study. Then, the algorithm converts each input data into Braille alphabet by looking at Table 1.

Random data was used to control the accuracy of the conversion process, that is, whether the device produces the correct result. For the OCR algorithm, a page was drawn from a random book, and for the voice recognition algo-

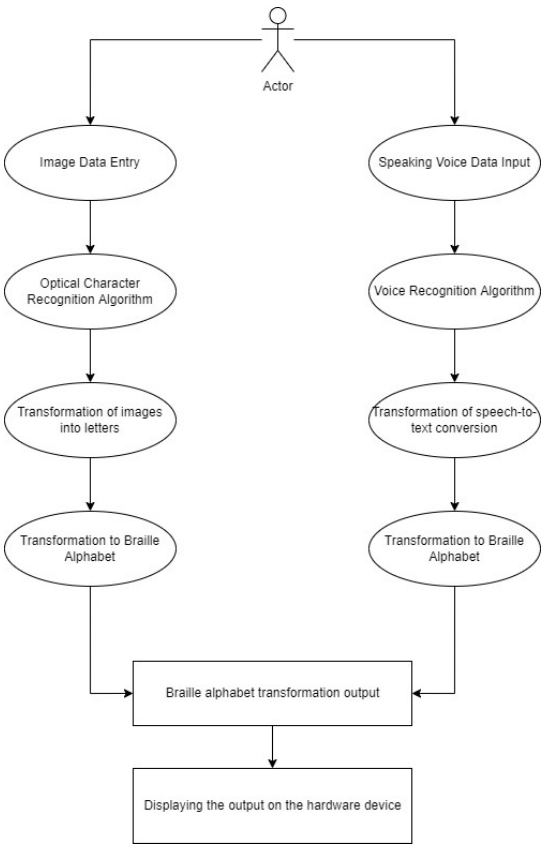


Figure 1. Unified Modelling Language(UML) Diagram of Conversion Project to Braille Alphabet with Optical Character Recognition (Algorithm 1) and Voice Recognition Algorithm (Algorithm 2).

rithm, a randomly found story was given as input, and the algorithm was run.

Optical Character Recognition Algorithm

Optical character recognition (OCR) technology can edit and convert documents, .pdf files, and images captured by the camera into searchable data. This technology selects and separates letters from pictures and gives us words from letters, sentences from words, and paragraphs as an accurate output. The optical character recognition background with black dots at the input is white, i.e. letters, numbers, symbols, or other images, etc. It has a structure to be perceived and read. Optical character recognition technologies are not used for the recognition of visual objects such as pictures, photographs, tables, and figures in the document. Fig. 2 shows the steps of the optical character recognition algorithm technique. In the preprocessing step, the color document is converted to a gray-level document. In the feature extraction step, the center of the character is taken, the longest radius, trace steps, the beginning of the sector, and the relationships of the pixels that make up the character are determined. In the next step, the characters are classified by looking at the attributes extracted in the previous step. In the model step after the process, the characters that cannot be de-

Table 1. Symbols and Braille Letter Values of Symbols

Symbol	Braille	Symbol	Braille
' '	' '	'!'	'⠖'
'"'	'⠐⠂'	'#'	'⠩'
'$'	'⠫'	'%'	'⠩⠴'
'&'	'⠯'	''	'⠄'
'('	'⠷'	')'	'⠾'
'*'	'⠡'	'+'	'⠬'
','	'⠐'	'-'	'⠤'
'.'	'⠲'	'/'	'⠌'
'0'	'⠴'	'1'	'⠂'
'2'	'⠆'	'3'	'⠒'
'4'	'⠲'	'5'	'⠢'
'6'	'⠖'	'7'	'⠶'
'8'	'⠦'	'9'	'⠔'
':'	'⠱'	';'	'⠰'
'<'	'⠣'	'='	'⠿'
'>'	'⠜'	'?'	'⠹'
'@'	'⠈'	'a'	'⠁'
'b'	'⠃'	'c'	'⠉'
'd'	'⠙'	'e'	'⠑'
'f'	'⠋'	'g'	'⠛'
'h'	'⠓'	'i'	'⠊'
'j'	'⠚'	'k'	'⠅'
'l'	'⠇'	'm'	'⠍'
'n'	'⠝'	'o'	'⠕'
'p'	'⠏'	'q'	'⠟'
'r'	'⠗'	's'	'⠎'
't'	'⠞'	'u'	'⠥'
'v'	'⠧'	'w'	'⠺'
'x'	'⠭'	'y'	'⠽'
'z'	'⠵'	'['	'⠪'
'\'	'⠳'	']'	'⠻'
'^'	'⠘'	'_'	'⠸'

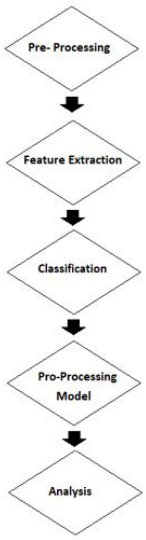


Figure 2. Block Diagram of Optical Character Recognition Algorithm 1

tected correctly with the optical character are tried to be defined. Basically, this process is performed by a method that is applied over the similarity ratios to the previously properly translated characters. In the final step, all translated characters are analyzed and verified.

Optical character recognition algorithm technology has made it very easy to convert documents into digital copies. In this way, it has advantages such as saving individuals time, reducing their efforts and reducing human errors.

Voice Recognition Algorithm

With the development of technology, there are many technological developments such as voice recognition, automatic voice recognition systems, conversion of voice to text or text to voice. Voice recognition system, which is a popular field of study, has been a field that has been studied since the late 1950s. Microsoft describes this field of study as a technological revolution [19]. Within the scope of this project, the algorithm of converting the voice to text has been used. Voice to text (STT: Speech to text) technology is used in microphones, voice recorders, telephones, computers, etc. It enables the voice spoken by people to be converted into a readable text with technological devices [20]. Speech recognition systems are widely used in many fields such as voice response system (IVR: Interactive Voice Response), education systems, call centers, devices used in smart home systems, security systems, interviews in the field of news and journalism, interviews or archiving of interviews. In situations such as interviews and interviews, there is a need for the voice to be converted into text. In this context, Fig. 3. In



Figure 3. General Architecture of the System [10].

the work architecture in the study, it is ensured that the silence is perceived first and then transferred to the text, and the texts are obtained by combining the words [21].

Hardware Device

With the hardware device made within the scope of the project, a prototype device that displays the Braille alphabet that visually impaired individuals can read has been developed. The materials used for this device are Raspberry Pi 4, six servo motors, adapter, servo motor driver and 3D printer.

Raspberry Pi 4

Raspberry Pi 4 is a small computer released in 2019. Raspberry Pi 4 in Fig. 4. This card, developed by the Raspberry Pi Foundation in the United Kingdom, plays a major role in making children interested in coding and loving electronic products thanks to this electronic circuit [22].

Raspberry Pi 4 [23] can be used like a computer if the



Figure 4. Raspberry Pi 4 [23].

monitor, keyboard and mouse are powered together.

Raspberry Pi 4 features: Broadcam BCM2711 processor and operating frequency of 1.5 GHz, Cortex-A72 with 4-core Advanced RISC Machines architecture (ARM architecture), LPDDR4 Random Access Memory (RAM) and three different RAM options, 2 GB, 4 GB, 8 GB, two Universal Serial Bus (USB) 3.0 and two there are USB 2.0 ports, bluetooth 5.0, two micro High Definition Multimedia Interface (HDMI) ports and General-Purpose input/output (GPIO) pins. Raspberry Pi 4 has 10% faster speed than its predecessor [24].



Figure 5. Tower Pro MG90s Servo Motor [25].

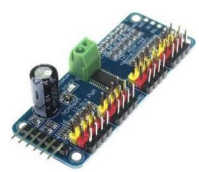


Figure 6.PCA9685 16 Channel 12 Bit PWM Motor Driver Circuit [26].

MG90S Metal Gear Motor

The servo motor in the image in Fig. 5. is an ideal servo motor for small mechanisms produced by Tower Pro company. It has metal gears for strength and durability. This servo motor is on the market as an ideal product for RC Airplane, helicopter, quadcopter or robot. It can rotate approximately 180 degrees (90 degrees in all directions). Servo motors can be used with servo code, hardware materials or coding in the servo motor library.

Tower Pro MG90s Servo motor features: dimensions 62.5mm x 25.4mm x 3mm, with 60Hz update rate, with three pin connectors in groups of four, 16 servos can be connected at once, motor driver circuit uses Inter-Integrated Circuit(I2C) address between 0x60-0x80 and adjustable Pulse-width modulation (PWM) frequency up to about 1.6 KHz.

3D Printer

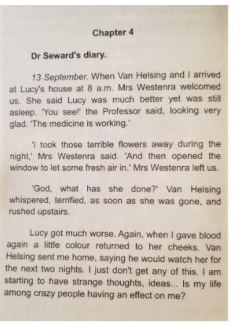
Three-dimensional printer technology is seen as a great development that is considered revolutionary after the industrial revolution. The standard dimensions of 3D printers are generally described as 990x1035x1540 mm [27]. AutoCAD, 3DS Max, SketchUp etc for 3D printers. Modeling operations can be done with programs such as Thanks to these printers, a modeled design can be produced quickly and transformed into tangible objects in a short time. Plastic, ceramic, metal, resin, powder, food raw materials, biomaterial materials etc for 3D printers. Such products are used as raw materials [28]. There are two types of filaments as Acrylonitrile Butadiene Styrene (ABS) and Polylactic Acid (PLA).

The primary uses of 3D printers are prototype and mold creation, topographic solid modeling, mass customization, medical and dental applications, spare parts production. In the production of the hardware product within the scope of this project, production was achieved by targeting the use of prototype and mold creation.

RESULTS AND DISCUSSION

Within the scope of this section, the results of OCR and Voice Recognition algorithms, the conversion of the letters formed as a result of the algorithm into Braille letters and then their display on the hardware device are included.

Within the scope of the study, tesseract in the optical character recognition algorithm and google translate in the voice recognition algorithm were used. The application is developed in Python language and PyCharm IDE is used. Tesseract is an open source optical character recognition engine developed for various operating systems. After the installation on the computer, the process was carried out



Chapter 4

Dr Seward's diary.

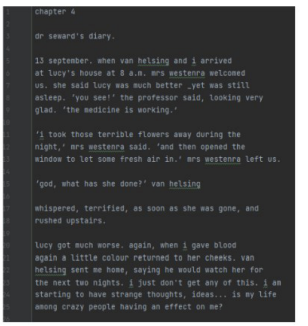
13 September. When Van Helsing and I arrived at Lucy's house at 8 a.m. Mrs Westenra welcomed us. She said Lucy was much better yet was still asleep. 'You see!' the Professor said, looking very glad. 'The medicine is working.'

'I took those terrible flowers away during the night,' Mrs Westenra said. 'And then opened the window to let some fresh air in.' Mrs Westenra left us.

'God, what has she done?' Van Helsing whispered, terrified, as soon as she was gone, and rushed upstairs.

Lucy got much worse. Again, when I gave blood again a little colour returned to her cheeks. Van Helsing sent me home, saying he would watch her for the next two nights. I just don't get any of this. I am starting to have strange thoughts, ideas... Is my life among crazy people having an effect on me?

Figure 7. Book page image.



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chapter 4

dr seward's diary.

13 september. when van helsing and i arrived
at lucy's house at 8 a.m. mrs westenra welcomed
us. she said lucy was much better yet was still
asleep. 'you see!' the professor said, looking very
glad. 'the medicine is working.'

'i took those terrible flowers away during the
night,' mrs westenra said. 'and then opened the
window to let some fresh air in.' mrs westenra left us.

'god, what has she done?' van helsing

whispered, terrified, as soon as she was gone, and
rushed upstairs.

lucy got much worse. again, when i gave blood
again a little colour returned to her cheeks. van
helsing sent me home, saying he would watch her for
the next two nights. i just don't get any of this. i am
starting to have strange thoughts, ideas... is my life
among crazy people having an effect on me?
```

Figure 8. Picture output given as OCR Algorithm input.

by installing the pytesseract module and the Pillow library in Python. For the voice recognition algorithm, the Google Speech Recognition structure was used. The operation was carried out using the speech_recognition module in the algorithm developed with Python.

Within the scope of the project, the letters on the images such as pictures, documents and articles provided with the OCR algorithm were transferred to digital media. For this OCR algorithm, a page was drawn from a random book and the algorithm was run. Fig. 7. It contains a picture taken from the original phone camera. In Fig. 8 the results of the letters obtained as a result of the OCR algorithm of the picture taken are shown. Space, character, letter, image, number, etc. on the picture. All symbols are reflected on the screen in the same way, by processing symbols such as OCR with the OCR algorithm and creating a digital copy.

A transformation was obtained by entering the letters obtained after the optical character recognition algorithm into the Braille alphabet conversion code one by one. This conversion output is shown in Fig. 9. For Braille letters consisting of six dots in the conversion process, marked/unmarked areas specific to each letter are specified as 1.0. Signed fields are defined as 1 and unmarked fields are defined as 0 for the six point Braille letter.

In the voice recognition algorithm, speech sounds obtained by devices such as speech, voice recording devices, microphones and computers are converted into readable

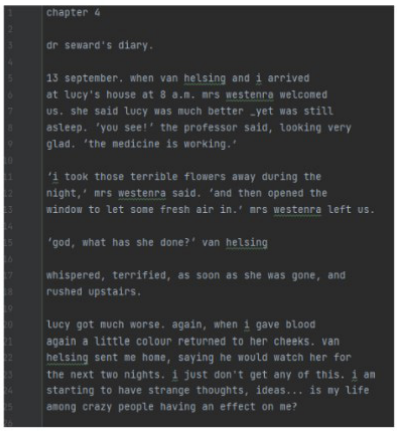


Figure 9. Converted digital letters obtained after OCR algorithm to Braille alphabet.

text. Along with the voice recognition algorithm, a randomly found story was given as input and the algorithm was run. As a result of the algorithm, there are two different outputs. Fig. 10. There are letters and words obtained from the voice recording as a result of the output voice recognition algorithm in it. After the voice recognition algorithm process of the voice given as input, a digital output of the letters in the voice recording was obtained.

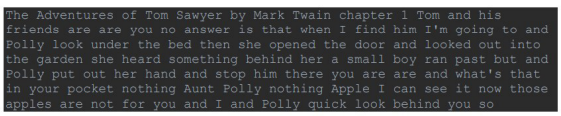


Figure 10.CAD drawing of the axial compression test setup

After the voice recognition algorithm, the letters obtained digitally were inserted into the Braille alphabet conversion code and a transformation was obtained. The output obtained after this transformation is Fig. 11. In addition, for Braille letters consisting of six dots, marked/unmarked areas specific to each letter are defined as 1, 0.

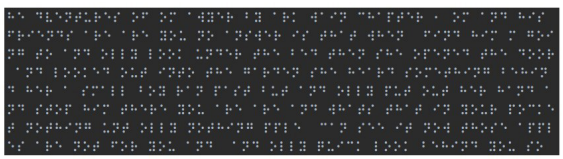


Figure 11. Transforming the digital letters obtained after the voice recognition algorithm into Braille alphabet.

A prototype original hardware device, shown in Fig. 12, has been developed for the display of Braille letters obtained as a result of two different processes with optical character recognition and voice recognition algorithms. Thanks to this prototype device, it has been ensured that visually impaired individuals can access resources such as articles, newspapers, books, magazines, etc. that normal individuals can access.

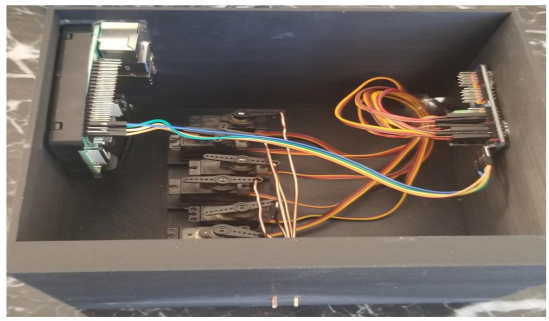


Figure 12. Prototype device developed within the scope of the project.

In this embedded system, there are Raspberry Pi 4, six servo motors, motor driver and metal wires for the display of Braille letters. The six point symbols, which are formed after the digital data obtained as a result of optical character recognition and voice recognition algorithms are converted into Braille alphabet, with the help of metal wires in the hardware device, it is ensured that visually impaired individuals can access and read those resources that normal individuals can access.

Braille letters, which can be read by visually impaired individuals, are expressed with six dots consisting of two columns and three rows located in front of the device. 64 different combinations can be created with these six points.

The results obtained after the conversion of the input information given as a result of these points into Braille alphabet with the optical character recognition and voice recognition algorithm are shown with the help of six metal wires in the hardware device. Thanks to this physical device in their hands, visually impaired individuals can also access the resources that normal individuals can access quickly. Thanks to this hardware device developed within the scope of the project, they are able to access and read all kinds of written texts such as magazines, books, web pages, or sources such as interviews, training videos, audio recordings recorded with human voice in their daily lives.

CONCLUSION

In this project work, it is aimed to find a solution to one of the many problems in the lives of visually impaired individuals, and thus to create documents, articles, etc. that other individuals can access and read. products have been made accessible to visually impaired individuals. In line with the literature research, there are studies on optical character recognition in general.

Within the scope of the project, there is a data reading system with two different algorithms. These algorithms are optical character recognition and voice recognition algorithms.

With the optical character recognition algorithm, the data that is requested to be translated into Braille alphabet is run by giving input to the algorithm, such as books, magazines, brochures, articles, educational contents, and the letters and words in the text parts of the content are transferred to the digital environment.

The voice recognition algorithm converts the speech voice created by people with technological devices such as voice recording devices, phones, computers, tablets, microphones into readable text, and these products recorded with voice are also transferred to digital media.

For the system developed within the scope of the study, the fact that the necessary input in the conversion to the Braille alphabet is taken both in writing and verbally reveals the original side of the study. With this hardware system, the number of resources that visually impaired individuals can access and read has been increased.

As a result of the algorithms, the letters transferred to the digital environment have been converted into Braille alphabet, which can be read by the visually impaired. The letters in the Braille alphabet are formed as a result of different combinations of six dots arranged in a rectangle consisting of three rows and two columns.

The accuracy of converting the system to Braille alphabet has been tested. Thus, the system enables books, articles, written documents, audio recordings, education systems, devices used in smart home systems, and interviews to be processed as input and converted into Braille alphabet thanks to optical character recognition and voice recognition algorithms.

Within the scope of the project, a unique hardware device has been developed so that visually impaired individuals can access and read the resources that other normal individuals can access. There are raspberry pi 4, six servo motors, motor driver circuit and six metal wires for the display of letters in the prototype device made for the Braille letters to be created in this original hardware device and printed with a 3D printer. As a result of the conversion of the letters obtained as a result of optical character recognition and voice recognition algorithms into Braille letters, this prototype was displayed from 6 points on the device, allowing the visually impaired individual to access the items they want to access, such as books, documents, voice narration, interviews, and interviews with a physical device. In this way, a solution has been produced for this difficult area in which visually impaired individuals live in the resources that normal individuals can easily access.

AUTHOR CONTRIBUTION

Authors approve that to the best of their knowledge, there is not any conflict of interest or common interest with an institution/organization or a person that may affect the eview process of the paper.

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