US011393361B1

(12) **United States Patent**
Latif et al.

(10) **Patent No.: US 11,393,361 B1**
(45) **Date of Patent: Jul. 19, 2022**

(54) **BRAILLE READER SYSTEM USING DEEP LEARNING FRAMEWORK**

(71) Applicant: **Prince Mohammad Bin Fahd University**, Dhahran (SA)

(72) Inventors: **Ghazanfar Latif**, Dhahran (SA); **Jaafar Alghazo**, Dhahran (SA); **Shurouq Alufaisan**, Dhahran (SA); **Wafa Albur**, Dhahran (SA); **Shaikha Alsedrah**, Dhahran (SA)

(73) Assignee: **Prince Mohammad Bin Fahd University**, Dhahran (SA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/668,964**

(22) Filed: **Feb. 10, 2022**

Related U.S. Application Data

(60) Provisional application No. 63/288,224, filed on Dec. 10, 2021.

(51) **Int. Cl.**
G09B 21/00 (2006.01)

(52) **U.S. Cl.**
CPC ***G09B 21/007*** (2013.01); ***G09B 21/006*** (2013.01); ***G09B 21/008*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2018/0197433 A1* 7/2018 Tavares G09B 21/007

FOREIGN PATENT DOCUMENTS

CN	110298236 A	10/2019
JP	2011-70530	4/2011
KR	10-2007-0057351	6/2007

OTHER PUBLICATIONS

Agrawal, Leena,"Real-Time Braille to Speech Conversion", R.N.S. Institute of Technology, Bengaluru, 41st Series—Seminar and Exhibition of Student Project Programme, Aug. 2018 (accessed at: http://www.kscst.iisc.ernet.in/spp/41_series/SPP41S/ for description of Exhibition of article; and http://www.kscst.iisc.*

Nanayakkara, Suranga, "EyeRing: A Finger-worn Assistant", May 2012 (accessed at: https://www.sutd.edu.sg/cmsresource/idc/papers/2012_Eyering_A_Finger_Worn_Assistant.pdf).*

Alsalman, et al. ; A Deep Learning-Based Recognition Approach for the Conversion of Multilingual Braille Images ; Computers, Materials & Continua, vol. 67, No. 3 ; 2021 ; 18 Pages.

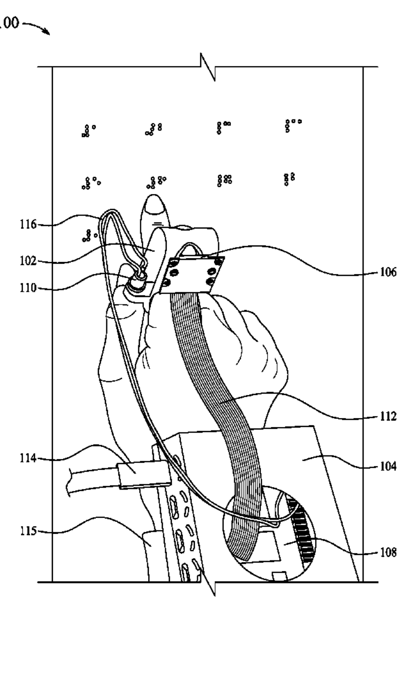
* cited by examiner

Primary Examiner — James B Hull
(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

A device, method, and system for converting printed Braille dots to speech. A Braille image of the printed Braille dots is captured by a digital camera mounted on a 3D ring case. Data processing and one or more image recognition operations are performed by a microprocessor to match the Braille image to a textural character corresponding to the Braille image. The textural character is converted to an audio waveform. The audio waveform is transmitted to a speaker. The speaker generates a sound representative of a spoken word corresponding to the textural character.

17 Claims, 10 Drawing Sheets



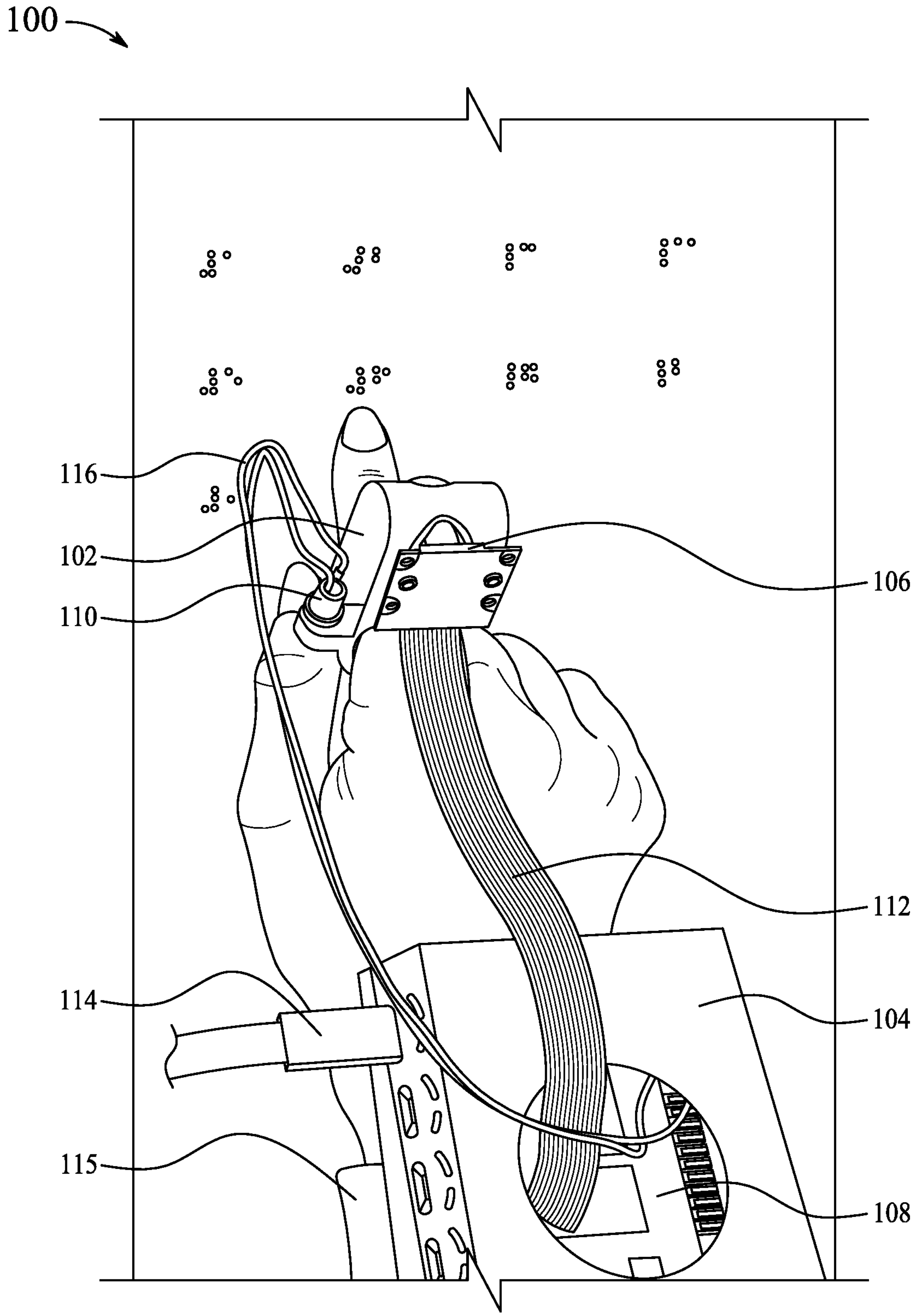


FIG. 1

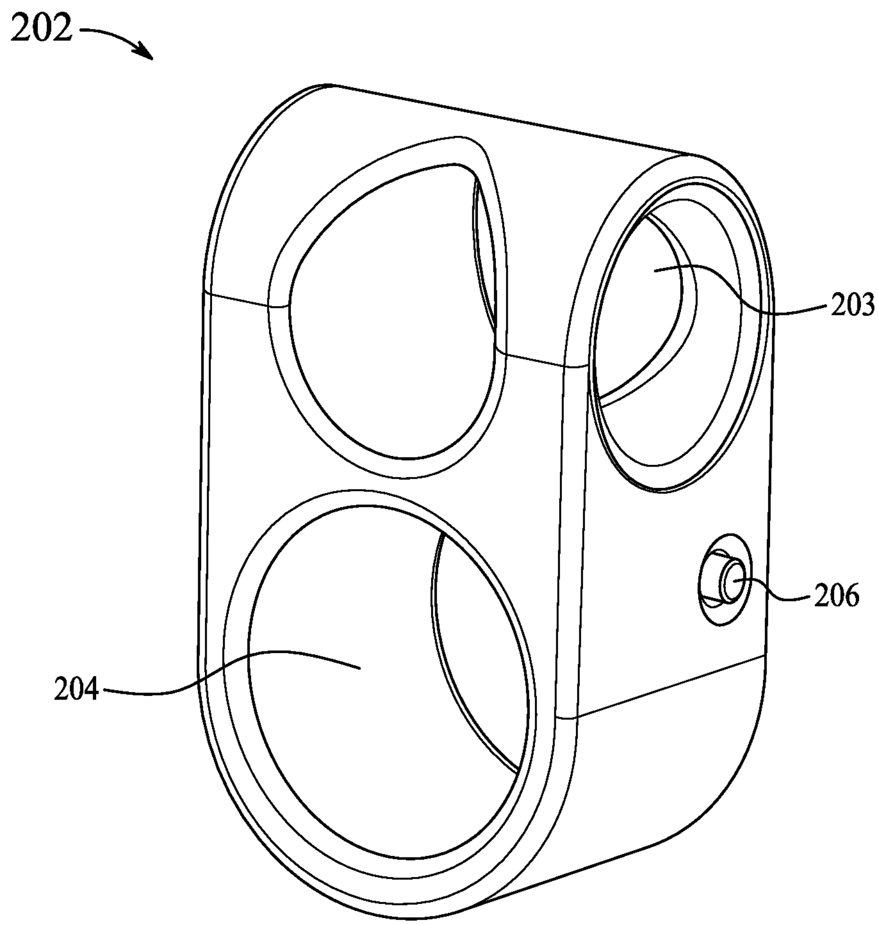


FIG. 2

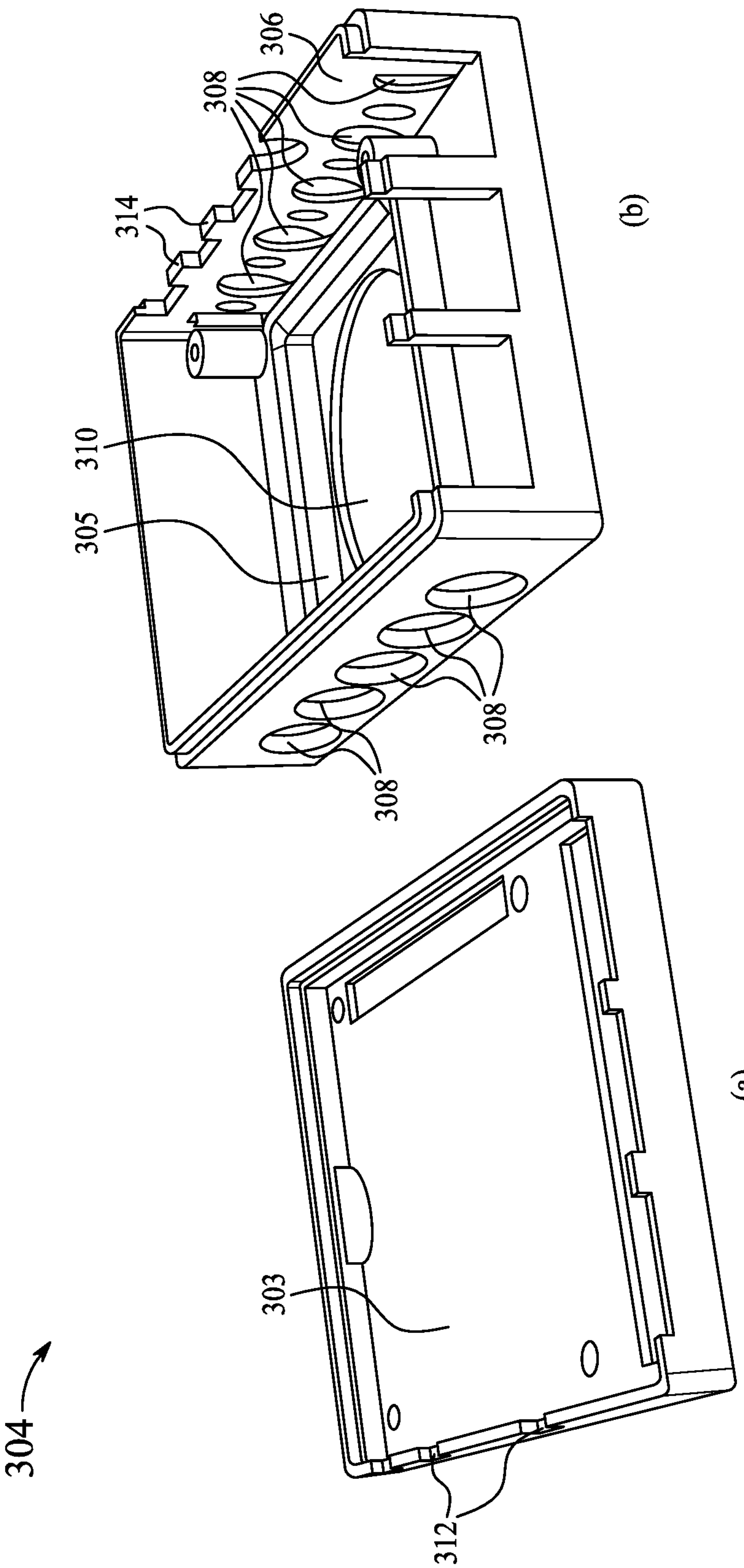


FIG. 3A

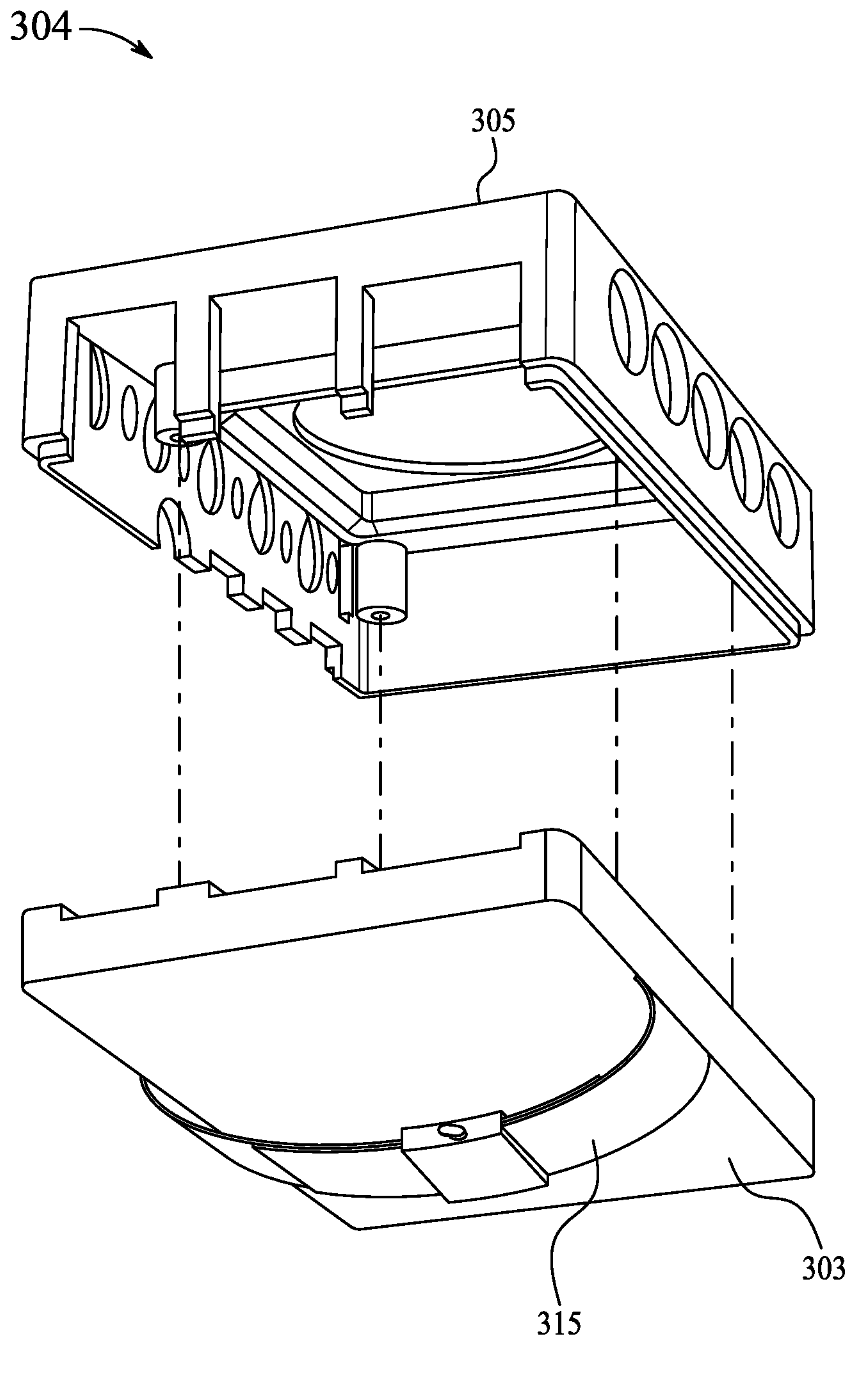


FIG. 3B

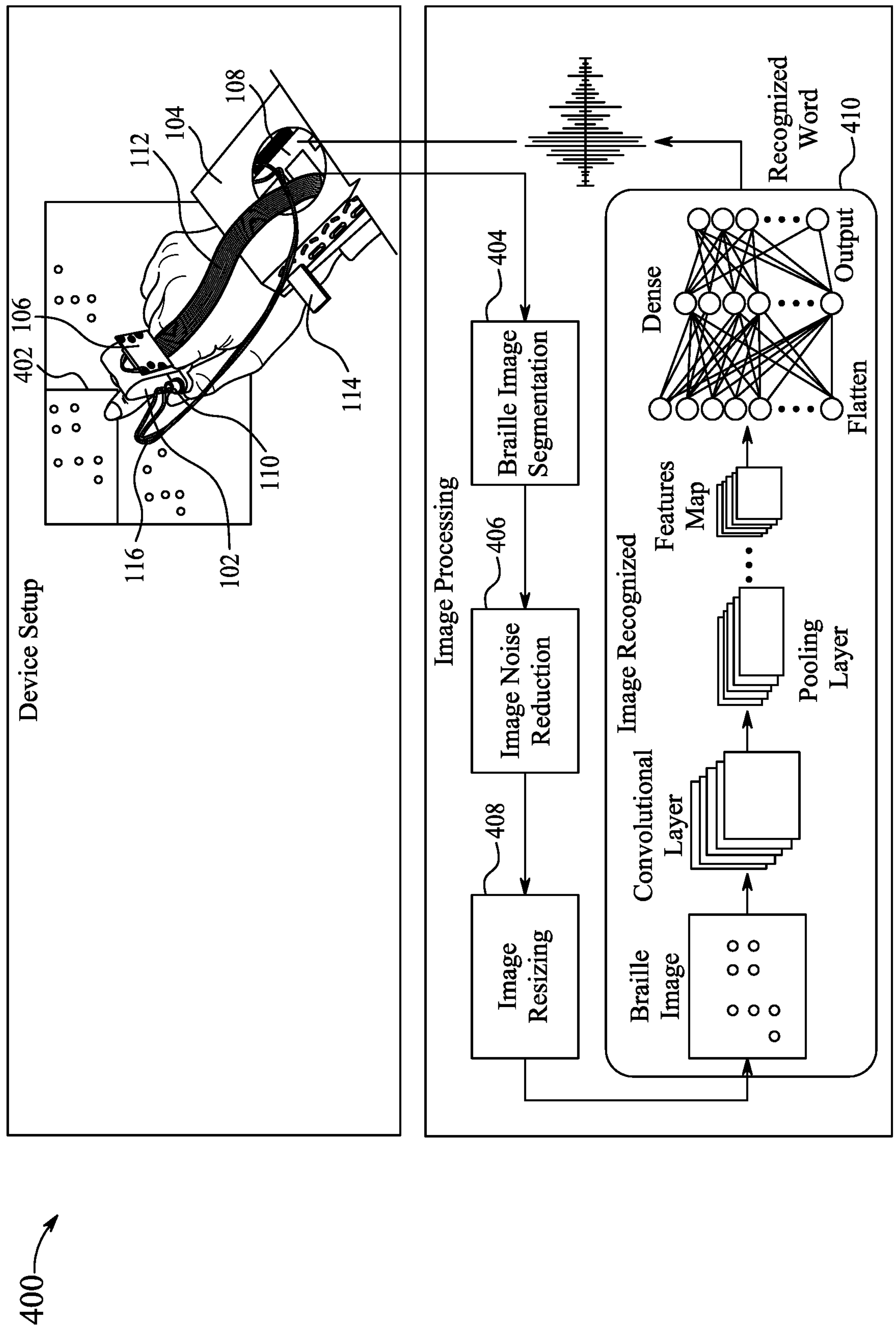

400
Device Setup
402
106
112
104
108
114
110
116
102
Image Processing
Braille Image Segmentation
404
Image Noise Reduction
406
Image Resizing
408
Image Recognized
Braille Image
Convolutional Layer
Pooling Layer
Features Map
Flatten
Dense
Output
Recognized Word
410

FIG. 4

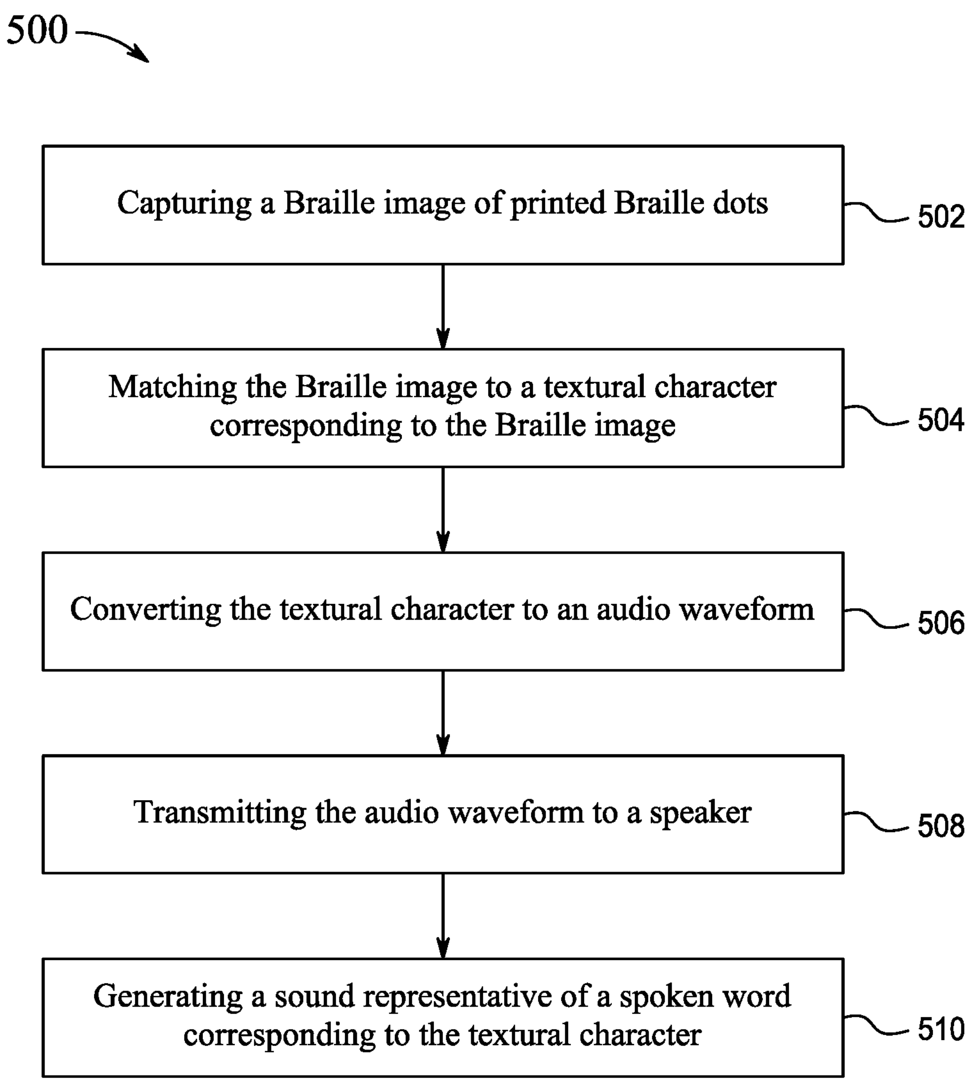

500
Capturing a Braille image of printed Braille dots
502
Matching the Braille image to a textural character corresponding to the Braille image
504
Converting the textural character to an audio waveform
506
Transmitting the audio waveform to a speaker
508
Generating a sound representative of a spoken word corresponding to the textural character
510

FIG. 5

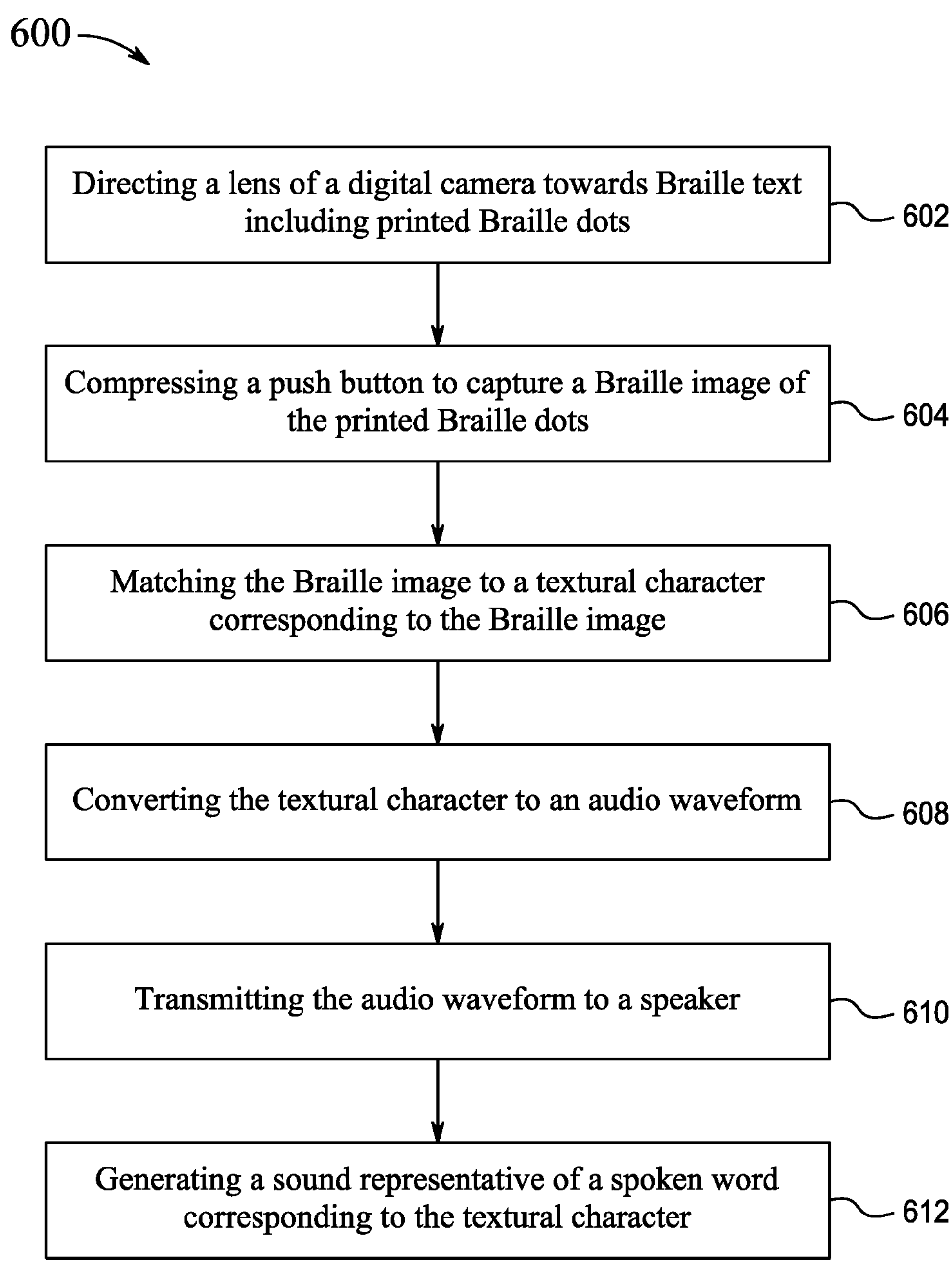

600
Directing a lens of a digital camera towards Braille text including printed Braille dots
602
Compressing a push button to capture a Braille image of the printed Braille dots
604
Matching the Braille image to a textural character corresponding to the Braille image
606
Converting the textural character to an audio waveform
608
Transmitting the audio waveform to a speaker
610
Generating a sound representative of a spoken word corresponding to the textural character
612

FIG. 6

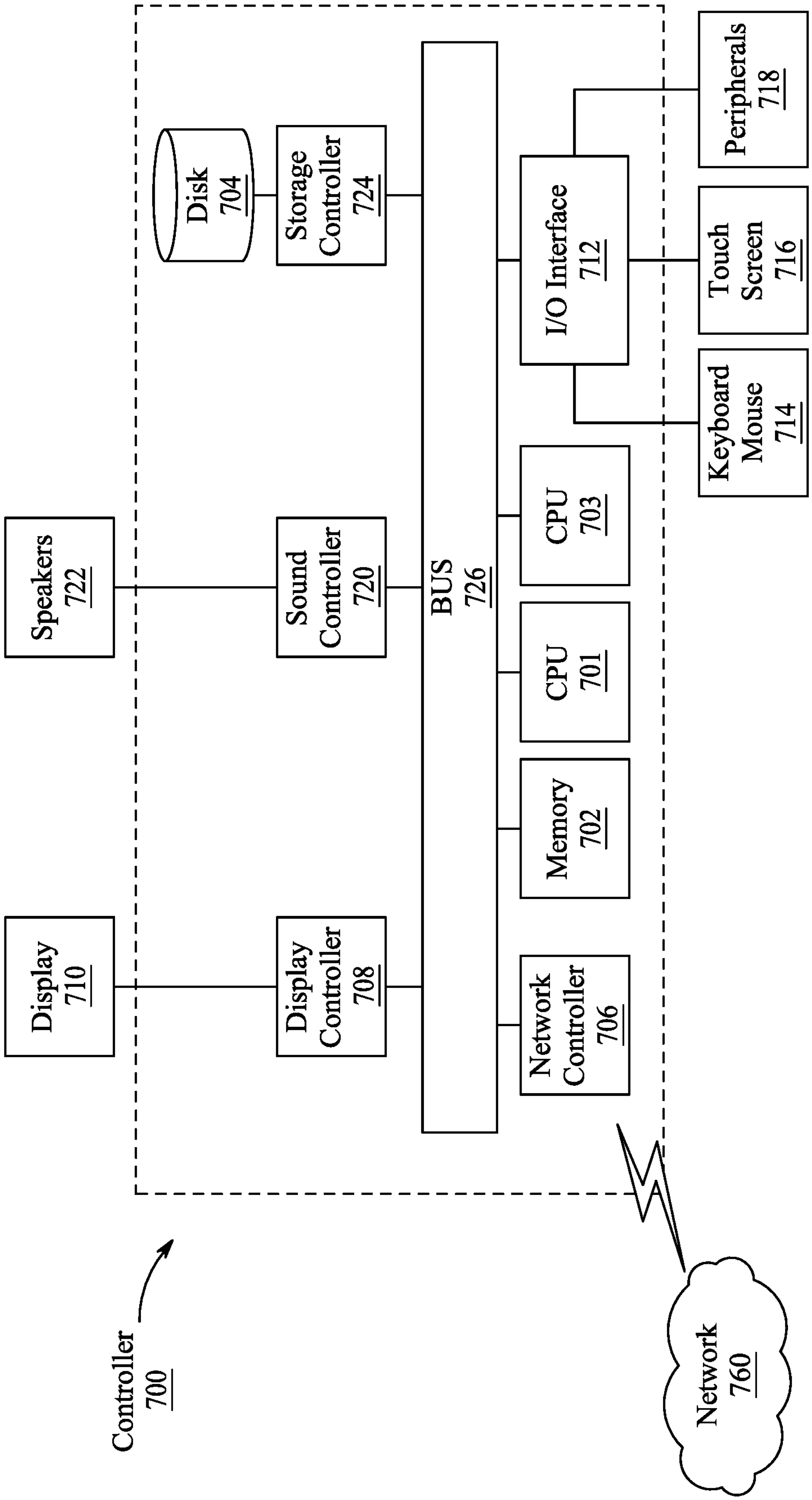

Controller
700
Display
710
Speakers
722
Disk
704
Display
Controller
708
Sound
Controller
720
Storage
Controller
724
BUS
726
Network
Controller
706
Memory
702
CPU
701
CPU
703
I/O Interface
712
Keyboard
Mouse
714
Touch
Screen
716
Peripherals
718
Network
760

FIG. 7

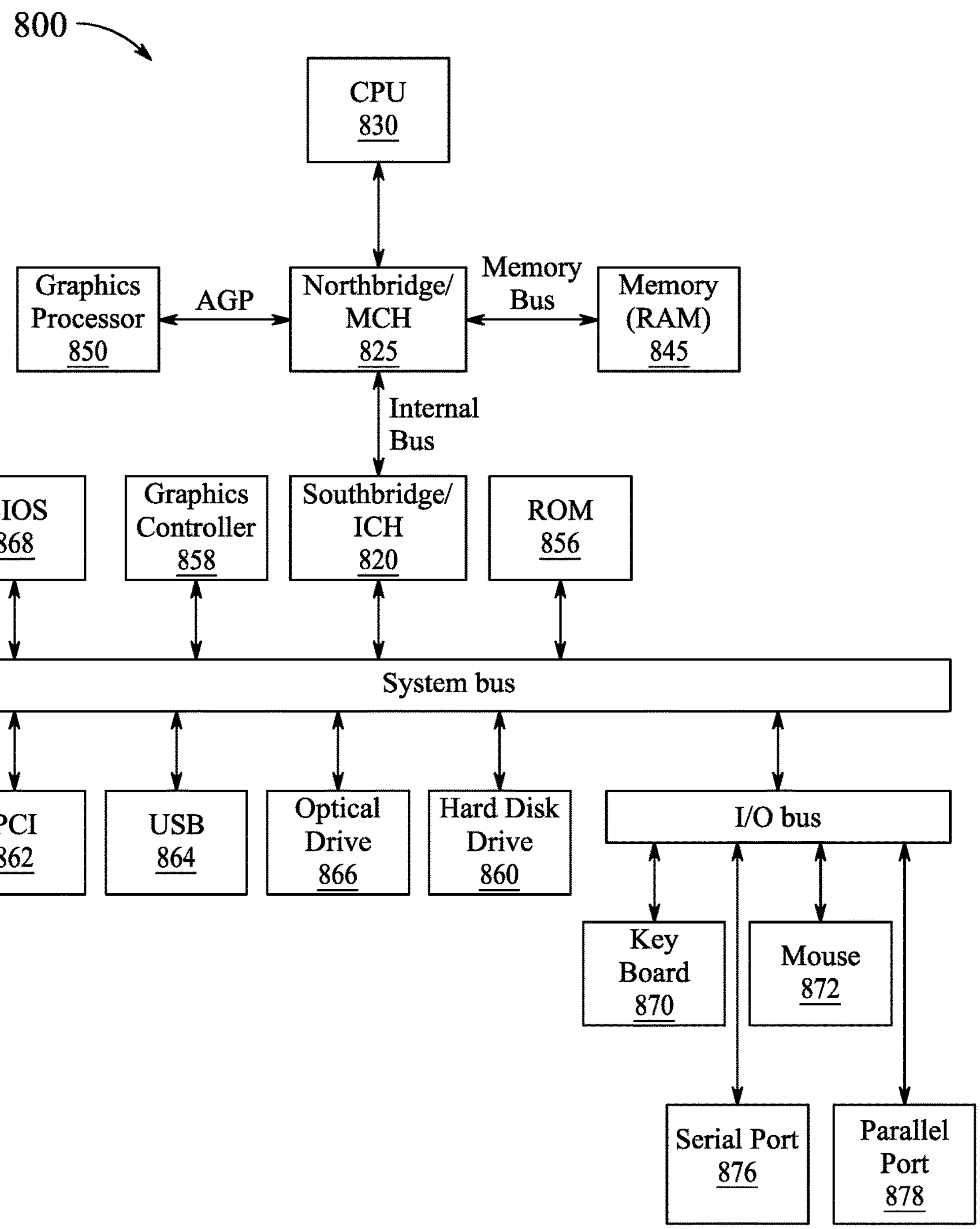

800
CPU
830
Graphics
Processor
850
AGP
Northbridge/
MCH
825
Memory
Bus
Memory
(RAM)
845
Internal
Bus
BIOS
868
Graphics
Controller
858
Southbridge/
ICH
820
ROM
856
System bus
PCI
862
USB
864
Optical
Drive
866
Hard Disk
Drive
860
I/O bus
Key
Board
870
Mouse
872
Serial Port
876
Parallel
Port
878

FIG. 8

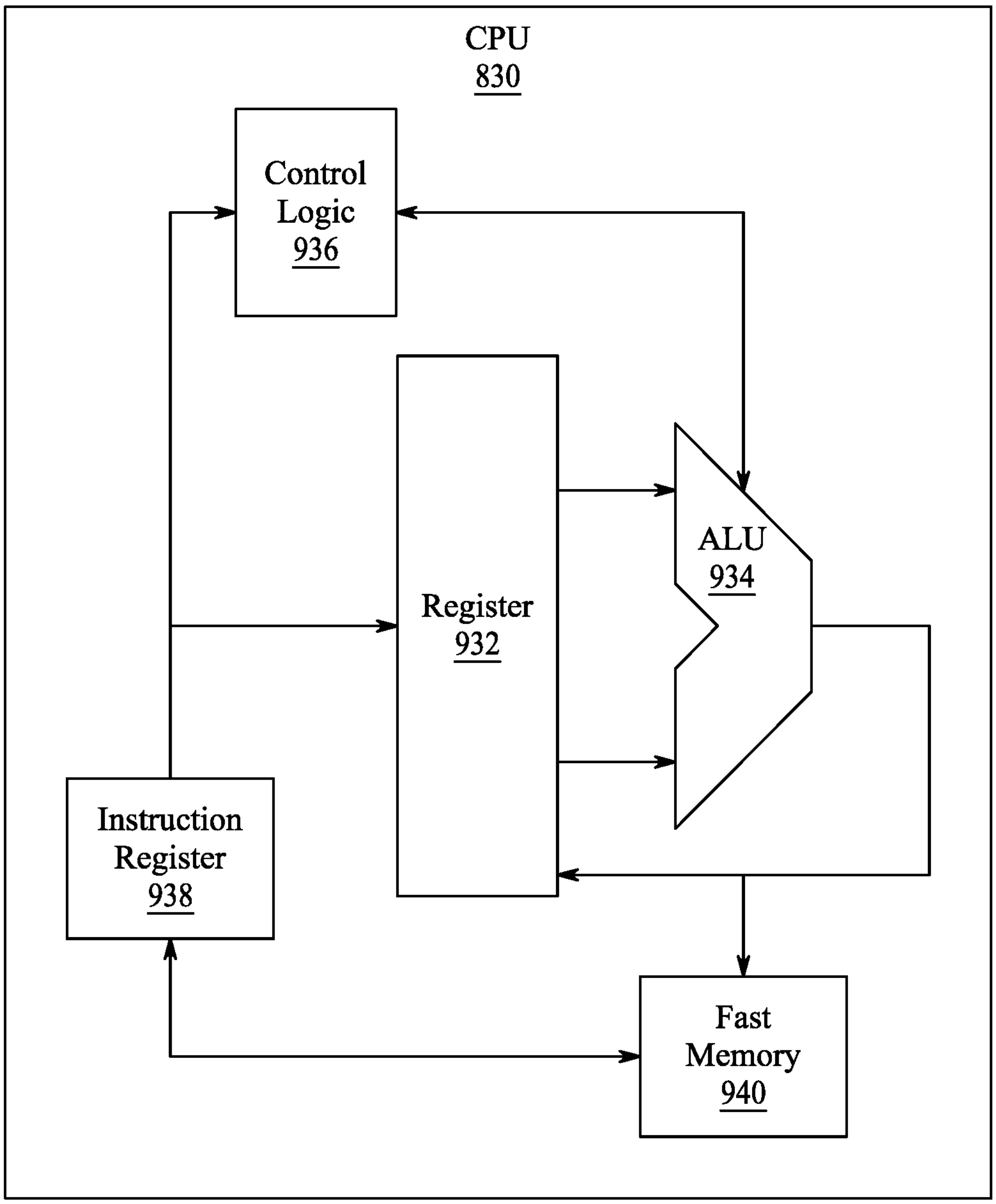

CPU
830
Control
Logic
936
Register
932
ALU
934
Instruction
Register
938
Fast
Memory
940

FIG. 9

BRAILLE READER SYSTEM USING DEEP LEARNING FRAMEWORK

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority to U.S. Provisional Application No. 63/288,224, filed Dec. 10, 2021, the entire contents which is incorporated by reference herein in its entirety for all purposes.

BACKGROUND

Technical Field

The present disclosure is directed to a Braille reader system including a deep learning framework which converts printed Braille dots to speech.

Description of Related Art

The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present invention.

Braille is a form of written language used by visually impaired persons to read a document consisting of raised dots. In Braille, characters or words are represented by patterns of raised dots that are felt with the fingertips. Braille script is comprised of Braille cells, each representing a character or a word. A Braille sheet is a paper embossed with raised dots that are arranged in Braille cells. A Braille cell is represented by a collection of 6 raised dots arranged in two columns of 3 dots each. Braille script may be presented on Braille paper, on a refreshable Braille display device with dots or round-tipped pins raised through holes in a flat surface, by a Braille input device, and on public notices and signboards.

Various computer vision and image processing techniques may be used to recognize the characters or words from scanned documents and images of Braille script and convert the recognized characters or words to speech. Such techniques may assist a visually disabled person, an instructor or trainer in reading the Braille scripts.

Various solutions have been developed in recent years for the recognition of Braille scripts. A contact type image sensor that can be worn on a finger and configured to superimpose multiple images obtained from the contact type image sensor to obtain a composited image, convert the composited image into a Braille pattern, and convert the Braille pattern into a corresponding voice was described in JP2011070530A, "Contact type image sensor and image recognition device", incorporated herein by reference in its entirety. However, this reference has a drawback that the contact type image sensor comes in contact with the Braille pattern instead of the finger of the user. This drawback may hinder the learning experience of the blind person, as the tactile feedback from touching the Braille dots serves to orient the hand towards the next Braille word.

A mobile communication terminal to convert Braille points into voice by taking a picture of Braille points through a camera and recognize the Braille image to output the Braille image as a voice was described in KR2007057351A, "Mobile communication terminal for converting Braille points into a voice, especially concerned with recognizing the Braille points to output the recognized Braille points as the voice", incorporated herein by reference in its entirety. However, it is difficult for a blind person to take a picture of the Braille pattern with a camera, as the individual cannot orient the camera without vision.

A semantic segmentation model trained by using a convolutional neural network and Braille images are input into the semantic segmentation model which obtains a semantic segmentation result diagram of the Braille image was described in CN110298236A, incorporated herein by reference in its entirety. However, this reference outputs images of the Braille pattern which are not readable by a blind person.

Further, a deep convolutional neural network (DCNN) model that takes pre-processed Braille images as input to recognize Braille cells has been proposed. (See: Abdulmalik Alsalman, Amani Alsalman, Abdu Gumaei, and Suheer Ali Al-Hadhrami, "A Deep Learning-Based Recognition Approach for the Conversion of Multilingual Braille Images", Article in Computers, Materials and Continua, March 2021, DOI: 10.32604/cmc.2021.015614, incorporated herein by reference in its entirety). However, this reference does not convert the Braille pattern to speech so is not useful for a blind person.

Each of the aforementioned references suffers from one or more drawbacks hindering their adoption. Accordingly, it is one object of the present disclosure to provide a Braille reader system to capture and process Braille images for real time recognition of characters and words corresponding to Braille cells sensed by a finger of a user, and outputs speech.

SUMMARY

In an exemplary embodiment, a system for converting printed Braille dots to speech is disclosed. The system includes a 3D ring case and a digital camera mounted in the 3D ring case. The digital camera is configured to capture a Braille image of the printed Braille dots. The system further includes a rechargeable battery and a speaker. The system further includes a microprocessor operatively connected to the rechargeable battery, the digital camera, and the speaker. The microprocessor is configured to perform data processing and one or more image recognition operations which match the Braille image to a textural character corresponding to the Braille image. The microprocessor is further configured to convert the textural character to an audio waveform and transmit the audio waveform to the speaker. The speaker is configured to receive the audio waveform and generate a sound representative of a spoken word corresponding to the textural character.

In another exemplary embodiment, a method for converting printed Braille dots to speech is disclosed. The method includes capturing a Braille image of the printed Braille dots. The method further includes matching the Braille image to a textural character corresponding to the Braille image. Data processing and one or more image recognition operations are performed to match the Braille image to the textural character. The method further includes converting the textural character to an audio waveform and transmitting the audio waveform to a speaker. The method further includes generating, by the speaker, a sound representative of a spoken word corresponding to the textural character.

In another exemplary embodiment, a method for converting printed Braille dots to speech is disclosed. The method includes directing a lens of a digital camera towards Braille text including printed Braille dots. The digital camera is

confined in a 3D ring case. The method further includes compressing a push button to capture a Braille image of the printed Braille dots. The method further includes matching the Braille image to a textural character corresponding to the Braille image. A microprocessor is configured to perform data processing and one or more image recognition operations to match the Braille image to the textural character. The method further includes converting the textural character to an audio waveform and transmitting the audio waveform to a speaker. The method further includes generating, by the speaker, a sound representative of a spoken word corresponding to the textural character.

The foregoing general description of the illustrative embodiments and the following detailed description thereof are merely exemplary aspects of the teachings of this disclosure, and are not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of this disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1** is a schematic diagram of a Braille reading device, according to certain embodiments.

FIG. **2** is a schematic diagram of a 3D ring case, according to certain embodiments.

FIG. **3**A is a schematic diagram of a microprocessor housing, where (a) is a base and (b) is a lid of the microprocessor housing, according to certain embodiments.

FIG. **3**B is a schematic diagram of a microprocessor housing, according to certain embodiments.

FIG. **4** is a process flow diagram illustrating a conversion of printed Braille dots to speech, according to certain embodiments.

FIG. **5** is an exemplary process flow of a method for converting printed Braille dots to speech, according to certain embodiments.

FIG. **6** is an exemplary process flow of a method for converting printed Braille dots to speech, according to certain embodiments.

FIG. **7** is an illustration of a non-limiting example of details of computing hardware used in the computing system, according to certain embodiments.

FIG. **8** is an exemplary schematic diagram of a data processing system used within the computing system, according to certain embodiments.

FIG. **9** is an exemplary schematic diagram of a processor used with the computing system, according to certain embodiments.

DETAILED DESCRIPTION

In the drawings, like reference numerals designate identical or corresponding parts throughout the several views. Further, as used herein, the words "a," "an" and the like generally carry a meaning of "one or more," unless stated otherwise.

Furthermore, the terms "approximately," "approximate," "about," and similar terms generally refer to ranges that include the identified value within a margin of 20%, 10%, or preferably 5%, and any values therebetween.

Aspects of this disclosure are directed to a system, device, and method for converting printed Braille dots to speech. The present disclosure discloses a device to be worn by a user. The device includes a camera to capture images of printed Braille dots. The device includes a microprocessor that processes the captured images of printed Braille dots to determine textural characters or words corresponding to the images of printed Braille dots.

FIG. **1** depicts a schematic diagram of a Braille reading device **100** for reading Braille scripts, according to exemplary aspects of the present disclosure.

According to aspects of the present disclosure, the Braille reading device **100** includes a three-dimensional (3D) ring case **102**, a microprocessor housing **104**, a digital camera **106**, a microprocessor board **108**, a switch **110**, a flexible flat cable (FFC) **112**, a speaker **114**, a strap **115**, and a pair of connecting wires **116**.

Referring to FIG. **2**, the 3D ring case **102** includes a first ring **203** and a second ring **204**. The second ring is positioned below the first ring. The digital camera **106** is arranged in the first ring. The 3D ring case **102** is worn on a finger of a user by inserting the finger of the user in the second ring. The switch **110** is arranged on the 3D ring case **102**. The 3D ring case **102** is explained in further detail with reference to FIG. **2**.

Referring to FIG. **1** and FIG. **3**A, the microprocessor housing **104** may include a base **303** and a lid **305**. The base holds the microprocessor board **108**. The lid may be placed on top of the base to enclose components arranged on the base. A top side of the lid includes a cut-out portion to receive the FFC **112**. The microprocessor board **108**, enclosed in the microprocessor housing **104**, is connected to the digital camera **106** by the FFC **112** passing through the cut-out portion. The base includes the strap **115** (shown as **315**, FIG. **3**B) for the user to wear the microprocessor housing **104** on the wrist of the user. The lid further includes another cut-out portion on a sidewall (or a lateral side) to hold the speaker **114**. In an aspect of the present disclosure, the speaker **114** may be arranged within the microprocessor housing **104**. The microprocessor housing **104** is explained in further detail with reference to FIG. **3**A and FIG. **3**B.

Referring back to FIG. **1**, the Braille reading device **100** further includes a battery (not shown) to power one or more of the digital camera **106**, the microprocessor board **108**, and the speaker **114**. The battery may be arranged in the microprocessor housing **104**. In an aspect of the present disclosure, the battery may be a rechargeable battery. The microprocessor housing **104** may include a power interface that may be connected to a power charging adapter to charge the rechargeable battery. In an aspect of the present disclosure, the battery may be replaced with a new battery when the battery runs out of power.

In an aspect of the present disclosure, the speaker **114** may be an external speaker or a headphone that may connect to the microprocessor board **108** via one or more audio interfaces. The one or more audio interfaces may include a wired audio interface or a wireless audio interface. The wired audio interface may include high definition multimedia interface (HDMI), a 3.5 mm audio jack, and a universal serial bus (USB) interface. The wireless audio interface may include Bluetooth or Wireless Fidelity (Wi-Fi) connection. The speaker **114** may be powered by the battery of the Braille reading device **100**, by an in-built battery in the speaker **114**, or an external AC or DC power supply.

The pair of connecting wires **116** connects the switch **110** to the microprocessor board **108**. The pair of connecting wires **116** passes through the cut-out portion on the top side of the lid to connect the switch **110** to the microprocessor board **108** enclosed in the microprocessor housing **104**. In an aspect of the present disclosure, the microprocessor board **108** may include General-Purpose Input/Output (GPIO) pins. The GPIO pins provide a physical interface between the microprocessor board **108** and external components. One end of the pair of connecting wires **116** is connected to the switch **110**, and the other end of the pair of connecting wires **116** is connected to the GPIO pins. The switch **110** activates the Braille reading device **100**.

In operation, the user may wear the 3D ring case **102** on a finger of either hand and wear the microprocessor housing **104** on the wrist of the same hand. To read or learn Braille script, the user may scan the Braille script by sensing printed Braille dots with the finger. The user may press the switch **110** to activate the Braille reading device **100** to identify one or more characters or words corresponding to the printed Braille dots sensed by the finger. When the user presses the switch **110**, the digital camera **106** captures a Braille image of the Braille dots. The Braille image is transmitted to the microprocessor board **108** over the FFC **112**. The microprocessor board **108** comprises a microprocessor that performs one or more image processing techniques or algorithms to process the Braille image for image recognition. Further, the microprocessor may input the processed Braille image to a trained deep learning based convolutional neural network (CNN) model. The trained deep learning based CNN model is trained on a dataset of images of Braille scripts. The trained deep learning based CNN model accepts the processed Braille image, extract features from the processed Braille image, and classifies them into respective classes to recognize one or more characters or words corresponding to the Braille image. The microprocessor generates an audio waveform corresponding to the recognized characters or words and transmits the audio waveform to the speaker **114**. The speaker **114** outputs the sound corresponding to the audio waveform.

In a non-limiting example, the microprocessor board **108** may be one of a Raspberry Pi series or other similar single-board computers. The microprocessor board **108** may include the processor, the GPIO pins to provide a physical interface between the microprocessor board **108** and external components, memory module such as a random access memory (RAM), one or more HDMI ports, camera serial interface (CSI) to connect the digital camera **106** through the FFC **112**, one or more USB ports to connect peripheral devices and power supply, one or more micro USB ports, and one or more wireless connectivity modules, such as Bluetooth and Wi-Fi and secure digital (SD) card slot.

In an aspect of the present disclosure, the Braille reading device **100** may be communication-enabled using various wired and wireless connectivity protocols, such as Wi-Fi and Personal Area Network. The processor of the Braille reading device **100** may load the trained deep learning based CNN model from a host machine or a server.

FIG. **2** depicts a schematic diagram of a 3D ring case **202**, according to exemplary aspects of the present disclosure.

According to aspects of the present disclosure the 3D ring case **202** is designed to be worn on a finger of the user and to accommodate the digital camera **106** and the switch **110**. The 3D ring case **202** corresponds to the 3D ring case **102** of FIG. **1**. The 3D ring case **202** includes a first opening **203**, a second opening **204** below the first opening **203**, and a switch **206**. The digital camera **106** may be arranged in the first opening **203**. The 3D ring case **202** may be worn on a finger of the user by inserting the finger of the user in the second opening **204**. The switch **206** may be arranged on either of the lateral sides of the 3D ring case **202**.

Although the first opening **203** and the second opening **204** as shown in FIG. **2** are round in shape, one or both the first opening **203** and the second opening **204** may be of any other shape depending on design requirements. For example, shape and size of the first opening **203** may be designed based on shape and size of the digital camera **106** to be arranged in the first opening **203**.

In an aspect of the present disclosure, the 3D ring case **202** may be custom designed to provide a slot, in place of the switch **206**, for accommodating the switch **110** on the 3D ring case **202**. The 3D ring case **202** may be custom designed to have dimensions in accordance with requirements and components of Braille reading device **100**. In an aspect of the present disclosure, the 3D ring case **202** may be printed by a 3D printer.

In an aspect of the present disclosure, the 3D ring case **202** may be designed in a plurality of sizes for the second opening **204**. In a non-limiting example, the 3D ring case **202** may be designed for three different sizes, i.e., small, medium, and large size of the second opening **204**, which can be selected to fit a finger size of a user. In an aspect of the present disclosure, the 3D ring case **202** may be designed such that size of the second opening **204** may be adjusted to fit size of the finger of the user. In an aspect of the present disclosure, the 3D ring case **202** may be custom designed in accordance with physical appearance preferences of different users.

FIG. **3**A depicts a schematic diagram of a microprocessor housing **304**, where (a) is a base and (b) is a lid of the microprocessor housing, according to exemplary aspects of the present disclosure.

According to aspects of the present disclosure the microprocessor housing **304** is designed to accommodate the microprocessor board **108**, the speaker **114**, and the battery. The microprocessor housing **304** corresponds to the microprocessor housing **104** of FIG. **1**. The microprocessor housing **300** includes a base **303** and a lid **305**. The base **303** is designed to hold the microprocessor board **108** and the battery. The base **303** includes a strap **315**. The strap **315** is used to wear the microprocessor housing **304** on a wrist of the user as shown in FIG. **3**B.

The lid **305** includes a plurality of cutout portions **308** on sidewalls **306** (or lateral sides). The plurality of cut-out portions **308** may enable air flow in the microprocessor housing **304**. At least one of the plurality of cut-out portions **308** is used to arrange the speaker **114**. A top side of the lid **305** includes a cut-out portion **310**. The FFC **112** passes through the cut-out portion **310** to connect the digital camera **106** to the microprocessor board **108**.

The base **303** further includes a plurality of slots **312** and the sidewalls **306** include a plurality of tabs **314**. Each tab **314** aligns with a corresponding slot **312** when the lid **305** and the base **303** are joined together.

Although the plurality of cut-out portions **308** and the cut-out portion **310** as shown in FIG. **3**A are round in shape, the plurality of cut-out portions **308** and the cut-out portion **310** may be of any other shape depending on design requirements.

FIG. **3**B depicts a schematic diagram of a microprocessor housing **304**, according to exemplary aspects of the present disclosure. The base **303** includes the strap **315**. In an aspect of the present disclosure, the strap **315** may be an elastic band which may be worn on the wrist of the user by stretching the elastic band and slipping (or sliding) the hand through the elastic band. In another aspect of the present disclosure, the strap **315** may include a first elastic wristband connector and a second elastic wristband connector. The first elastic wristband connector and the second elastic wristband connector may be coupled together to wear the microprocessor housing **304** on a wrist of the user. In an aspect of the present disclosure, the base **303** may include coupling means, such as fasteners, hooks, clips, and buckles to couple the strap **315** with the base **303**. The coupling means may be arranged on exterior sides or exterior bottom of the base **303**. In an aspect of the present disclosure, the base **303** may include slots on opposite side and the strap **315** may pass through the slots.

In an aspect of the present disclosure, the microprocessor housing **304** may be custom designed to have dimensions in accordance with requirements and components of Braille reading device **100**. In an aspect of the present disclosure, the microprocessor housing **304** may be printed by a 3D printer.

In an aspect of the present disclosure, the microprocessor housing **304** may be designed to have a slim profile such that the microprocessor housing **304** can be hidden under sleeve of garment worn by the user. In an aspect of the present disclosure, the microprocessor housing **304** may be designed in the shape of one or more cartoon characters, superhero characters, animals, or may be custom designed to any desired shape and size, so as to appeal to children learning Braille.

FIG. **4** depicts a process flow diagram **400** illustrating conversion of Braille dots to speech, according to exemplary aspects of the present disclosure. As shown in FIG. **4**, a user may wear the Braille reading device **100**. The user may wear the microprocessor housing **104** on a wrist and the 3D ring case **102** on a finger. The user may scan a Braille script **402** with the finger to sense Braille dots. The Braille script **402** may be presented on one or more of: a Braille paper or textbook with printed dots, a refreshable Braille display device with dots or round-tipped pins raised through holes in a flat surface, a Braille input device, and public notices, bathroom doors, and signboards and the like.

In an aspect of the present disclosure, the user may wear the 3D ring case **102** on the index finger of a hand. For ease of operation, the user may press the switch **110** with the thumb of the same hand. In an aspect of the present disclosure, the user may wear the 3D ring case **102** in any finger on either hand, and use any finger on either hand to press the switch **110**.

In an aspect of the present invention, the user may wear the 3D ring case **102** on the same finger with which the user senses the Braille dots. One or more of focal length, position, and optical angle of the digital camera **106** may be appropriately adjusted to capture images of the Braille dots sensed by the user.

By sensing the Braille dots with the finger, the user may identify the location of the Braille dots. After the user identifies the location of the Braille dots, the user actuates the digital camera **106**. In an aspect of the present disclosure, after sensing the Braille dots, the user may move the finger behind the Braille dots such that the finger does not overlap the Braille dots and the Braille dots are in the field of view of the digital camera **106**. In an aspect of the present disclosure, optical axis and/or field of view of the digital camera **106** may be oriented to capture Braille images of the Braille dots in one or more directions with respect to the finger of the user. The digital camera **106** may capture Braille images of the Braille dots above the finger and on the right and left side of the finger. In an aspect of the present disclosure, the microprocessor may be configured to adjust the optical axis and/or field of view of the digital camera **106** based on user preferences. In an aspect of the present disclosure, the user may manually adjust the optical axis and/or field of view of the digital camera **106** by adjusting position and/or orientation of the digital camera **106** in the first opening **203**.

The user presses the switch **110** to actuate the digital camera **106** to capture a Braille image of the Braille dots. The digital camera **106** transmits the Braille image to the microprocessor included in the microprocessor board **108** over the FFC **112**.

In an aspect of the present disclosure, when the user presses the switch **110**, the digital camera **106** may begin to capture the Braille images at predetermined time intervals. The user may press the switch **110** again to stop capturing the Braille images. The microprocessor may be configured to capture the Braille images at the predetermined time intervals. The predetermined time interval may be adjusted based on reading speed and/or proficiency of the user.

The microprocessor may apply one or more digital image processing and/or computer vision techniques or algorithms to process the Braille image. The Braille script **402** is comprised of a plurality of Braille cells, each representing a character or a word. A Braille cell is represented by a collection of 6 raised dots arranged in two columns, each having three dots. The Braille image captured by the digital camera **106** may include one or more Braille cells, each representing a character or a word.

The microprocessor processes the Braille image by applying an image segmentation process **404** to the Braille image. Applying the image segmentation process **404** to the Braille image segments the Braille image into a plurality of segments. The plurality of segments in the segmented Braille image distinguishes individual Braille cells in the Braille image. The image segmentation process **404** may also distinguish the Braille cells from the background in the captured Braille image. In an aspect of the present disclosure, one or more image segmentation algorithms may be used to distinguish the Braille cells from the background and to distinguish individual Braille cells across a single line and/or multiple lines in the Braille image.

The microprocessor may further process the Braille image by applying an image noise reduction process **406** to the segmented Braille image. The quality of the Braille image captured by the digital camera **106** may be degraded due to various factors, such as a non-uniform ambient illumination, a low resolution imaging sensor, and an impulse noise. The image noise reduction process **406** may apply one or more image enhancement and denoising techniques to remove noise and enhance the quality of the segmented Braille image. The output of the image noise reduction process **406** is a denoised segmented Braille image.

The microprocessor may further process the Braille image by applying an image resizing process **408** to the denoised segmented Braille image. The plurality of segments in the denoised segmented Braille image may be appropriately resized for recognition of character or word corresponding to each of the plurality of Braille cells. One or more image interpolation and resizing techniques may be used to resize the plurality of denoised segments in the Braille image to generate a resized Braille image.

The microprocessor performs an image recognition process **410** on the resized Braille image. To perform the image recognition process **410**, the resized Braille image is input to the trained deep learning based CNN model. The image recognition process **410** is performed to recognize characters or words corresponding to each of the plurality of Braille cells, i.e., the plurality of segments.

In an aspect of the present disclosure, the deep learning based CNN model may be trained on a dataset of Braille scripts. The dataset of Braille scripts which train the deep learning based CNN model may include a plurality of labeled images of Braille scripts in one or more languages. The plurality of labeled images of Braille scripts may include alphabets, numerals, and text. For example, dataset of Braille scripts may include one or more of Arabic Braille numerals, Arabic Braille alphabet, Arabic Braille text, Arabic numerals, Arabic alphabet, Arabic text, English Braille numerals, English Braille alphabet, English Braille text, English numerals, English alphabet and English text. The plurality of labeled images of Braille scripts generates a plurality of Braille script recognition classes. The dataset of Braille scripts is not limited to English or Arabic and may also include numerals, alphabet and text in any language in which Braille is used.

The resized Braille image is input to the trained deep learning based CNN model to recognize characters or words corresponding to the Braille image. The trained deep learning based CNN model is a sequence of convolutional layer and pooling layer. The important features of the Braille image are kept in the convolution layers and intensified in the pooling layers and kept over the network, while discarding all the unnecessary information. The convolutional layers and pooling layers are consecutively connected to extract features of the resized Braille image to generate a features map. A flattening function may then be applied to the features map. The flattened features map may be passed through a neural network of fully connected layers or dense layers followed by an output layer. In the output layer, the Braille script recognition class is determined for the resized Braille image input to the trained deep learning based CNN model. The image recognition is complete, and the text corresponding to the captured Braille image is determined.

The processor may generate or extract an audio waveform of the text corresponding to the captured Braille image and transmit the audio waveform to the speaker **114**. The speaker **114** may generate a sound corresponding to the audio waveform of the text corresponding to the captured Braille image. In an aspect of the present disclosure, the microprocessor may be configured to change the sound corresponding to the audio waveform. For example, the user may select the sound to be a man's voice, a woman's voice, a child's voice, a cartoon character's voice, and any other voice from a selection of voice options.

In an aspect of the present disclosure, the microprocessor may connect to a computing device, such as a mobile phone or a server computing device to configure the sound of the Braille reading device **100**. In an aspect of the present disclosure, the Braille reading device **100** may pair with a mobile computing device running an application corresponding to the Braille reading device **100**. The user may adjust one or more configurations of the Braille reading device **100** via the application running on the mobile computing device. In an aspect of the present disclosure, the application may provide a user interface to present the learning progress of the user.

In an aspect display of the present disclosure, a display device may be connected to the digital camera **106**. At least one of a written text or a picture representative of the text corresponding to the captured Braille image may be displayed on the display device.

In an aspect of the present disclosure, the trained deep learning based CNN model may be implemented using open source Python libraries, such as TensorFlow, Keras, NumPy, and OpenCV.

In an aspect of the present disclosure, the microprocessor may be configured to run a programming code written in a programming language, such as R and Python. Running the programming code may cause the microprocessor to run the deep learning based CNN model to start the recognition process of the captured Braille image, and play an audio representation of the recognized text corresponding to the captured Braille image. In an aspect of the present disclosure, the trained deep learning based CNN model may be programmed on a host machine and configured on the microprocessor. The microprocessor may connect with the host machine to receive any updates related to the trained deep learning based CNN model and/or digital image processing.

Aspects of the present disclosure may enable a user, such as a visually impaired person or any other person reading or learning the Braille script to understand Braille scripts without assistance of a trainer. The user may sense the Braille dots and activate the digital camera **106** to capture the Braille image. The processor may process the captured Braille image and access the trained deep learning based CNN model to recognize text corresponding to the Braille image. Sounds of the recognized text may be played by the speaker **114** and/or displayed on a display screen. Thus, the Braille reading device **100** of the present disclosure provides real-time learning experience for the user with minimal or no assistance.

In an aspect of the present disclosure, the deep learning based CNN model may be trained on a dataset of Arabic braille numerals, alphabet, and text. Approximately 50,500 images may be collected for the dataset consisting of 10 classes for numerals, 28 classes for alphabet, and 60 classes of words in the Arabic language. Similar concept for training the deep learning based CNN model may be applied for other languages, thus, making the Braille reading device **100** compatible with any other language. The microprocessor may load the trained deep learning based CNN model for any other language to recognize text corresponding to Braille in that language.

FIG. **5** shows an exemplary process flow **500** of the present invention illustrating a method for converting printed Braille dots to speech, according to exemplary aspects of the present disclosure.

At step **502**, the method includes capturing a Braille image of the printed Braille dots.

At step **504**, the method includes matching the Braille image to a textural character corresponding to the Braille image. Data processing and one or more image recognition operations may be performed to match the Braille image to the textural character.

At step **506**, the method includes converting the textural character to an audio waveform.

At step **508**, the method includes transmitting the audio waveform to the speaker **114**.

At step **510**, the method includes generating a sound representative of a spoken word corresponding to the textural character. The speaker **114** generates the sound representative of the spoken word.

FIG. **6** shows an exemplary process flow **600** of the present invention illustrating a method for converting printed Braille dots to speech, according to exemplary aspects of the present disclosure.

At step **602**, the method includes directing a lens of the digital camera **106** towards Braille text including printed Braille dots. The digital camera is confined in the 3D ring case **102**.

At step **604**, the method includes compressing the switch **110** to capture a Braille image of the printed Braille dots.

At step **606**, the method includes matching the Braille image to a textural character corresponding to the Braille image. The microprocessor is configured to perform data processing and one or more image recognition operations to match the Braille image to the textural character.

At step **608**, the method includes converting the textural character to an audio waveform.

At step **610**, the method includes transmitting the audio waveform to the speaker **114**.

At step **612**, the method includes generating a sound representative of a spoken word corresponding to the textural character. The speaker **114** generates the sound representative of the spoken word.

The first embodiment is illustrated with respect to FIGS. **1**-**9**. The first embodiment describes a system for converting printed Braille dots to speech. The system comprises a 3D ring case **102**, **200**, a digital camera **106** mounted in the 3D ring case **102**, **200**, wherein the digital camera **106** is configured to capture a Braille image of the printed Braille dots, a rechargeable battery, a speaker **114**, a microprocessor operatively connected to the rechargeable battery, the digital camera **106** and the speaker **114**, the microprocessor configured to perform data processing and one or more image recognition operations which match the Braille image to a textural character corresponding to the Braille image, convert the textural character to an audio waveform, and transmit the audio waveform to the speaker **114**, and wherein the speaker **114** is configured to receive the audio waveform and generate a sound representative of a spoken word corresponding to the textural character.

The printed Braille dots are configured to represent an Arabic Braille textural character and the speaker **114** is configured to output a sound representative of an Arabic spoken word.

The textural character is configured to include one or more letters, one or more numbers, or one or more words.

The one or more letters include an Arabic letter or an English letter, the one or more numbers include an Arabic number or an English number, and the one or more words include an Arabic word or an English word.

The system further comprises a display connected to the digital camera **106**, wherein the display is configured to display one of a written word or a picture representative of the word corresponding to the Braille image.

The rechargeable battery is a lithium battery.

The digital camera **106** is connected to the microprocessor by a serial bus configured to transmit data signals representative of the Braille image from the digital camera **106** to the microprocessor.

The 3D ring case **102**, **200** includes a first ring configured to receive the digital camera **106**, a second ring configured to be worn on a finger of a user, wherein the second ring is arranged below the first ring, and a switch configured to actuate the digital camera **106** to capture the Braille image.

The system further comprises a microprocessor housing. The microprocessor housing includes a base configured to hold the microprocessor and the rechargeable battery, the base having a first elastic wristband connector and a second elastic wristband connector, a lid configured with sidewalls having a first plurality of cut outs configured for air flow and a second cut out configured to hold the speaker **114**, wherein a top of the lid has a third cut out configured to receive the serial bus, and wherein the base includes a plurality of slots around its periphery and the sidewalls include a plurality of tabs, wherein each tab is configured to align with a respective slot when the lid and the base are joined together.

The system further comprises a serial bus port located on the microprocessor; a power port configured to connect the rechargeable battery to the microprocessor, a first output pin configured to connect to a first wire, wherein the first wire is connected to a power input of the push button switch, a second output pin configured to connect a second wire, wherein the second wire is connected to a power output of the digital camera **106**, and a third output pin configured to connect to the speaker **114**.

The microprocessor is configured to perform the data processing by segmenting the Braille image into a plurality of segments, reducing image noise from the plurality of segments to generate a plurality of denoised segments, and resizing the plurality of denoised segments to generate a plurality of resized denoised segments.

The microprocessor is configured to perform one or more image recognition operations on the plurality of resized denoised segments to match the Braille image to a textural character corresponding to the Braille image by: training a deep learning based convolutional neural network on a dataset of Braille scripts, the Braille scripts including one or more of Arabic Braille numerals, Arabic Braille alphabet, Arabic Braille text, Arabic numerals, Arabic alphabet, Arabic text, English Braille numerals, English Braille alphabet, English Braille text, English numerals, English alphabet and English text to generate a plurality of Braille script recognition classes; applying the plurality of resized denoised segments to the deep learning based convolutional neural network, matching each of the plurality of resized denoised segments to a Braille script recognition class, and retrieving the audio waveform associated with the Braille script recognition class.

The second embodiment is illustrated with respect to FIGS. **1**-**9**. The second embodiment describes a method for converting printed Braille dots to speech. The method comprising capturing a Braille image of the printed Braille dots, matching, by performing data processing and one or more image recognition operations, the Braille image to a textural character corresponding to the Braille image, converting the textural character to an audio waveform, transmitting the audio waveform to a speaker **114**, and generating, by the speaker **114**, a sound representative of a spoken word corresponding to the textural character.

The method further comprising segmenting the Braille image into a plurality of segments, reducing image noise from the plurality of segments to generate a plurality of denoised segments, and resizing the plurality of denoised segments to generate a plurality of resized denoised segments.

The method further comprising training a deep learning based convolutional neural network on a dataset of Braille scripts, the Braille scripts including one or more of Arabic Braille numerals, Arabic Braille alphabet, Arabic Braille text, Arabic numerals, Arabic alphabet, Arabic text, English Braille numerals, English Braille alphabet, English Braille text, English numerals, English alphabet and English text to generate a plurality of Braille script recognition classes; applying the plurality of resized denoised segments to the deep learning based convolutional neural network, and matching each of the plurality of resized denoised segments to a Braille script recognition class, and retrieving the audio waveform associated with the Braille script recognition class.

The third embodiment is illustrated with respect to FIGS. **1**-**9**. The third embodiment describes a method for converting printed Braille dots to speech. The method comprising directing a lens of a digital camera **106** confined in a 3D ring case **102**, **200** towards Braille text including printed Braille dots, compressing a push button to capture a Braille image of the printed Braille dots, matching, by a microprocessor configured to perform data processing and one or more image recognition operations, the Braille image to a textural character corresponding to the Braille image, converting the textural character to an audio waveform, transmitting the audio waveform to a speaker **114**, and generating, by the speaker **114**, a sound representative of a spoken word corresponding to the textural character.

The method further comprising segmenting the Braille image into a plurality of segments, reducing image noise from the plurality of segments to generate a plurality of denoised segments, and resizing the plurality of denoised segments to generate a plurality of resized denoised segments.

The method further comprising training a deep learning based convolutional neural network on a dataset of Braille scripts, the Braille scripts including one or more of Arabic Braille numerals, Arabic Braille alphabet, Arabic Braille text, Arabic numerals, Arabic alphabet, Arabic text, English Braille numerals, English Braille alphabet, English Braille text, English numerals, English alphabet and English text to generate a plurality of Braille script recognition classes, applying the plurality of resized denoised segments to the deep learning based convolutional neural network, matching each of the plurality of resized denoised segments to a Braille script recognition class, and retrieving the audio waveform associated with the Braille script recognition class.

The method further comprising transmitting, to the speaker, a sound representative of an Arabic spoken word corresponding to an Arabic textural character associated with Arabic Braille printed dots.

The method further comprising displaying, on the digital camera **106**, one of a written word or a picture representative of the textural character corresponding to the Braille image.

FIG. **7** is an illustration of a non-limiting example of details of computing hardware used in the computing system, according to exemplary aspects of the present disclosure. In FIG. **7**, a controller **700** is described is representative of the system **600** of FIG. **6** in which the controller is a computing device which includes a CPU **701** which performs the processes described above/below. The process data and instructions may be stored in memory **702**. These processes and instructions may also be stored on a storage medium disk **704** such as a hard drive (HDD) or portable storage medium or may be stored remotely.

Further, the claims are not limited by the form of the computer-readable media on which the instructions of the inventive process are stored. For example, the instructions may be stored on CDs, DVDs, in FLASH memory, RAM, ROM, PROM, EPROM, EEPROM, hard disk or any other information processing device with which the computing device communicates, such as a server or computer.

Further, the claims may be provided as a utility application, background daemon, or component of an operating system, or combination thereof, executing in conjunction with CPU **701**, **703** and an operating system such as Microsoft Windows 7, Microsoft Windows 10, UNIX, Solaris, LINUX, Apple MAC-OS, and other systems known to those skilled in the art.

The hardware elements in order to achieve the computing device may be realized by various circuitry elements, known to those skilled in the art. For example, CPU **701** or CPU **703** may be a Xenon or Core processor from Intel of America or an Opteron processor from AMD of America, or may be other processor types that would be recognized by one of ordinary skill in the art. Alternatively, the CPU **701**, **703** may be implemented on an FPGA, ASIC, PLD or using discrete logic circuits, as one of ordinary skill in the art would recognize. Further, CPU **701**, **703** may be implemented as multiple processors cooperatively working in parallel to perform the instructions of the inventive processes described above.

The computing device in FIG. **7** also includes a network controller **706**, such as an Intel Ethernet PRO network interface card from Intel Corporation of America, for interfacing with network **760**. As can be appreciated, the network **760** can be a public network, such as the Internet, or a private network such as an LAN or WAN network, or any combination thereof and can also include PSTN or ISDN subnetworks. The network **760** can also be wired, such as an Ethernet network, or can be wireless such as a cellular network including EDGE, 3G and 4G wireless cellular systems. The wireless network can also be WiFi, Bluetooth, or any other wireless form of communication that is known.

The computing device further includes a display controller **708**, such as a NVIDIA GeForce GTX or Quadro graphics adaptor from NVIDIA Corporation of America for interfacing with display **710**, such as a Hewlett Packard HPL2445w LCD monitor. A general purpose I/O interface **712** interfaces with a keyboard and/or mouse **714** as well as a touch screen panel **716** on or separate from display **710**. General purpose I/O interface also connects to a variety of peripherals **718** including printers and scanners, such as an OfficeJet or DeskJet from Hewlett Packard.

A sound controller **720** is also provided in the computing device such as Sound Blaster X-Fi Titanium from Creative, to interface with speakers/microphone **722** thereby providing sounds and/or music.

The general purpose storage controller **724** connects the storage medium disk **704** with communication bus **726**, which may be an ISA, EISA, VESA, PCI, or similar, for interconnecting all of the components of the computing device. A description of the general features and functionality of the display **710**, keyboard and/or mouse **714**, as well as the display controller **708**, storage controller **724**, network controller **706**, sound controller **720**, and general purpose I/O interface **712** is omitted herein for brevity as these features are known.

The exemplary circuit elements described in the context of the present disclosure may be replaced with other elements and structured differently than the examples provided herein. Moreover, circuitry configured to perform features described herein may be implemented in multiple circuit units (e.g., chips), or the features may be combined in circuitry on a single chipset, as shown on FIG. **8**.

FIG. **8** shows a schematic diagram of a data processing system, according to certain embodiments, for performing the functions of the exemplary embodiments. The data processing system is an example of a computer in which code or instructions implementing the processes of the illustrative embodiments may be located.

In FIG. **8**, data processing system **800** employs a hub architecture including a north bridge and memory controller hub (NB/MCH) **825** and a south bridge and input/output (I/O) controller hub (SB/ICH) **820**. The central processing unit (CPU) **830** is connected to NB/MCH **825**. The NB/MCH **825** also connects to the memory **845** via a memory bus, and connects to the graphics processor **850** via an accelerated graphics port (AGP). The NB/MCH **825** also connects to the SB/ICH **820** via an internal bus (e.g., a unified media interface or a direct media interface). The

CPU Processing unit **830** may contain one or more processors and even may be implemented using one or more heterogeneous processor systems.

For example, FIG. **9** shows one implementation of CPU **830**. In one implementation, the instruction register **938** retrieves instructions from the fast memory **940**. At least part of these instructions are fetched from the instruction register **938** by the control logic **936** and interpreted according to the instruction set architecture of the CPU **830**. Part of the instructions can also be directed to the register **932**. In one implementation the instructions are decoded according to a hardwired method, and in another implementation the instructions are decoded according to a microprogram that translates instructions into sets of CPU configuration signals that are applied sequentially over multiple clock pulses. After fetching and decoding the instructions, the instructions are executed using the arithmetic logic unit (ALU) **934** that loads values from the register **932** and performs logical and mathematical operations on the loaded values according to the instructions. The results from these operations can be feedback into the register and/or stored in the fast memory **940**. According to certain implementations, the instruction set architecture of the CPU **830** can use a reduced instruction set architecture, a complex instruction set architecture, a vector processor architecture, a very large instruction word architecture. Furthermore, the CPU **830** can be based on the Von Neuman model or the Harvard model. The CPU **830** can be a digital signal processor, an FPGA, an ASIC, a PLA, a PLD, or a CPLD. Further, the CPU **830** can be an x86 processor by Intel or by AMD; an ARM processor, a Power architecture processor by, e.g., IBM; a SPARC architecture processor by Sun Microsystems or by Oracle; or other known CPU architecture.

Referring again to FIG. **8**, the data processing system **800** can include that the SB/ICH **820** is coupled through a system bus to an I/O Bus, a read only memory (ROM) **856**, universal serial bus (USB) port **864**, a flash binary input/output system (BIOS) **868**, and a graphics controller **858**. PCI/PCIe devices can also be coupled to SB/ICH **888** through a PCI bus **862**.

The PCI devices may include, for example, Ethernet adapters, add-in cards, and PC cards for notebook computers. The Hard disk drive **860** and CD-ROM **866** can use, for example, an integrated drive electronics (IDE) or serial advanced technology attachment (SATA) interface. In one implementation the I/O bus can include a super I/O (SIO) device.

Further, the hard disk drive (HDD) **860** and optical drive **866** can also be coupled to the SB/ICH **820** through a system bus. In one implementation, a keyboard **870**, a mouse **872**, a parallel port **878**, and a serial port **876** can be connected to the system bus through the I/O bus. Other peripherals and devices that can be connected to the SB/ICH **820** using a mass storage controller such as SATA or PATA, an Ethernet port, an ISA bus, a LPC bridge, SMBus, a DMA controller, and an Audio Codec.

Moreover, the present disclosure is not limited to the specific circuit elements described herein, nor is the present disclosure limited to the specific sizing and classification of these elements. For example, the skilled artisan will appreciate that the circuitry described herein may be adapted based on changes on battery sizing and chemistry, or based on the requirements of the intended back-up load to be powered.

Additionally, some implementations may be performed on modules or hardware not identical to those described. Accordingly, other implementations are within the scope that may be claimed.

The above-described hardware description is a non-limiting example of corresponding structure for performing the functionality described herein.

Obviously, numerous modifications and variations of the present disclosure are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

The invention claimed is:

1. A system for converting printed Braille dots to speech, the system comprising:

a 3D ring case;

a digital camera mounted in the 3D ring case, wherein the digital camera is configured to capture a Braille image of the printed Braille dots;

a rechargeable battery;

a speaker;

a microprocessor operatively connected to the rechargeable battery, the digital camera and the speaker, the microprocessor configured to perform data processing and one or more image recognition operations which match the Braille image to a textural character corresponding to the Braille image, convert the textural character to an audio waveform, and transmit the audio waveform to the speaker;

wherein the speaker is configured to receive the audio waveform and generate a sound representative of a spoken word corresponding to the textural character; and

wherein the microprocessor is configured to perform the data processing by:

segmenting the Braille image into a plurality of segments,

reducing image noise from the plurality of segments to generate a plurality of denoised segments, and

resizing the plurality of denoised segments to generate a plurality of resized denoised segments.

2. The system of claim **1**, wherein the printed Braille dots are configured to represent an Arabic Braille textural character and the speaker is configured to output a sound representative of an Arabic spoken word.

3. The system of claim **1**, wherein the textural character is configured to include one or more letters, one or more numbers, or one or more words.

4. The system of claim **3**, wherein the one or more letters include an Arabic letter or an English letter, the one or more numbers include an Arabic number or an English number, and the one or more words include an Arabic word or an English word.

5. The system of claim **1**, further comprising:

a display connected to the digital camera, wherein the display is configured to display one of a written word or a picture representative of the word corresponding to the Braille image.

6. The system of claim **1**, wherein the rechargeable battery is a lithium battery.

7. The system of claim **1**, wherein the digital camera is connected to the microprocessor by a serial bus configured to transmit data signals representative of the Braille image from the digital camera to the microprocessor.

8. The system of claim 7, wherein the 3D ring case includes:

a first ring configured to receive the digital camera;

a second ring configured to be worn on a finger of a user, wherein the second ring is arranged below the first ring; and

a switch configured to actuate the digital camera to capture the Braille image.

9. The system of claim 1, wherein the microprocessor is configured to perform one or more image recognition operations on the plurality of resized denoised segments to match the Braille image to a textural character corresponding to the Braille image by:

training a deep learning based convolutional neural network on a dataset of Braille scripts, the Braille scripts including one or more of Arabic Braille numerals, Arabic Braille alphabet, Arabic Braille text, Arabic numerals, Arabic alphabet, Arabic text, English Braille numerals, English Braille alphabet, English Braille text, English numerals, English alphabet, and English text to generate a plurality of Braille script recognition classes;

applying the plurality of resized denoised segments to the deep learning based convolutional neural network;

matching each of the plurality of resized denoised segments to a Braille script recognition class; and

retrieving the audio waveform associated with the Braille script recognition class.

10. A system for converting printed Braille dots to speech, the system comprising:

a 3D ring case;

a digital camera mounted in the 3D ring case, wherein the digital camera is configured to capture a Braille image of the printed Braille dots;

a rechargeable battery;

a speaker;

a microprocessor operatively connected to the rechargeable battery, the digital camera and the speaker, the microprocessor configured to perform data processing and one or more image recognition operations which match the Braille image to a textural character corresponding to the Braille image, convert the textural character to an audio waveform, and transmit the audio waveform to the speaker; and

a microprocessor housing, the microprocessor housing including:

a base configured to hold the microprocessor and the rechargeable battery, the base having a first elastic wristband connector and a second elastic wristband connector;

a lid configured with sidewalls having a first plurality of cut outs configured for air flow and a second cut out configured to hold the speaker, wherein a top of the lid has a third cut out configured to receive the serial bus; and

wherein the base includes a plurality of slots around its periphery and the sidewalls include a plurality of tabs, wherein each tab is configured to align with a respective slot when the lid and the base are joined together,

wherein the speaker is configured to receive the audio waveform and generate a sound representative of a spoken word corresponding to the textural character;

wherein the digital camera is connected to the microprocessor by a serial bus configured to transmit data signals representative of the Braille image from the digital camera to the microprocessor; and

wherein the 3D ring case includes:

a first ring configured to receive the digital camera,

a second ring configured to be worn on a finger of a user, wherein the second ring is arranged below the first ring, and

a switch configured to actuate the digital camera to capture the Braille image.

11. The system of claim 10, further comprising:

a serial bus port located on the microprocessor;

a power port configured to connect the rechargeable battery to the microprocessor;

a first output pin configured to connect to a first wire, wherein the first wire is connected to a power input of the push button switch;

a second output pin configured to connect a second wire, wherein the second wire is connected to a power output of the digital camera; and

a third output pin configured to connect to the speaker.

12. A method for converting printed Braille dots to speech, the method comprising:

capturing a Braille image of the printed Braille dots;

matching, by performing data processing and one or more image recognition operations, the Braille image to a textural character corresponding to the Braille image;

converting the textural character to an audio waveform;

transmitting the audio waveform to a speaker;

generating, by the speaker, a sound representative of a spoken word corresponding to the textural character;

segmenting the Braille image into a plurality of segments;

reducing image noise from the plurality of segments to generate a plurality of denoised segments; and

resizing the plurality of denoised segments to generate a plurality of resized denoised segments.

13. The method of claim 12, further comprising:

training a deep learning based convolutional neural network on a dataset of Braille scripts, the Braille scripts including one or more of Arabic Braille numerals, Arabic Braille alphabet, Arabic Braille text, Arabic numerals, Arabic alphabet, Arabic text, English Braille numerals, English Braille alphabet, English Braille text, English numerals, English alphabet, and English text to generate a plurality of Braille script recognition classes;

applying the plurality of resized denoised segments to the deep learning based convolutional neural network; and

matching each of the plurality of resized denoised segments to a Braille script recognition class; and

retrieving the audio waveform associated with the Braille script recognition class.

14. The method of claim 12, further comprising:

training a deep learning based convolutional neural network on a dataset of Braille scripts, the Braille scripts including one or more of Arabic Braille numerals, Arabic Braille alphabet, Arabic Braille text, Arabic numerals, Arabic alphabet, Arabic text, English Braille numerals, English Braille alphabet, English Braille text, English numerals, English alphabet, and English text to generate a plurality of Braille script recognition classes;

applying the plurality of resized denoised segments to the deep learning based convolutional neural network;

matching each of the plurality of resized denoised segments to a Braille script recognition class; and

retrieving the audio waveform associated with the Braille script recognition class.

15. The method of claim **14**, further comprising:

transmitting, to the speaker, a sound representative of an Arabic spoken word corresponding to an Arabic textural character associated with Arabic Braille printed dots.

16. The method of claim **14**, further comprising:

displaying, on the digital camera, one of a written word or a picture representative of the textural character corresponding to the Braille image.

17. A method for converting printed Braille dots to speech, the method comprising:

directing a lens of a digital camera confined in a 3D ring case towards Braille text including printed Braille dots;

compressing a push button to capture a Braille image of the printed Braille dots;

matching, by a microprocessor configured to perform data processing and one or more image recognition operations, the Braille image to a textural character corresponding to the Braille image;

converting the textural character to an audio waveform;

transmitting the audio waveform to a speaker;

generating, by the speaker, a sound representative of a spoken word corresponding to the textural character;

segmenting the Braille image into a plurality of segments;

reducing image noise from the plurality of segments to generate a plurality of denoised segments; and

resizing the plurality of denoised segments to generate a plurality of resized denoised segments.

* * * * *