

Voice Activated Page Turner for People with Limited Bilateral Upper Extreme Functionality

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ABSTRACT

It is very difficult for the people with limited bilateral upper extreme functionality to perform simple tasks such as book reading because of their inability in flipping the pages of a book. A page turner is an assistive device for such people that help them to flip the pages of a book towards left or right depending on the user's requirement. Although many devices are available for automatically turning the pages only a few of them are meant for people with disabilities. It is difficult for these special people to operate the switches of the paper turning machine. Furthermore, the price of these devices is very high. So, there is a need for a low cost portable device which does not use switches alone for turning the pages of a book so that it is convenient for the physically challenged people to use it with dexterity. This paper proposes a voice activated automatic page turner for people who are deprived off their upper extremities. This device can be operated in voice activation mode and silent mode. These modes help the user to comfortably use it in any type of places. The proposed device can turn the pages one by one and also can turn multiple pages in the voice mode. This device can be used for papers with any sort of thickness.

Keywords: Neurological Impairment, Page Turner, Assistive Device, voice activation

1. INTRODUCTION

Limited bilateral upper extreme functionality is caused by neurological impairment, musculo skeletal problems and general weakness [1]. Furthermore, people who have suffered cerebro vascular accidents, spinal cord injuries Amyotrophic Lateral Sclerosis (ALS), multiple sclerosis Cerebral Palsy (CP) and arthritic joint changes also face the same problems regarding their motor activity [2]. As the said population has limited motor activity, it would be very difficult for them to perform simple tasks such as book reading because of their inability in flipping the pages of a book. A page turner is an assistive device for such people that help them to flip the pages of a book towards left or right depending on the user's requirement.

There are two types of page turners available in the literature. They are: manually operated page turners and automatic page turners. A manual page turner comprises of a stick that can held by means of a hand or in the mouth. The rubber tip of the stick slides the pages of the book. This type of device causes inconvenience to the user as it restricts the usage of mouth and hands and also is very painful. While using the page turner with mouth it hurts the corners of the mouth and also causes a lot of salivation. Automatic page turners are electrically powered devices. They can hold the book and turn the pages by the activation of switches. The switches can be electrical, pneumatic or that have suck and blow operation [3].

A review of literature is made on page turners that can help physically challenged people. DLF manufactures electric page turners that can clamp the book and turns the pages by switches. However, the cost of this device is very high and is about £2000 [4]. Rehab mart also manufactures this device which can hold the book and slide the pages. This device has three modes: For musicians, for disabled people and for avid readers. For people with disabilities it uses sip and puff switches. However the biggest drawback with this device is feeding the papers in to the device. At a time only twenty papers can be fed in to the device and a caretaker has to feed the papers after every twenty pages [5].

KH Tsai et al designed and developed a page turner for people with upper cervical spinal injury in 2001. Besides being controlled by hands it can also be connected with other controllers such as blowing and treading to meet the needs of various patients [6]. Andreas Arzt et al developed an automatic page turner for musicians via real time machine listening in 2008. Their system is based on a new algorithm for following an incoming audio stream in real time and aligning it to a music score [7]. In 2013, Yoshihiro et al developed an automatic page turner machine for high speed book digitization. This machine turns the pages in a contact less manner by utilizing the elastic force of the paper and an air blast [8]. Although many devices are available for automatically turning the pages only a few of them are meant for people with disabilities. It is difficult for these special people to operate the switches of the paper turning machine. Furthermore, the price of these devices is very high. So, there is a need for a low cost portable device which does not use switches alone for turning the pages of a book so that it is convenient for the physically challenged people to use it with dexterity. This paper proposes a voice activated automatic page turner for people who are deprived off their upper extremities. The rest of the paper is organized as follows: Section 2 describes the architectural details of the proposed page turner; section III describes the algorithmic flow for the implementation of flipping the pages using voice commands. Section IV describes the operational details of the page turner and finally section V concludes the paper.



2. Hardware Architecture of Voice Activated Page Turner

The hardware architecture for the voice activated page turner is shown in Fig.1.

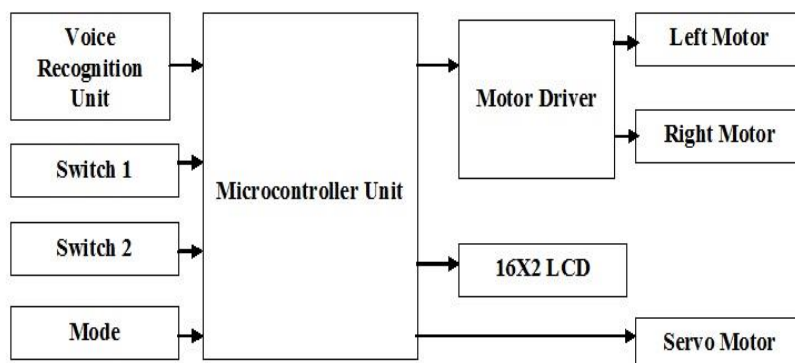


Fig.1: Hardware Architecture of Voice Activated Page Turner

As shown in Fig.1, the page turner unit consists of a mode selection switch. This switch is used to keep the page turner either in the Voice Activation mode or in the Silent Mode. When the selected mode is in the silent mode, the page turner acts like any other device that is used for sliding the pages. The switch 1 is used for flipping the pages from left to right and the switch 2 is used to flip the pages from right to left. The Silent mode can be used by the user when he is in places like library or in public places. When the selected mode is the Voice Activation (VA) mode, the page turner gets operated by the voice commands coming from the voice recognition unit. A 16X2 LCD is connected to the unit in order to display the selected mode, voice commands recognized and also to display the message “Un recognized command” when the user gives a command that is not stored in its memory. The pages are turned from left to right by means of two dc motors which are driven by motor driver module. A servo motor is used to give support for the flip of pages. The details of each of the sub systems used in the page turner unit are described below:

2.1. Voice Recognition Unit [9]

The Voice recognition module used in this device is made by elechouse. This module has two controlling ways: Serial port control and General Input control. The serial port control is fully functional while the general input control can control a part of the function. The voice commands are divided into three groups where each group can have a maximum of five commands. At any time five commands are effective if group control is being used. If it is not using group control, eighty voice commands can be recognized by the unit with each voice command limited to a duration of 1500ms. The grouping of voice commands in voice recognition unit is shown in Fig.2.

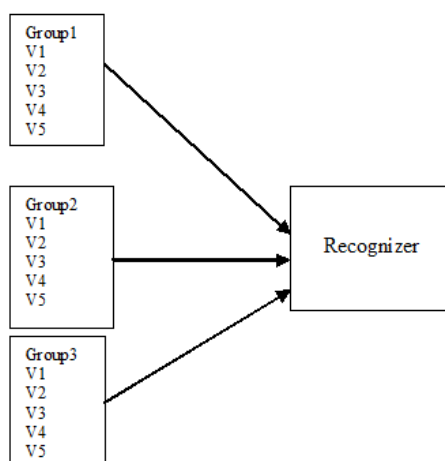


Fig.2: Voice Commands Group Control

2.2. Motor Driver Unit [10]

The motor driver unit in this device is the L293 D module. It can drive two dc motors at a time. It can drive currents up to 500mA and can drive voltage in the range of 5Vdc to 24V dc. The pin-out of L293D is shown in Fig.3.

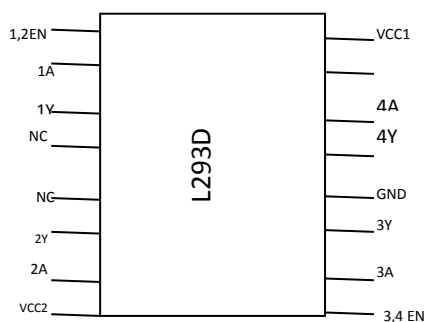


Fig.3: Pin-Out of L293 D Motor Driver

The pin-out diagram of L293D is shown in Fig. 3. The dc motor1 is connected between the outputs 1Y and 2Y. The input is applied to the terminal 1A and the other input terminal 2A is connected to ground. The dc motor2 is connected between the outputs 3Y and 4Y. The input is applied to the terminal 3A and the other input terminal 4A is connected to ground. When the motor driver is enabled, the motor vibrates according the PWM commands coming from the microcontroller.

2.3. Liquid Crystal Display [11]

The block diagram of a 16X2 LCD is shown in Fig.4. It can display 16 characters of data in 2 rows.

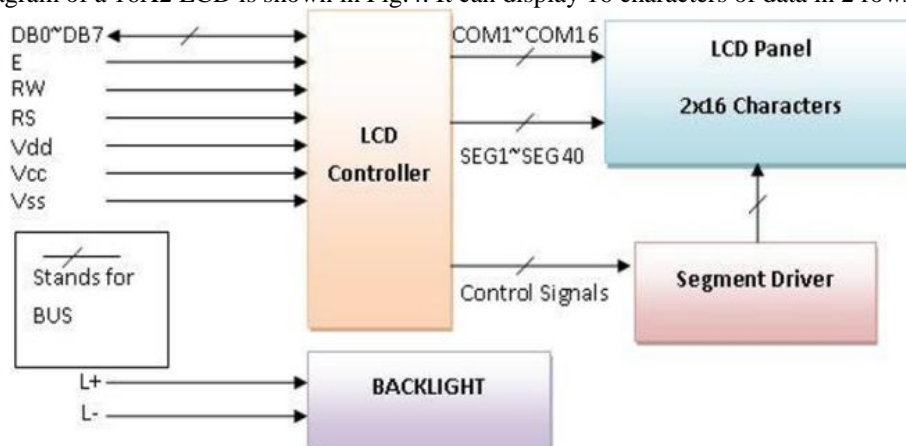


Fig.4: Block Diagram of 16X2 LCD

As shown in Fig.4, the LCD receives eight bit data from the microcontroller and displays it on the screen. For writing the data on to the screen, the enable signal must be set to high and the RW signal must be set to low logic level. A power supply of +5V is connected to L⁺ to adjust the back light. A preset is used to set the contrast of the monitor in order to display the characters properly on the screen.

2.4. Motors

Two 12V 60 rpm dc motors and a 5V servo motor are used in this device. The two dc motors are used to turn the pages left and right and the servo motor is used to give support to the flipping of pages.

All the above mentioned components are carefully assembled in a casing keeping in view of ergonomics and ease of use for the persons with limited bilateral upper extreme functionality. The details of the design of the outer case of the voice activated page turner are presented in the next section.

2.5. Outer Case Design

As shown in Fig.5, the voice activated page turner has two switches for flipping the pages from left to right. A mode selection switch is placed on the top of the device. This switches the device between the voice activation mode and the silent mode of operations. A microphone is placed on the top corner of the device in order to give voice commands that flip the pages. A finger tip like structure comes out of the top box in order to press the page and push it up for turning. A support to completely turn down the page is placed at the center of the top box. A base is provided to place the book.

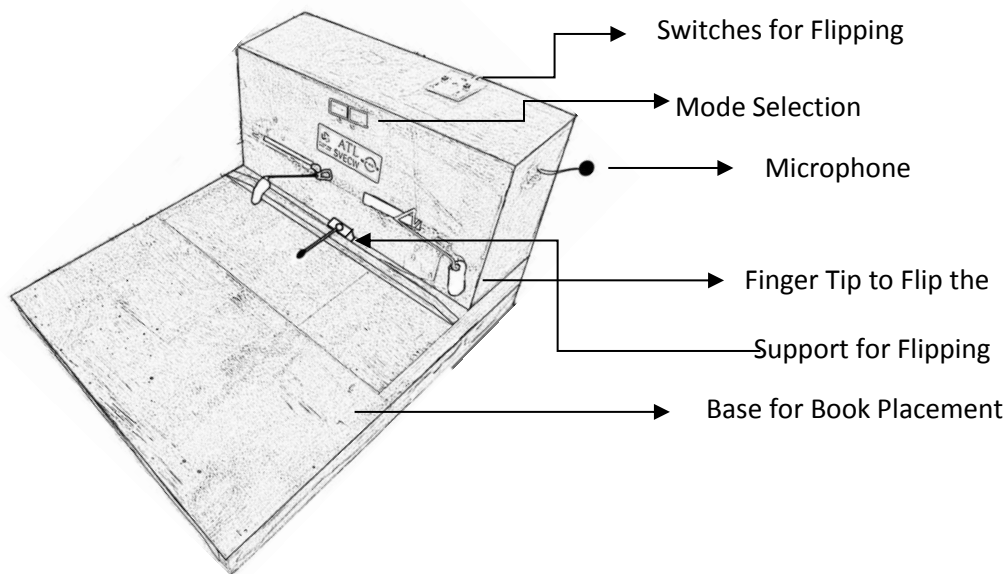


Fig.5: Outer Case Design of Voice Activated Page Turner

3. Software Implementation Details

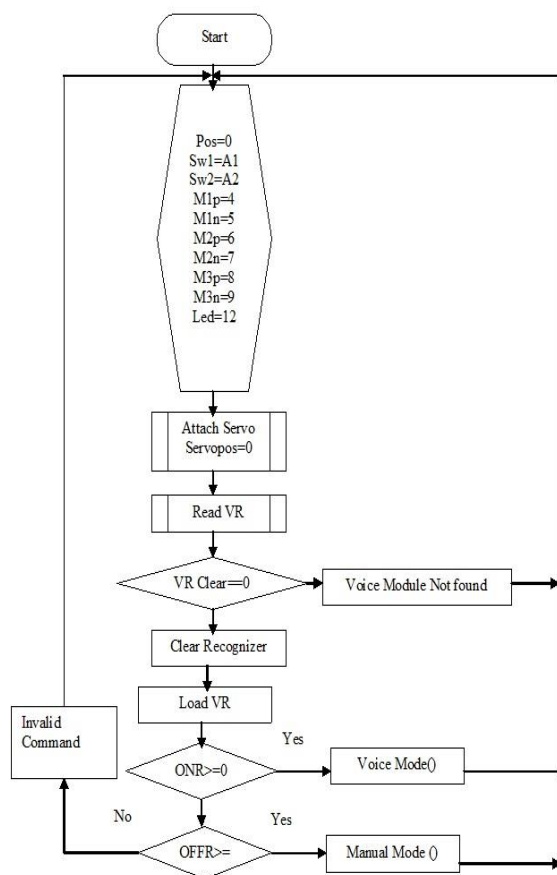


Fig.6: Flow Chart for Software Implementation

The device acts in two modes of operation and in one mode of operation it should respond to the voice commands. The software implementation details are provided in the flow chart shown in Fig.6. Initially the position of the servomotor is set to zero. The two terminals of the first dc motor are connected to pins 4 and 5 of the microcontroller and that of the second dc motor are connected to pins 6 and 7 of the microcontroller. The servo motor is connected to the pins 8 and 9 of the microcontroller. The LED to indicate the mode of operation is connected to pin 12 of the microcontroller. The LCD is connected to the digital pins 2, 12, 13 14, 15 of the microcontroller. Initially the servo is attached to the microcontroller to begin its operation and its position is set to zero. Then the signal VR coming from the voice recognition module is read through the serial port of the microcontroller. To initiate the voice recognition module, the module is cleared by using the clear command. If there is a proper communication between voice recognition module and the microcontroller, the voice recognition module is cleared. Otherwise, the microcontroller displays the message “Voice Module not Found. Check the connection” on the LCD. Then the next phase of the process is divided into two parts: Training Mode and Action Mode. In the training mode the voice commands to perform the operations like mode selection, turn the first dc motor left and right, turn the second dc motor left and right are trained and are stored in the memory of the voice recognition module. A total of five commands are used to perform the operation of turning the pages. During the Action mode: the voice commands are loaded into the voice module through the microphone connected to the device. If the command $ONR \geq 0$ the device is set to Voice activation mode else if the command $OFFR \geq 0$ the device is set to the manual mode of operation. If both the commands are less than zero, then a message “Command not Recognized” is displayed on the LCD screen. The entire operation is repeated in an infinite loop.

3.1. Voice Activation Mode

The voice activation mode can be explained with the help of the flow chart shown in Fig.7. The microcontroller checks if the data in the $ONR1 \geq 0$. If this condition is satisfied then it activates the dc motor on the right side. The motor makes the finger tip structure to press the paper and push it upwards through the mid way. Then the servomotor position changes from 0° to 90° . The servo motor waits for the paper to come till that position. After a certain delay the servomotor changes its position by 90° in the forward direction so that the paper is pressed down to completely turn the page from left to right. The same action in the reverse direction is repeated when $OFFR1 \geq 0$ to turn the page from left to right. This time the driving force for turning the page comes from the dc motor connected on the left side.

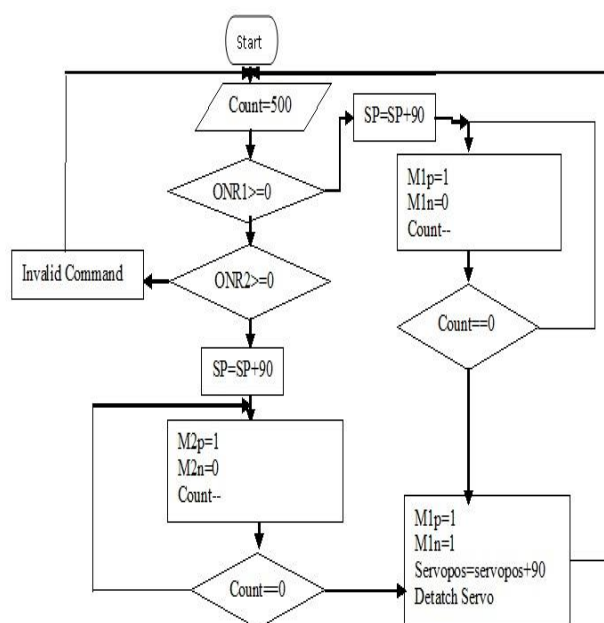


Fig.7 Flow Chart for Voice Activation Mode

The manual mode of operation is just similar to the voice activation mode except for the operations are performed based on switch action but not on voice commands. The manual mode can be explained with the help of the flow chart shown in Fig.8. The microcontroller checks if switch Sw1 is HIGH. If this condition is satisfied then it activates the dc motor on the right side. The motor makes the finger tip structure to press the paper and push it upwards through the mid way. Then the servomotor position changes from 0° to 90° . The servo motor waits for the paper to come till that position. After a certain delay the servomotor changes its position by 90° in the forward direction so that the paper is pressed down to completely turn the page from left to right. The same action in the reverse direction is repeated when Sw2 is HIGH to turn the page from left to right.

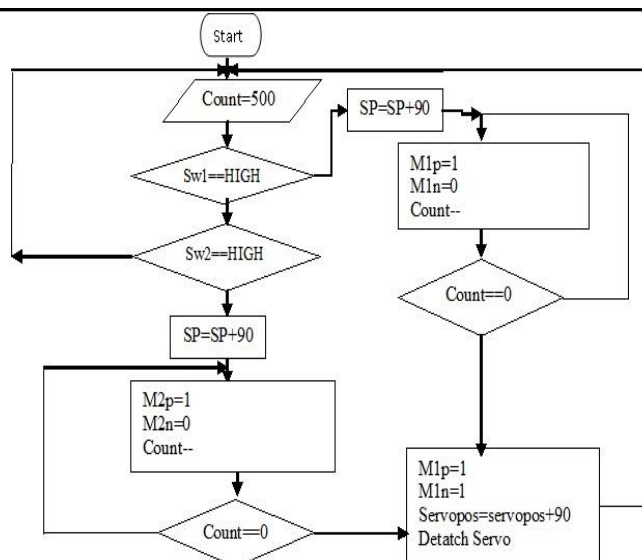


Fig.8: Flow Chart for Manual Mode of Operation

Till now the hardware architecture and the software implementation of voice activated page turner are presented in detail. The next section presents the details of working of voice activated page turner.

4. Working

As mentioned earlier the voice activated page turner works in two modes: voice activation mode and Silent mode. Silent mode is used when the user is sitting in crowded places where it is difficult to register the voice commands or in places like library where there is a restriction on talking and strict silence is to be maintained. In all other places the user can go with the voice activation mode. In either of the cases the page turner performs the following tasks based on voice commands or switching action:

1. Push the page down
2. Release the Page through Midway
3. Put down the Page

The actions performed by the page turner just mimic the way in which normal people turn the pages to read a book.

When the voice command is received or a switch is activated for turning the page from right to left: the top unit is panned towards right side of the unit as shown in Fig. 9(a). The finger tap attached to the dc motor on the right side comes down until it presses the page firmly down towards the base as shown in Fig. 9(c). In the meanwhile, the flap connected to the servo motor changes its position from rest to ninety degree position waiting to support the page to be put down.

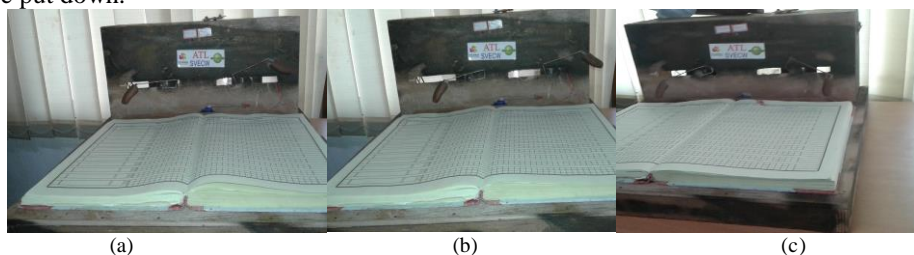


Fig.9: (a) Zero Position of Page Turner (b) Finger Tip Coming Down (c) Finger Tip Pushing the Page

After the paper is firmly pressed down the finger tip slowly slides the page upward and increases its speed to release it through half way of the book in the air. The said action is illustrated in Fig.10.

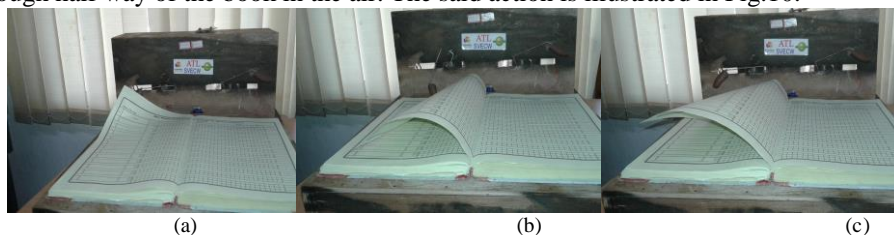


Fig.10: (a) Sliding the page (b) Folding the Page (c) Release through Halfway

After the paper is released through half way of the page turner the flap of the servo motor gives support to the paper so that it does not fall back. Then the servo position changes its position by ninety degrees and pushes the

paper down to the opposite side. In this way the pages are turned from left to right. The same actions are repeated for turning the page from right to left also.

The voice activated page turner can lift and turn the pages with utmost precision and accuracy. It is so designed that it can turn any number of pages from left to right or vice versa. There is no need for any mechanism that would feed papers in the device. The user just needs to put the book on the base of the page turner making a top alignment as marked on the base of the page turner. It can turn the pages one by one or it can turn multiple pages based on the voice commands. However it can turn only page by page when it is in switching mode. It can be used for books with any type of thickness. The final prototype of the voice activated page turner is shown in Fig.11.



Fig.11: Prototype of Page Turner

5. Conclusions

A voice activated page turner is designed and developed that would help the people with limited bilateral functionality. This device operated in voice activation mode and silent mode. These modes help the user to comfortably use it in any type of places. The proposed device can turn the pages one by one and also can turn multiple pages in the voice mode. This device can be used for papers with any sort of thickness.

ACKNOWLEDGEMENTS

The author would like to thank the management of Sri Vishnu Educational Society in general and Sri K. V. Vishnu Raju garu, Chairman in particular for providing all the funds required in executing the project and incorporating the sense of research in her mind. She also would like to express her gratitude to Dr. G. Srinivasa Rao garu for his all round encouragement in making this project. She also would like to extend her fond appreciation to all the student members involved in this project. Furthermore, she wish to acknowledge the support extended by ATL staff in doing this project.

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