Available online at www.uofk.edu
Proceedings Vol. 1 pp. 177 - 182
Annual Conference of Postgraduate Studies and Scientific Research
17-20 February 2012-10-17 Friendship
Hall, Khartoum

A Novel Tactile Web Navigator Device

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Abstract: In recent years, the internet has been a major source of information. Blind or visually impaired people have limited access to the internet; they may use screen readers, screen magnifiers, refreshable Braille displays or Braille printers. The level of user convenience provided by each tool is different and Braille display is found to be the most popular tool. Other tools have certain limitations on the speed of access and interaction. This paper presents a low cost novel tactile web navigator device aimed at enabling blind people to have feasible internet accessibility. This navigator design includes a microcontroller that communicates with the browser software running on the PC to acquire the text from a web page. The text is subsequently displayed using an array of solenoids which gives the required tactile sense. The blind user then uses his/her tactile sense to recognize the text in Braille language. It is recognized that only a small percentage of blind people are familiar Braille, another mode for output was developed which uses the English characters. The English characters may also appear in their conventional shapes to be sensed by the blind user. Many navigation functions like loading a webpage address, clicking on links and entering data (E-mails, passwords, etc) have been provided. The cost of the implementation is ~12% of the commercial Braille displays. The navigator was tested with volunteer blind users and the results were good; they were able to read Braille characters. Recording their notes, some limitations were discovered and will be eliminated in future models.

Keywords: *Braille; Tactile; Web navigator.*

1. INTRODUCTION

The Internet is now known as a mass communication media that links the whole world together; it does provide the knowledge, experience, news, social networks, E-commerce and jobs. Blind people have difficulties to find the feasible mean to access the internet. Most of these means are expensive and not dedicated to the internet navigation, e.g. [1]. The major issue among these tools is their high price [2], [3] and [5]. Blind people strongly need such means in their daily life to enroll into jobs and extend their knowledge sources. These means vary greatly in the levels of user convenience they provide. They include screen readers, screen magnifiers (for those who are not totally blind), Braille printer and Braille tactile displays. Each method has its wonders and limitations as will be depicted. Screen magnifiers are not suitable for totally blind individuals.

Blind people who are using hardcopy Braille printout or synthesized voice output from the computer face limitations of interaction speed and accuracy. They do not have the flexibility of 'reading' the screen and making the necessary changes instantaneously. To receive and process the voice output, the person using the computer must be quite alert in listening. Also, the vocabulary of the synthesized voice is limited. Words with slightly different spelling but having similar phonetics may be pronounced in the same manner, resulting in incorrect interpretation. Character by character sound output is very slow for interactive use of computers. A soft Braille display device, on the other hand, allows the users to 'read' the characters on their own pace and make on-line changes instantaneously [1]. A conceptual view of the tactile web navigator system is shown in figure 1. The system design comprises software and hardware design as will be depicted in the rest of this paper.

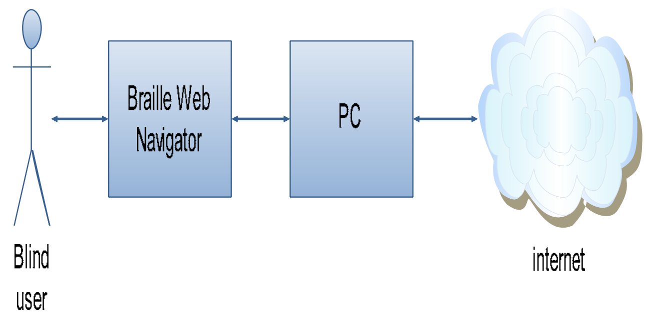

Figure (1). System overview

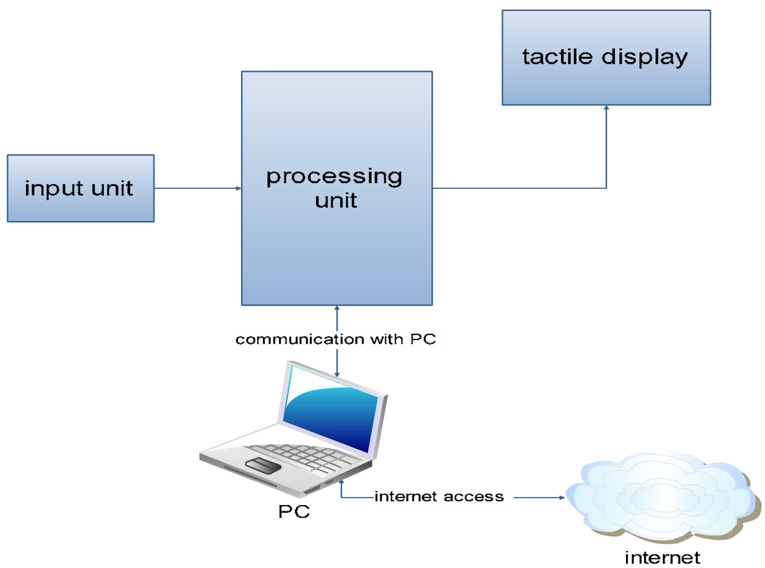

Figure (2). Block diagram of the navigator

2. SYSTEM REQUIREMENTS

The target system is intended to provide the following set of functions:

- A tactile display that can display the webpage text by tactile means: two modes to provide, Braille and English languages (the user selects).
- Cursor keys to move back and forth in the text.
- Many function keys for different functions.
- A keypad for text input.
- A communication link between the navigator and the PC.
- A sound feedback to inform that the device has started and a tactile feedback to indicate that the page loading has completed.
- The system must be able to provide the following navigation functions:
  - Loading the page by entering its address
  - Loading a page by clicking on a link
  - Inputting data into forms and submitting it
  - Reading the page content

3. DESIGN OBJECTIVES

The Braille navigator was designed to meet many design goals:

- Economic: relative low cost.
- Flexibility: ease of modification and upgrading.
- Ease of use: simplicity and regularity.

4. SYSTEM DESIGN

Our navigator, like any other embedded system, must wait for the user to press a key, perform some processing and takes the appropriate action. The navigator has many input keys, a processing unit that can communicate with the internet-enabled PC and a tactile display as an output as shown in figure 2.

The input unit is simply a key set that is arranged in a simple manner for the goal of simplicity of use. Each one of the navigation functions mentioned in the system requirements section was assigned a separate function key. Read function is considered the default function after the completion of other functions and hence had never assigned a function key. A cancel key has also been provided to skip the initiated function and stay in the current webpage. Moreover, a set of cursor keys are provided to enable the user to move through the webpage reading the content; there are two keys for moving forward and backward in the page text and two other keys for selecting among a list (links or forms). For text input, a keypad is provided to enter data like email addresses and passwords. English letters are distributed among the keys in an easy memorisable manner. Each key comprises three letters plus the numbers and some special characters (like _, @, space …etc).

The processing unit is the brain of the embedded system where the PC communications and control are carried out. We used a programmable microcontroller chip as our processing unit since we need a number of I/O ports. The data which is transferred using the PC communication link may include predefined messages and the webpage text; all are transferred from the internet-enabled PC to the navigator and vice versa.

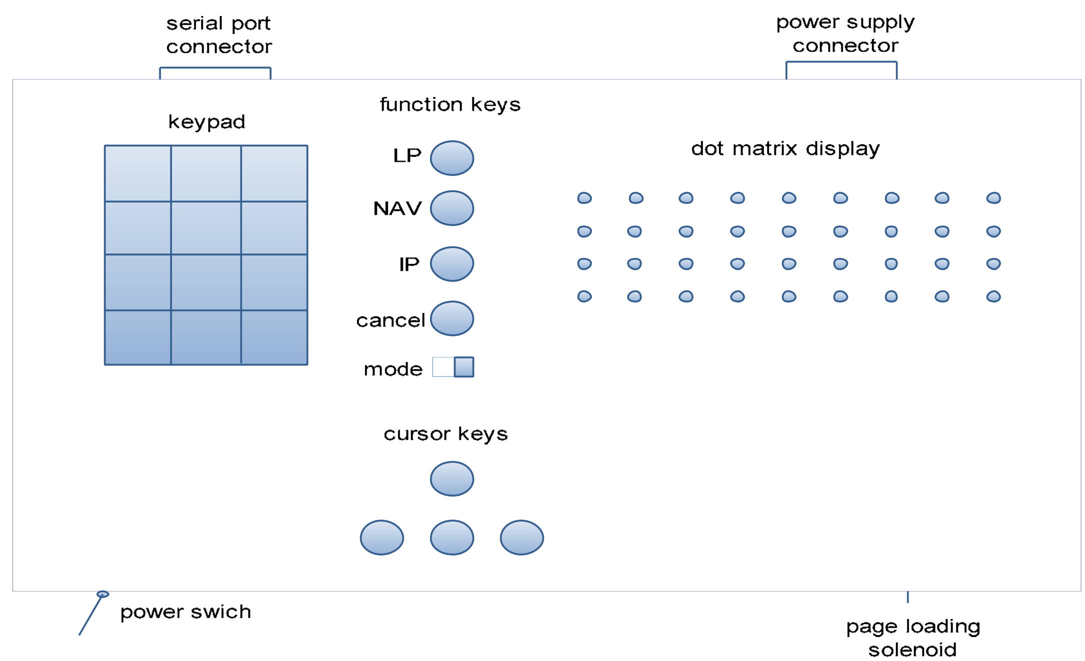

Figure (3). The layout of the navigator device

The processing unit then controls the ***output*** unit which is a tactile display that could display the characters in British Braille code or the ordinary English language (the mode toggle switch selects among). The tactile display is composed of a matrix of solenoids that rise and lower to make characters sensible and recognizable to the user's tactile sense (a solenoid is a coil with a plunger in the middle; it's shown in figure 5). In the design of the navigator, we heavily cared about the total cost as it is one of the design goals. For that purpose, we proposed a way to avoid the need of a large Braille display with 40 or 80 Braille cells. We replaced it by scrolling solenoid dot matrix that shifts one column left when the right cursor button is pressed and continues shifting left with a constant speed when the key is held. The scrolling speed could be adjusted to suit every user's sense-and-recognition speed. The user should receive some form of feedback when he/she issues a command. A tactile feedback was also provided by a single separate solenoid to indicate that a webpage has been loaded; the solenoid is activated when the page is being loaded and deactivated when the page has been loaded. An acoustic feedback was also provided to indicate that the device is ready when the user switches it on.

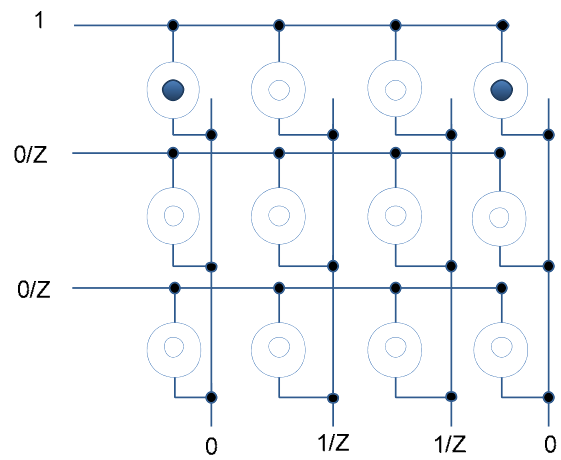

Figure (4). The multiplexing technique

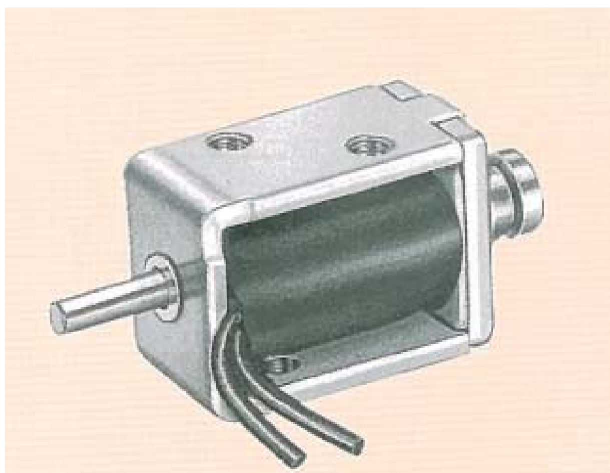

Figure (5). A solenoid

5. CONTROLLING THE TACTILE DISPLAY (THE SOLENOID DOT MATRIX)

The dot matrix requires individual control of dots to display characters. Individual control lines may be used but it isn't economic; we consume as many control pins as the number of dots (think about increasing the matrix size). In order to avoid using individual control lines for each dot, a multiplexing technique was used.

Multiplexing simply means turning on one row of dots for a short period of time and then turning on the next. If you do this fast enough then tactile sense will not notice any flicker (this idea was actually taken from [6]). We connect the solenoids in row and column manner (as shown in figure 4). We apply a positive voltage to the first row and hence each dot in that row is waiting for a ground to activate. We then apply a ground to the required dots in that row to a short period of time and shift the positive supply to the next row. Doing that very rapidly, the user will never sense these discontinuities in voltage. Of course the duty cycle per a dot is less in this case. Figure 4 shows the dot matrix with two activated dots (shown in blue). The dots are activated when a positive voltage is applied in one end and a ground at the other. The rows with 0/Z label are either with ground connected to them or tristated and so for the columns. Next the second row gets the positive voltage and a ground is applied where the dots must be activated and so on. The benefit is: for an m*n dot matrix we only require m+n control lines. By the help of an external decade counter chip we can reduce the number of control lines further to n+2.

6. SOFTWARE DESIGN

The behavior of the system is determined by the software. The system's behavior was described by state diagrams that show the predefined messages and how they're exchanged between the two parties: the navigator and the PC interface/agent. A state diagram scenario was developed for each one of the navigation functions mentioned in the design requirements section and for the two parties, the navigator microcontroller and the PC.

7. SYSTEM IMPLEMENTATION

The implementation comprised a keypad for text input, a set of function keys, a set of cursor keys, a processing unit and a 4*9 solenoid dot matrix display (a top view of the device layout is shown in figure 3). The circuit for this implementation is shown in figure 6.
The implementation also comprised:

- Atmel® ATMEGA32 was the microcontroller used.
- USART serial protocol was the PC communication link (the PC's serial port).
- The p-type power MOSFET IRF9640 was used to provide high-side switching for each row. ULN2003 transistor array chip was also used to drive the columns of the matrix to ground.
  - An external power supply was used to provide 5v and 12v. The 5v was used for the digital Integrated Circuits and a converter circuit was implemented to convert the 12v to 8v to supply the solenoids.
- A cooling fan, a buzzer feedback (sound) and a solenoid feedback (tactile).
- 4017 decade counter to select rows by sequence (one after another) and to reduce the control pins required from the microcontroller.

A double-sided PCB was used to accommodate the circuit.

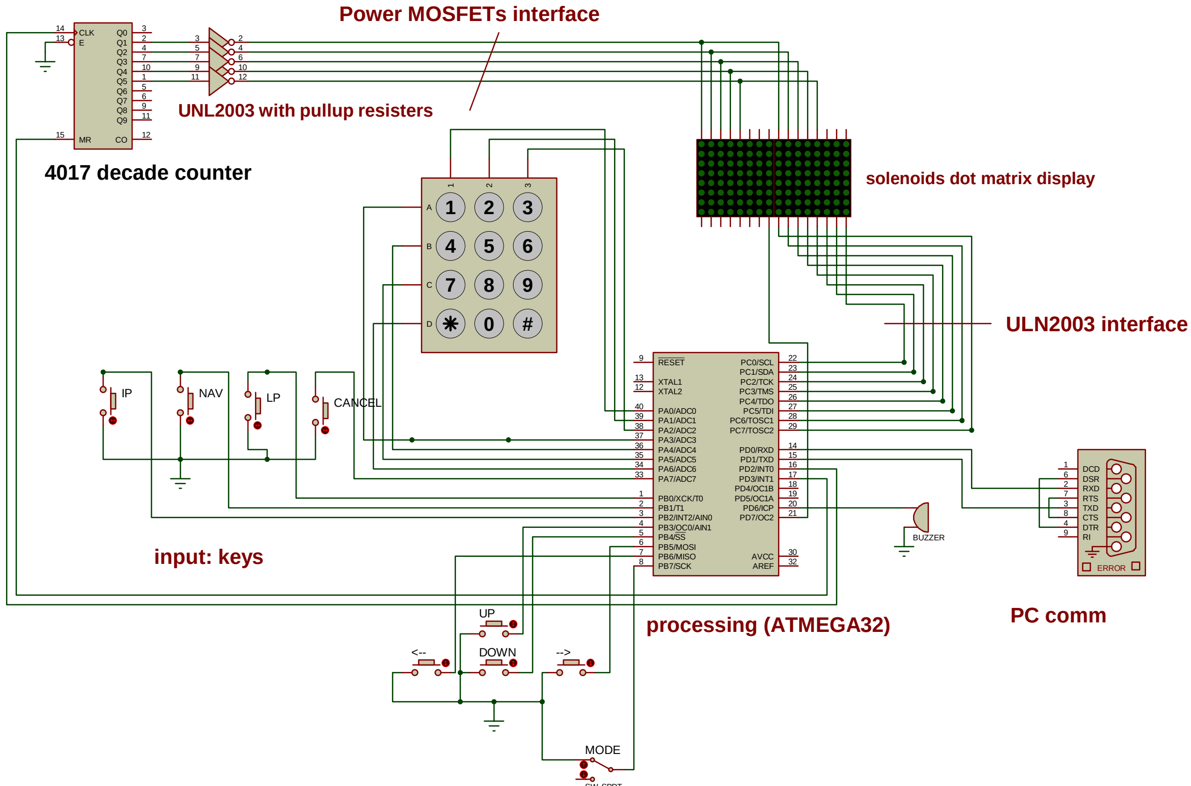

Figure (6). The navigator circuit diagram

The software implementation process was started by coding the state diagrams described previously in the system design. Two software programs were developed, the PC interface using Visual Basic language and the MCU code using embedded C. Microsoft Visual Studio 2008 IDE was used for Visual Basic programming and CodeVisionAVR IDE for embedded C programming. The PC interface comprises a web browser to surf the internet.

8. CONCLUSIONS

A functional novel tactile web navigation system has been successfully developed for blind internet users. Hardware and software design and implementation of the navigator were described. The navigator was also tested by volunteer blind users, and the results were good. The users were able to read Braille characters. Some limitations regarding the speed, size and comfort were identified and recommendations were made to enhance the next models. This system could be improved with the following proposed modifications:

- No need for PC: the navigator may be upgraded to be connected directly to a network access link eliminating the need for the intermediate PC.
- Support for the PC keyboard: as the standard keyboard was always seen as the preferable input device for the blind users.
- Replace the high current inductive load solenoids by piezoelectric linear motors will further reduce power consumption, size and performance.
- Support for USB2.0 interface: The USART serial interface has already started to depreciate since it is barely supported by laptop computers on recent days. Using USB2.0 would facilitate the ease of interface.
- Augmenting searching and bookmarking functionalities.

9. ACKNOWLEDGEMENTS

The authors would like to acknowledge the financial support provided by the Sudanese Engineers Union, Khartoum. The authors are also grateful to the technical staff of the Electronics Laboratory (UofK), members of the Cubestat project and the staff of Elneel Research Centre for value assistance. Special thanks are due to Dr. El-Sadig of Faculty of Arts, UofK, for volunteering to test this system and for providing valuable comments.

REFERENCES

[1] Braille display terminal for personal computers, N. Sriskanthan, K. R. Subramanian, Nanyang Technological Institute, Singapore

[2] Focus Braille Displays for the Visually Impaired by Freedom Scientific. Article at: http://www.freedomscientific.com/products/fs/focus-product-page.asp

[3] JAWS Screen Reading Software by Freedom Scientific. Article at:

[4] http://www.freedomscientific.com/products/fs/jaws-product-page.asp

[5] Blind people and the World Wide Web, Alasdair King, Gareth Evans, Paul Blenkhorn, UMIST, Manchester, UK.

[6] Article at: http://www.webbie.org.uk/webbie.htm

[7] How to drive an LED display matrix. Article at:http://www.best-microcontroller-projects.com/led-dot-matrix-display.html