Touchpad to Read Text Document for Blind People

Dhaval V. Waghulde[#1], Kishor S. Gaikwad[*2]
Undergraduate Student[#1],Electronics and Telecommunication Engineering, College of Engineering, Pune[#1]
*Undergraduate Student[*2],Electrical Engineering, College of Engineering, Pune[*2]*

Abstract
Aim of the project is to develop reading assistance technology for the blind, this paper presents the idea to provide visually impaired people access to any printed material or soft copies available in computer. The project is a suitable alternative to the Braille version of books. This initiative enables a blind person to converse with texts which are not available in Braille format. Image sensor provided facilitates user to take images of the text to be read. The dots of the script sensed by user are elevated electromagnetically by precise actuators. Experiments were carried out and results analyzed for distinct cases. Withaccurate processing, recognition and detection techniques it is possible to extract text from the image. Along with these features, many custom user settings are available, making it possible for the blind to read any printed work or a distant text by clicking an image. The algorithm can further be improved with noise rejection techniques, attempting userconvenience in interaction with real world. This paper discusses implemented electrical circuitry and software algorithms in detail and mechanical assembly in brief.

Keywords—*Actuators, image-processing, MATLAB*

I. INTRODUCTION

Reading is a means of sharing information and ideas. Visually impaired people are deprived of knowledge accessible through books and unprinted document files. Considerable efforts are made to make their lives easy, this project attempts to do the same.Braille script is a standard system used by blind for reading and writing. Using traditional embossed paper is costly, resource consuming, bulky and time consuming. Moreover, printing all publications on such paper is difficult. To help them use their imagination to create a setting, visible to mind's eye, the idea of text to Braille converter is being proposed. This experiment aims to develop a hardware prototyping pattern of dots which can elevate corresponding to input given. To get such elevations, solenoid actuator is an appropriate choice. The aim was to develop an independent assembly, using which people can read anything without any other assistance. This idea can be extended to work in a reverse manner to allow blind people to write text in books or a computer. This report presents experimental efforts and practical approach to the idea and is intended to the development of improved and superior design in the future.

II. PROPOSED SOLUTION

The project design consists of micro-controller interfaced with MATLAB and image sensor and actuators required to produce equivalent Braille elevation of a letter. This design operates in the two modes. In the first mode, actuatorsare controlled by soft copy of the text file. Microcontroller reads text file letter by letter and drives corresponding Solenoid Actuator. This produces elevations corresponding to Braille equivalent of that letter for the blind to sense so as to analyze the pattern. While in the second mode, images of the hard copy of a printed material are captured by camera sensor. This image is fed to the computer using serial port by micro-controller. Using MATLAB interfacing and image processing techniques the image file is converted into text file. Similar process of fragmentation of English lettersinto braille script takes place and actuators produce the required pattern.

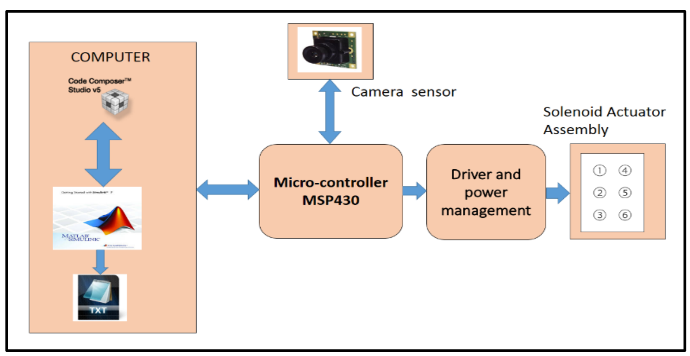

Figure 1: Block Diagram of System

III. IMPLEMENTATION

A. Hardware Implementation

Hardware of this project can be divided into four modules. Power Supply forms the first module, Camera sensor and Micro-Controller form second, third module includes circuitry for driving actuators and fourth includes hardware of actuator.

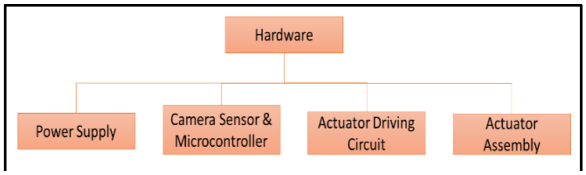

Figure 2: Hardware Implementation

Designing good power supply is critical to meet the power requirement, avoid any delays and necessary for full control of actuators. First phase of it is converting AC to DC. Current requirement for driving actuators being large we selected 18V 5A transformer. AC to DC conversion was done using a full bridge rectifier. Regulation of the voltage is the second phase. R-C filter was used to filter out ripples after rectification. This output is given to three precise voltage regulators 12V, 5V, 3,3V. The 12V regulator was an adjustable one to provide flexibility for change of actuators or actuator force. PCB tracks were kept wide for power lines and short for control signals. PCB optimisation rules were followed to ensure high efficiency and low regulation.

Load protection circuit forms the last phase of supply. UCC3915 was chosen because of its hot swap capability and circuit breaker functions.In case of an over current fault apart from protecting the user and circuital components from damaging performs another essential function as in case some actuators are OFF, the transformer may source a very large current to other actuators which are ON, damaging them in absence of this IC. The fault level is set well above normal consumption. This current limit settings is programmable with on-board switches. The board also has provision to notify user in case of fault.

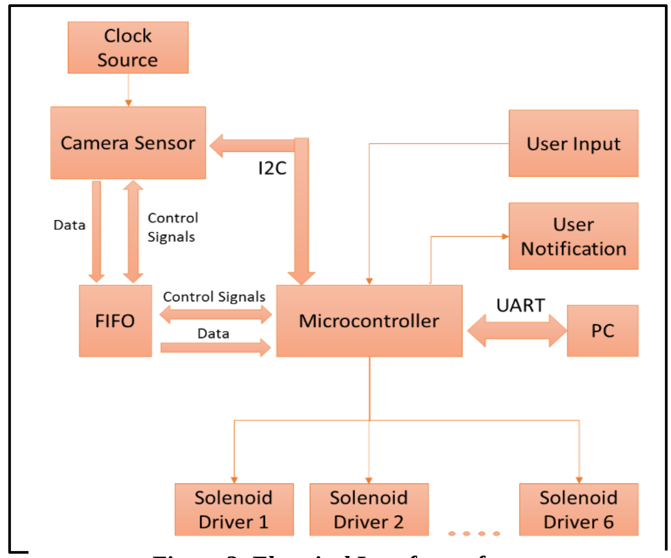

Figure 3: Electrical Interfaces of system

Next module is that of camera. Camera sensor chosen was OV7670. OV7670 is suitable for this project as it has an inbuilt DSP that can pre-process the image before it is sent. The internal DSP can be accessed via a SCCB (I2C) interface. This internal processor could perform essential functions such as conversion of raw data into standard format needed for this project. A dedicated clock source was given to image sensor considering criticality of application. This sensor is connected to a FIFO memory (AL422B) .The output of FIFO was connected to general purpose IO lines where data was read. A separate PCB was manufactured for soldering this camera so that it could be moved easily. This PCB was connected to main PCB using flexible wires for easy movement of camera.

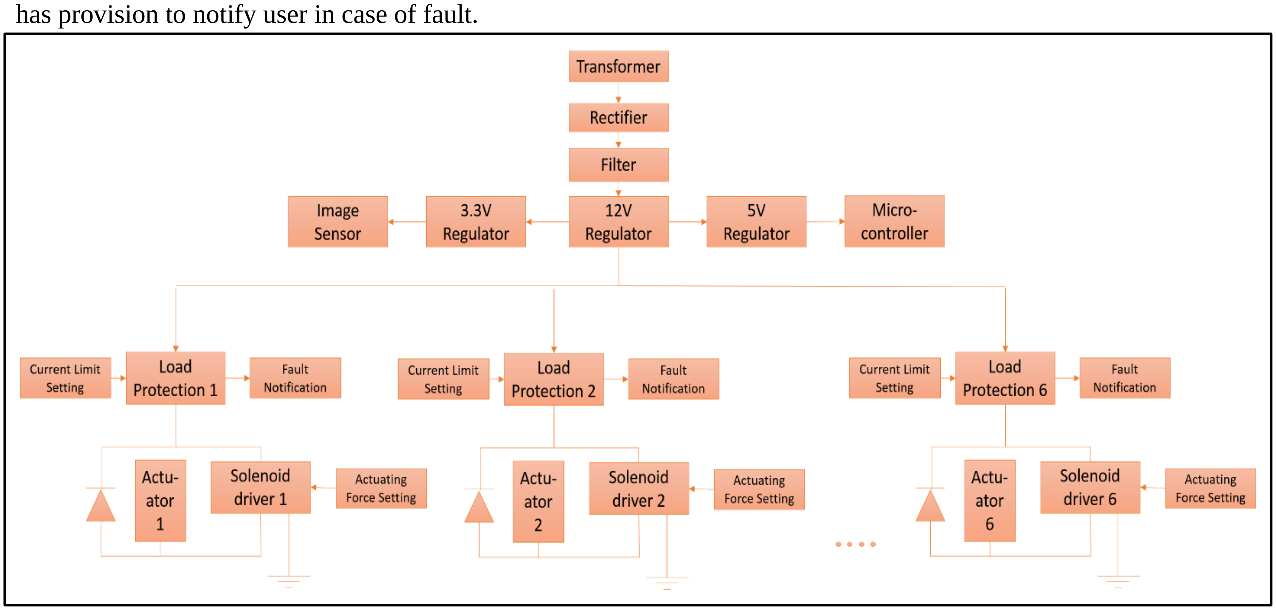

Figure 4: Electrical Block Diagram

MSP430 was selected as the central microcontroller for the entire system. It controls and takes decision on all the modules. It has been interfaced to PC through UART for transfer of image data to PC and English script from PC. It has control over all the actuators. It also interfaces switches which allow inputs from users and notification interface in the form of sound.

IC chosen for driving actuators is DRV103 which is a PWM low side driver designed specifically for driving solenoids, coils. Actuators being solenoids, IC is an appropriate driver. PWM allows fine control of power delivered to load, conserves power and reduces heat rise. Oscillator frequency was programmed through hardware to 100 kHz and duty cycle to 95 percent in order to avoid any misinterpretation of status (high or low) of actuator to the user and set maximum actuating force. Status OK flag was continuously monitored and a sound is produced in case of fault. Duty cycle is adjustable with on board switches, actuating force given by actuators can be adjusted using this. Solenoid actuators being highly inductive, a freewheeling diode was used to suppress delays in turn off of actuators.

Design ofactuators is done on ANSOFT Maxwell software, electromagnetic fields simulation software. Maxwell's accurate finite element analysis solved electromagnetic fields. Many factors such as Actuator's geometry, material properties, power consumption (current requirement), and desired output were all adjusted and a most efficient design possible considering cheap solution was selected for manufacturing. Tradeoff between current consumption and actuating force produced was a crucial step. One major problem faced was that its assembly was to meet the standards of Braille script, it required it to be very compact. Since the distances between the dots of the pattern are very less, a small geometrical design was finalized. Mechanical structure of the actuators was designed such that braille standard is maintained. Another requirement was elevation of actuator was to be precisely controlled for very short distances which are very difficult to obtain electromagnetically. Knowing the effect of magnetic field of one actuator on other actuator proper shielding was given to each of them. After optimizing these constraints final model was designed and analyzed electromagnetically as well as electromechanically and then implemented.

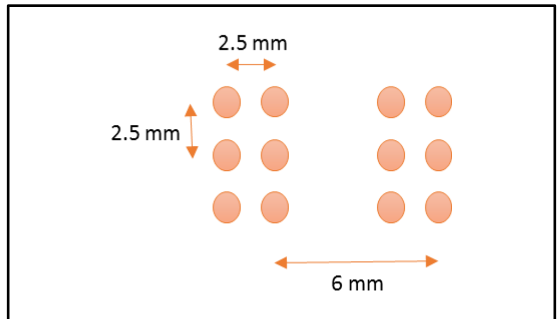

Figure 5: Standards of Braille Script Implemented

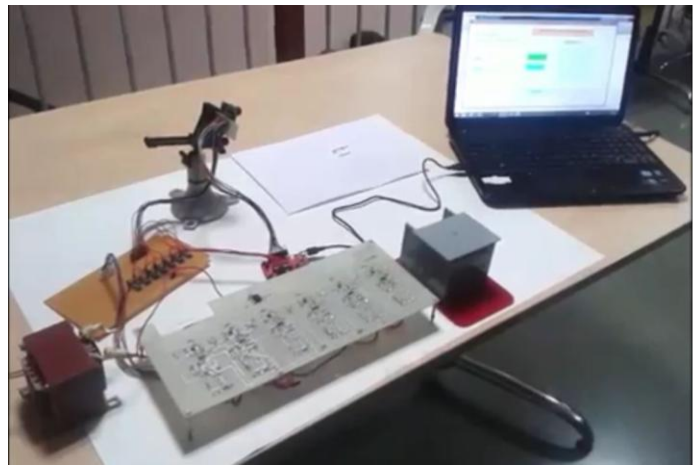

Figure 6: Hardware Setup

B. Software Implementation

Software for this project can be divided into three prominent aspects. Firstly acquiring image, processing the image to obtain English script and making it ready for next step. Secondly it involves conversion of English script to Braille format and lastly includes driving specific actuators according to Braille script obtained in second step.

First Step - This involved interfacing camera sensor OV7670 with Micro-Controller. This sensor was controlled using I2C for image settings while the data is obtained at the output of FIFO. Configuration settings were done in the sensor to select RGB as image pixel format and frame resolution was defined as VGA (640 x 480). AL422B provides 3Mbits of video frame buffer memory configured as a 393,216 byte x 8 bit FIFO.

It has prescalar and PLL multipliers which were varied for setting clock of camera to get the required frames per second.

Algorithm for converting image to text:

1) ***Binary Image Conversion***

The images received from the camera not only contain black and white coloured pixels but contain impurities like othercolours. This inconvenience is overcome by converting the image to binary image with the help of a threshold value. The threshold value was compared to the average value of red, green, blue values of each pixel. The pixels with average value lower than the threshold value were converted to black and other pixels to white.

2) *Split Lines and Letters*

The binary image extracted is stored in an image object. The image may contain one or many rows. The binary image contains multiple pixels, where this algorithm reads each and every pixel in the image first. When it encounters white colour, contiguously in a full row which represents the white line between two lines of texts then this sub-image of the whole image is stored in an object. Each line is stored in individual objects similarly.

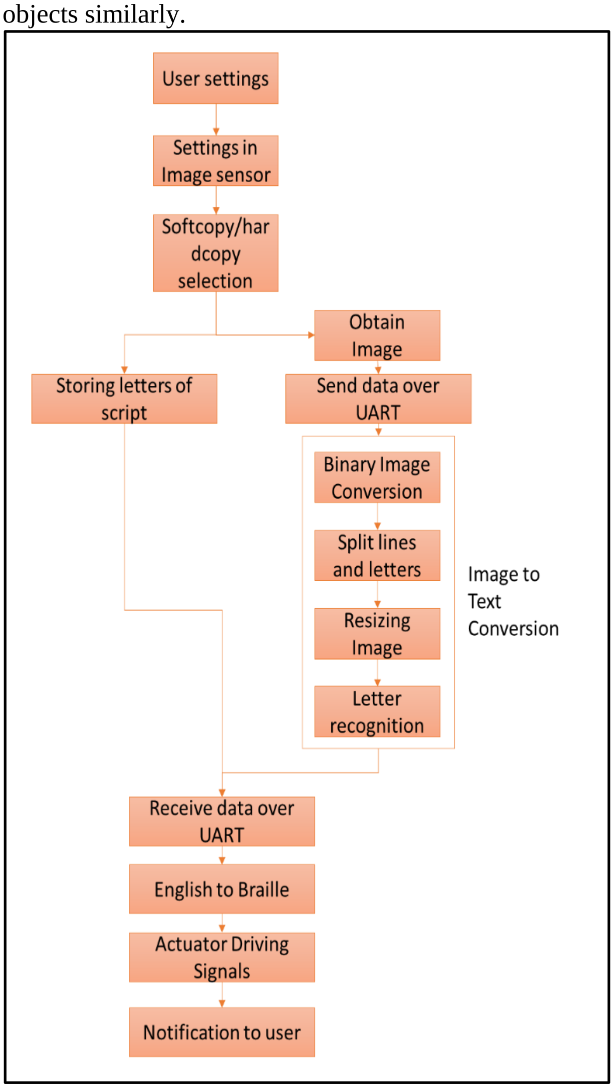

Figure 7: Software Algorithm

Now it reads each and every pixel in every object and when it encounters white colour in a full column which is the space between each letter, then this sub-image of this object is stored in a separate object. An array list of objects is created in which each object in the array holds the image of a letter and each array in the list holds the image of a line.

3) *Resizing the Image*

Each element in the array list of objects contains the image of single letter or number. The font size may vary for different images and even vary for different text with the same image. For this purpose each image present in the array list is resized and stored in the same place.

4) *Letter Recognition*

Now letters in each element of the array list is identified by using recognition algorithm. Each letter has unique appearance and matrix matching is performed where pixel by pixel image is matched with built-in database. Hence they are recognized and stored as English alphabets in a file.

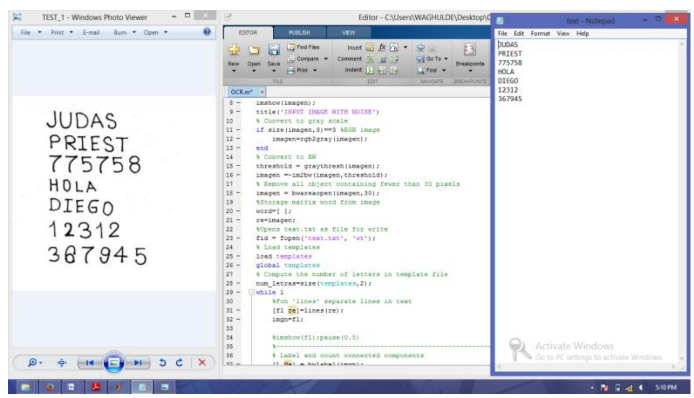

Figure 8: Snap of Image to Text Converted using MATLAB code

Second Step - involves file handling (picking letter by letter and storing it in a variable). Braille script has well defined pattern.This pattern is coded with respect to each character) and stored in structure variables. Character flags are maintained in the same structure to identify case of the letter, number and symbols differently.

Third Step - After obtaining Braille patterns, corresponding actuators are driven by configuring GPIO lines of controller as output lines. A proper delay was coded which can be changed by the user as per the requirement for driving next letter so that user can sense pattern properly.
Custom user settings have been provided to the user such as speed of actuation, selection of notifications and camera settings. This was done to ensure user is comfortable using this product.

Graphical user interface of MATLAB was designed for testing purposes and debugging the product. It monitors current letter pattern which has formed on the hardware and shows next letter to be actuated. Using GUI, soft copy of the document to be read is selected. MATLAB is connected to microcontroller through UART protocol. Following figures is the snap shot of the GUI. Image processing results are also shown here

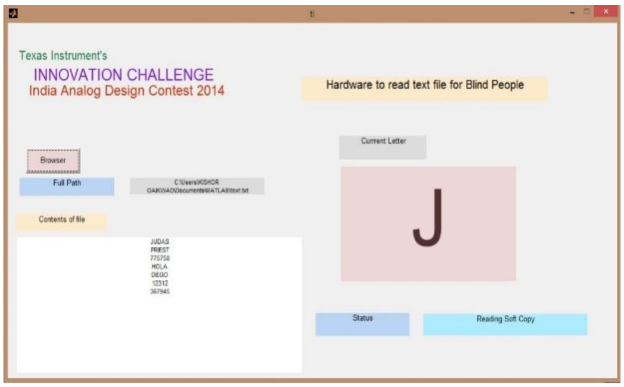

Figure 9: GUI Developed on PC

IV. OBSERVATIONS AND RESULTS

Initially all the modules were tested individually and then they were integrated and tested together.

Power supply was tested for ripples, voltage line regulation, and current souring capability with sudden load switching ON and OFF as would be the case while operating it. Filter design and regulator was changed accordingly.Current limiting IC was also testing for its function. Time delays in few microseconds was observed in turn off of the actuator after the fault was detected.It could serve the purpose of the project. Solenoid driving circuit was tested for inductive loads. Duty cycle and frequency of operation both were varied to tabulate power consumption and force of actuation for calibration. It was found that actuators took 0.65-0.7A current at 12V for actuating with maximum force. Two iterations on PCB layout were done improve power efficiency regulation and time delays.Control Signals from MSP were given to driver IC to test for simultaneous elevation of 6 actuators in different patterns

Assembly of actuators was experimented twice to achieve same force in small form factor. Bent rods were used keeping the size of actuators large to ensure dimensional constraints.It was made sure mechanically as well as magnetically that one actuator does not interfere with the other one working.

Image processing in MATLAB was tested with many images of different text colors, font sizes and different formats.Many different environments with different light conditions were also experimented. It was successful in all cases except some cases like when background color diffused with text. When letters in the image were very close to each other, it sometimes failed to recognize space between two words assuming a single word. In case text is not identified then notification is conveyed to user by making a sound. Delays of data transmission between controller and PC over UART were also calculated, particularly while transfer of image. Some image compression algorithms were also explored but raw data transfer was decided for higher reliability.

V. CONCLUSION AND FUTURE SCOPE

A large part of the proposed goal was successfully implemented and the concept was proved within its experimental limitations such as bulky hardware, large power consumption.This can be optimized to an extent in the future. Further it can be extended in a reverse manner to allow people to write on computer screens or books.

The output was a pattern for one letter only at a time with a scope to be extended more. The challenge of achieving a small form factor for the actuators while maintaining the Braille standards was overcome with minimum processing delays involved. Accurate elevations in terms of height and time is one of the strengths. Chosen actuators were analysed for their rigidity during their use in the end equipment, they could withstand typical force of fingers. Such devices could replace traditional braille embossed papers enabling ease of communication for visually impaired people.

VI. ACKNOWLEDGMENTS

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