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# Translator of printed Spanish texts into Braille system

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**Abstract**

In this research is presented the proposal for the design, the construction and the implementation of a translator of printed Spanish texts into Braille system, which aims to facilitate the access to information from documents that are not commonly available to people with visual disabilities. The translator is comprised of a mechanical system with linear actuators, which generates the Braille characters for reading, software designed for converting the acquired information from a text to recognizable symbols by this mechanism. It is possible to save, close and erase acquired data via camera to a text file. For improving the experience between the user and this device, a "text to speech" software is included to read instructions, menu and documents. An easy interface allows users to navigate quickly throw the main menu in order to manage files, get information about battery, storage, volume, etc. This device contains more features like translating Portable Document Format (PDF) and Microsoft word documents into Braille system.

**Keywords:** Braille system, optical character recognition, Spanish Translator..

## 1. Introduction

Blindness is a sensory functional disability consisting of the partial or total loss of the sense of sight (Becker, 2003). The World Health Organization estimates that some 285 million people in the World have a significant and uncorrectable visual impairment (World Health Organization, 2014). According to INEGI statistics, the population of the blind and visually impaired in Mexico exceeds one million people, ranking as the second cause of disability in Mexico (INEGI, 2015).

Access to information is a key issue for blind and partially sighted people. It is an essential part of achieving full participation in education, employment and the cultural heritage (Becker, 2003). Blindness affects people by avoiding the ability to view documents in their original form in which they were created. It is necessary a mean between the user and the information that allows creating independence and access to the knowledgehat presents the information in an easy way. The majority of the visually impaired use the touch as a communication medium, being the Braille system as the best way to use it.

In the 19th century the Braille system was created, a system of writing and reading designed for blind people through the sense of touch, which is formed by characters in relief points, resulting in a useful tool for reading and writing (Braille, 1829).

Since 1913 the idea of creating a machine for the blind to facilitate reading texts was purpose by d'Albe through his invention "Theoptophone to read" (d'Albe, 1920). Starting in 2000, many devices were created to allow the generation of Braille characters, however, some of them were prototyped because they presented problems with dimensions (Braille matrices were 20 times the normalized dimension), lack of mechanism for point generation,

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difficulties with the battery or high prices (United States of America Patente nº US 7407335 B2, 2008) (United States of America Patent No. WO 2015189863 A3, 2016) (Uniited States of Amerida Patente nº US20140356819, 2011) (United States of America Patent No. US20140242555, 2014).

## 2. Platform description

This description provides information about the inputs and outputs of information, energy and of each one of the subsystems in order to carry out the functions that meet the translator's objective.

### *2.1. Interface*

Contains a switch and four buttons to perform the following functions:

a) On / Off
b) Menu
c) Ok
d) Next
e) Previous

The main menu allows users to navigate easily through reading and writing options and indications by means of a text to speech API and the relief matrix respectively. An audio output is included to plug headphones or speakers in this device. Figure 1 shows options of the main menu.

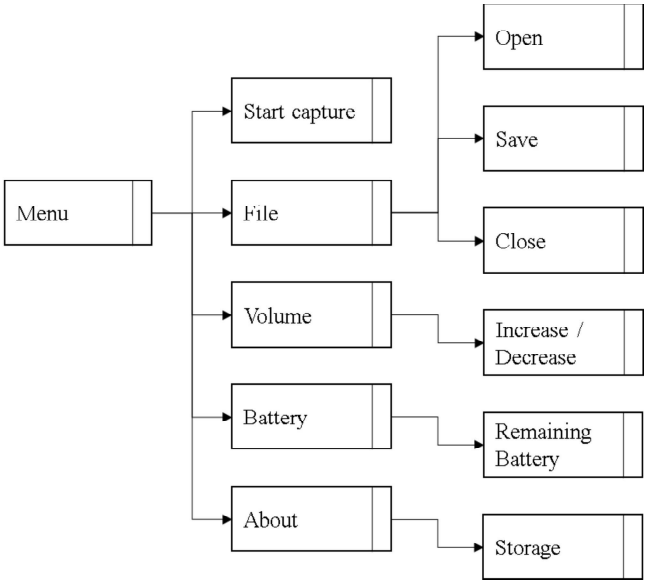


Figure 1. Main Menu.

#### *2.1.1. Start capture*

It begins with reading the instructions to place the device in the center of the document to be scanned. If the capture is successful, the user is notified and the first line is subsequently written to the array.

#### *2.1.2. File*

This section allows the user to open, save, close and delete a .docx, .pdf or .txt file.

#### *2.1.3. Volume*

If the button “previous” is pressed, the volume decreases, and with the button “next”, it increases. The volume percentage is displayed in the matrix in support with a sound sample for helping the user to change it.

#### *2.1.4. Battery*

The percentage of battery as well as the estimated time of use remaining are displayed in the relief matrix.

### *2.1.5. About*

It is possible to know the total storage of the device, available space, etc.

## *2.2. Central Process Unit*

This unit transforms the previous acquired ASCII characters from an image into recognizable signals so that the Braille matrix generates the relief of the letters, controls the actuators and receives user's commands through the interface.

In order to perform the programming and execution of all the sections involved in the system, it is necessary to contemplate an environment that provides the functionality of an operating system in a heterogeneous cluster. Thus, the platform ROS (Robot Operating System) provides standard services of an operating system such as hardware abstraction, low-level device control, implementation of commonly used functionality, message passing between processes and maintenance of packages. It is based on an architecture of graphs where the processing takes place in the nodes that can receive, send and multiplex messages of sensors, control, states, schedules and actuators, among others (Morgan Quigley, 2009). The library is based on UNIX system, resulting convenient because this project uses Debian 9 Jessie (a distribution).

Figure 2 indicates the connection between the different nodes (main, vision, buttons, matrix and status) and their messages (or topics) that allow communication between them.

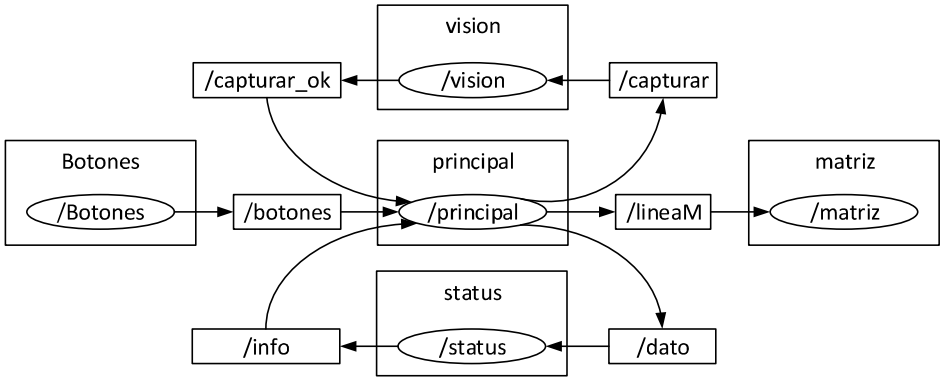


Figure 2. Nodes diagram and topics.

## *2.3. Computer Vision Algorithms*

We propose an algorithm to extract the text from a paper sheet using a camera to get an image and then process it. The algorithm performs seven steps: acquires an image, detects the border edge, detects Hough transform line, extracts area of interest, crops and rotates the image, gets the Wolf-Jolion binarization and finally transforms the binarized image into raw text. An OCR algorithm (Tesseract OCR) identifies text contained in an image and transforms it into an ASCII code. Figure 3 show the proposed algorithm.

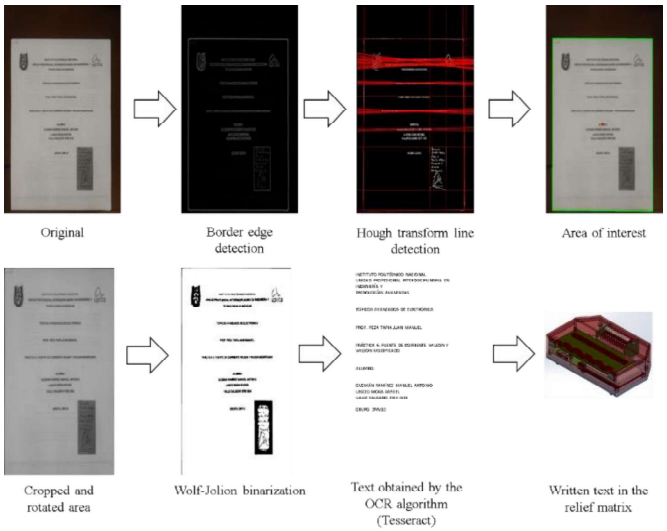


Figure 3. Text extraction algorithm

Text binarization represents a complicated task under varying illumination and noise. A number of factors contribute to complicate the thresholding scheme including variance of gray levels, ambient illumination, background, etc. The binarization methods can be categorized in different groups depending on which principal criteria they consider in calculating the threshold. However, in this research we compare only methods based on image variance (Otsu, Sauvola, Wolf-Jolion, Niblack and Adaptive) according to their performance based on image thresholding (Chaki, Shaik, & Saaed, 2014).

### *2.4. Acquisition System*

This section is responsible of image acquisition containing text, it is integrated in hardware by a Raspberry Pi Camera V2.1, and a 16 GB SD memory card that stores information for further processing and character recognition.

### *2.5. Electrical Supply*

It includes a power module to supply actuators and another one for CPU and peripherals. Battery charger is included.

### *2.6. Relief Matrix*

Set of 10 matrices of 2x3 points, controlled by linear actuators that react to electrical signals, has a control for the position of the actuators generated by the CPU. The positions of the matrix points, as well as their elevations, are based on the standards of the Center of Braille Innovation of the National Braille Technology (Runyan, 2009).

### *2.7. Structure*

Structure with asymmetric shape that allows to manipulate the device easily. Its design contains all the components of the device. The design of the structure has enough space to place each part that integrates the translator. Its dimensions are 20cm x 12.5cm x 4cm. The camera is located at the bottom, and rubber supports at the four corners. Figure 4 shows the purposed system design.

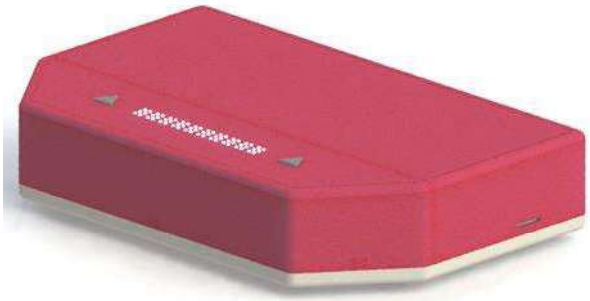

Figure 4. Purposed system design

## 3. Results

Figure 5 supports the last analysis. At first sight it is possible to distinguish that Sauvola and Wolf are the best methods for binarization but this idea should be based on an analysis of images.

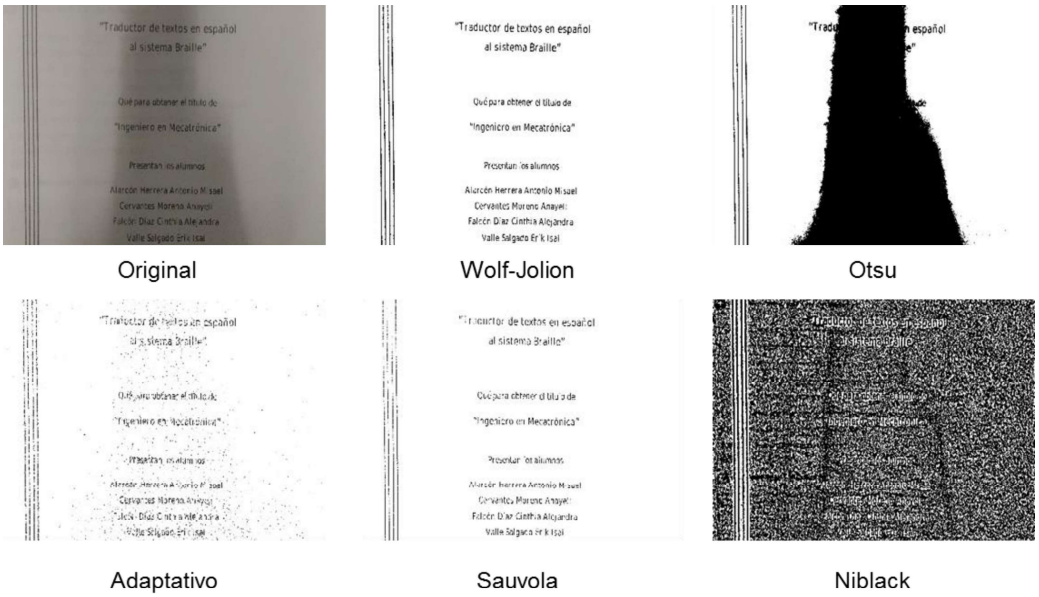


Figure 5. Comparison of Binarization Methods

We used 6 image repositories (10 images) with different noises and dimensions to test each method and compare them. Performance was obtained by means of Receiving Operating Characteristics (ROC) analysis (Fawcett, 2005). Table 1 shows results of ROC analysis and determines that Wolf-Jolion is the best method for this application.

Table 1. ROC Analysis

| Probabilistic Interpretation | Otsu | Adaptive | Niblack | Wolf-Jolion | Sauvola |
|---|---|---|---|---|---|
| F-Measure | 0.51043 | 0.55065 | 0.4516 | 0.79345 | 0.73615 |
| PSNR | 9.508 | 10.9036 | 6.2459 | 14.8209 | 12.6317 |

A repository of 9 types of solenoid was created to compare critical factors like length, diameter, turns, voltage and current. According to the Table 2, Test 5 has the best performance.

Table 2. Solenoid Test

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Length (mm) | 12 | 12 | 12 | 12 | 12 | 12 | 10 | 12 | 12 |
| Diameter (mm) | 5.1 | 4 | 7.1 | 5.2 | 6.6 | 5.5 | 7.3 | 5.8 | 5.9 |
| Wire gauge | 36 | 36 | 32 | 36 | 35 | 37 | 35 | 36 | 36 |
| Turns | 330 | 215 | 380 | 450 | 450 | 390 | 480 | 510 | 590 |
| Voltage (V) | 6.6 | 9.9 | 5 | 6.6 | 5 | 9 | 6.6 | 6.6 | 6.6 |
| Current (A) | 1.2 | >2 | 1.5 | 1 | 0.7 | 1.04 | 1.1 | 0.7 | 0.7 |

Thus, linear force for Solenoid 5 is:

$$F = -\frac{V^2 \mu_r \mu_0}{8\pi\gamma^2 l^3}\left(\frac{r_0}{r_a}\right)\alpha e^{-\frac{\alpha}{l}x} = 2.61\ g \quad (1)$$

## 4. Discussion and Conclusion

Equations describe characteristics of solenoids in ideal conditions, thus experiments were required to get real results about parameters. We found many theoretically feasible possibilities for solenoids, however fabricate them requires special tools and expensive equipment not available in Mexico, so that we created them. The production cost was reduced due to the elaboration of solenoids. We have already made a Relief Matrix that has a good performance, however we must decrease temperatures of solenoids and their energy consumption, make them smaller (diameter of 1 mm) and reduce electrical and magnetic noise generated by actuators.

Referring to image acquisition, autofocus correction is essential to avoid blurred and low quality images. Image binarization shall be enhanced to reduce noise and improve text fidelity. Some paper sheets, especially those containing light background and clear text, it is required to modify the parameters or the binarization algorithm to define at least the edges of those letters. It is convenient for the program to analyze only areas of interest that contain text (titles, paragraphs, etc.) and to delimit texts that are arranged in columns to avoid mixed writings and undesired results.

The translator focus only for visually impaired population that has the knowledge and ability to read in the braille system. The translation is for printed documents containing only text, excluding graphics, images, tables, maps, diagrams and mathematical formulas. It is necessary to control external variables of illumination; the translator performs text recognition in an environment with adequate lighting according to the norm NOM-025-STPS-2008, that considers a minimum illumination level of 300 lux. Character recognition is limited to printed text, so it does not consider handwriting translation. Text recognition should be printed on serif and sans serif typefaces and with a minimum font size of 12 points (Instituto Nacional de Tecnologías Educativas y de Formación del Profesorado, 2014).

This device was tested with blind people in the Vasconcelos library (Braille section). Users require mainly a light, small and portable device of low cost and a non-robotic text-to-speech voice. They were satisfied with the effectiveness of translation and especially because this prototype reads documents, instructions and options at the same time that writes them in the Relief Matrix. Customers remarked that this should be a low cost product. However, this device is only a prototype, in consequence the start cost is higher than its commercial version. This translator, compared with other commercial devices, will be cheaper, faster and available in Spanish and English.

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