2017 SBESC – Embedded System Competition – WND IoT Challenge

Final Report

Smart Cane: As a tool for inclusion of the visually impaired

Students: Ana Victória Araújo Maia, Camila Stéfany Diógenes Guerra, Johnny Marcos Silva Soares

Professor: Wagner Guimarães Al Alam

University: Universidade Federal do Ceará

JEMS ID: 170380

2017 SBESC – Embedded System Competition – WND IoT Challenge

Declaration of Originality

We hereby declare that this report and the work reported herein was composed and originated entirely by ourselves. Information derived from the published and unpublished work of others has been acknowledged in the text and a list of citations is given in the references section

Professor's Signature: Wagner G. A. Alam

Name (in Block Letters): WAGNER GUIMARÃES AL-ALAM

Student's Signature: Ana Victória Araújo Maia

Name (in Block Letters): ANA VICTÓRIA ARAÚJO MAIA

Student's Signature: Camila Stéfany Diógenes Guerra

Name (in Block Letters): CAMILA STÉFANY DIÓGENES GUERRA

Student's Signature: Johnny marcos Silva Soares

Name (in Block Letters): JOHNNY MARCOS SILVA SOARES

Date: 30/10/2017

SMART CANE: BENGALA INTELIGENTE COMO FERRAMENTA DE INCLUSÃO DE DEFICIENTES VISUAIS

ABSTRACT

Social inclusion and accessibility policies are democratic policies that seek to guarantee equal access to all, which tend to eliminate the barriers to access, incorporating these people into social interaction, allowing them to come and go, thus being an indispensable function in the sustainable economic , social and cultural. Aiming at the need for safe locomotion, this is one of the most recurrent problems, in which to move autonomously the visually impaired tools such as walking sticks, to optimize this tool, several electromechanical and computational proposals have been developed. In order to contribute to this development, we present a proposal for an electronic laser cane that identifies three-dimensional obstacles starting from the ground up to a height of the individual, the model and developed for the purpose of innovating the idea of a conventional walking stick, laser in conjunction with mirrors that by means of motors of the type servo move, directing the laser by diverse points detecting obstacles of ample and efficient form, thus giving to the best visual, greater security, safety and confidence for a locomotion. The validation test proved that it is a Smat Cane proved to be effective without recognition of obstacles, presenting only as a threat of methodology the identification of reflexive obstacles.

Key words: acessibility, SmartCane, visually impaired, obstacles**.**

Content

Chapter 1 Introduction

A recurring problem in the lives of visually impaired people is the difficulty in a security locomotion. Technological actions are still related to a wide range of existing needs, but they tend to make it possible for people with visual impairment to better occupy their places in society. Therefore, in view of this problematic developed of an equipment of easy handling and that is adjustable for people with different heights, a prototype of intelligent cane was developed through optical sensors that identifies threats to the users. The work aims to promote accessibility and social inclusion.

The term accessibility has its origin in the word access that comes from the Latin accessu, which means "entrance; input; Traffic; passage; arrival; approach; reach of something high, distant "(FERREIRA, 1986). Also according to the terms of art. 2 of Law 10.098/2000, accessibility is the possibility and scope for the use, with security and autonomy, of spaces, furniture and urban equipment, buildings, transportation and systems and means of communication, per person carrying disability or reduced mobility (LIMA, 2006).

Accessibility is also perceived as a word of similar of approximation, a way of giving each user resources that respect their special needs and preferences. In this way, the development of accessibility resources would be a real way to soften the obstacles and to include this individual in the most diverse types of environments.

Social inclusion is an important tool of democratization, since it enables the equality of all individuals. Under the terms of the Federal Constitution, it is one of the main objectives of the Brazilian nation. In view of this, the integration of disabled people into society represents compliance with the effects of citizenship. In this process, we can highlight visual impairment, which according to Decree No. 5.296/04, is conceptualized as visual impairment (BRASIL, 2004):

> Blindness - in which visual acuity is equal to or less than 0.05 in the best eye, with the best optical correction; Low Vision - means visual acuity between 0.3 and 0.05 in the best eye, with the best optical correction; Cases in which the sum of the visual field measure in both eyes is equal to or less than 60 °; Or the simultaneous occurrence of any of the previous conditions We emphasize the inclusion of people with low vision as of the edition of Decree nº 5.296/04. People with low vision are those who, even with regular glasses, contact lenses, or intraocular lens implants, can not have clear vision. People with low vision may have sensitivity to contrast, color perception and light intolerance, depending on the pathology causing visual loss. (Decree No. 5,296/04, article 5, paragraph 1, I, "c").

According to the 2010 Census data made by IBGE - Brazilian Institute of Geography and Statistics there are 35,774,392 Brazilians with visual impairment, of which 506,377 thousand are unable to see.

Based on these verifications, the following will be presented the development and tests of the study done on the solution to such problem.

Chapter 2 System Description

2.1Introduction

There are a large number of canes on the market, some models being strictly used by the visually impaired. The type of cane most used is the retractable cane, for being a portable, light and ergonomic model. However, in order to provide greater freedom for the visually impaired, we decided to innovate in the model of cane and the project followed with the use of a not so common device, avoiding the idea fixed to the term cane that refers to thinking something long, we made a small structure that joins electronic devices and has the same function and efficiency as a conventional, lightweight, practical and modern cane.

The developed system is an accessibility tool that detects obstacles that are ahead of the individual. The change of structure was proposed by almost all canes developed to assist the visually impaired are developed following the same model, in most cases with the use of ultrasonic sensors coupled to a common cane.

In this way, the smart cane changes the standard concept associated with walking sticks for the visually impaired. It is no longer a walking stick that will have constant contact with the ground and will not have any contact, being carried by the user and mapping the front area. In order for Smart Cane users to understand how the prototype works, we produce a detailed Braille instruction manual to assist primarily during testing.

2.2 Structure

The prototype was thought to support the implementation of the changes, a box in the cylindrical or rectangular format, as shown in Figure 1. However, there is a restriction in this method, because the sensors can only measure the distance of the objects in fixed points, it would only be possible to measure obstacles in a straight line. Therefore, the sensor would need to be coupled on a rotating base so that it could measure other directions.

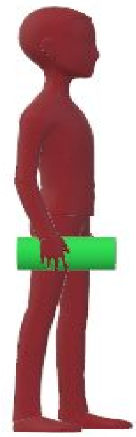


Figure 1 - Prototype Idea Smart Cane

The developed prototype aims at flexibility according to the option of the visually impaired, being able to choose which method of notification prefers. Possessing 2 types of warnings:

- Single-tone sound warnings, which according to distance variation would have an increase or decrease in the beep frequency. This feature can be used with the headset or not, as well as in parallel with the engine vibration system.
- Voice announcement, where a voice will indicate which side there are obstacles and the approximate distance the obstacle is in. Feature available for use of headset.

The traditional headset is used according to user preference, or in environments that cherish for silence, also trying not to affect the sounds of the external environment.

2.3 Sensors

Taking into account the innovative and comfortable format for the cane, it was thought which type of sensor would be used for a more efficient measurement, since there are several proximity and distance sensors in the market, with this it was proposed a series of tests to identify the ideal sensor for mapping the area. The sensors considered in the evaluation were:

- Measuring with Camera
- Infra-red
- Capacitive Proximity
- Ultrasound
- Laser Sensor

The use of the camera consisted of using a laser and a camera. The laser remained on throughout the system, so the camera captured the generated images, then an algorithm that recognized the lighter pixels (Laser effect) was used on the image, to calculate the distance of these pixels to the center and use mathematical rules to discover the distance to the object reached by the Laser. However, this method was quickly ruled out by the fact that the cane has daily use in open environments and with a high luminosity, greatly affecting the measurement.

The most widely used capacitive proximity sensors in the market have a very short measuring distance, thus only detecting the obstacle when the obstacle was already very close to the individual.

Ultrasonic sensors are generally more used for this type of application, however, it did not show good returns on the turntable. Due to the need to wait for the ultrasound signal to return to calculate the distance, it was always necessary to wait for the signal return time to change the angle of the cane. Due to the low speed of sound compared to the speed of light that is used in the laser detection sensors, this measurement method presents a high response time. Therefore, for the reason of response time and accuracy in the detection of obstacles was selected for the tests the laser sensor, the most appropriate and efficient according to what we look for in terms of effectiveness, precision and long life.

In this way our prototype finally consists of a Laser Distance Meter X-40 sensor, chosen for its low cost compared to others in the same market segment. Its operation consists of emitting a beam of light and computes how long that beam returns, calculating the distance traveled, besides the sensor there are two mirrors for the reflection of the light generated by the sensor, one mirror turns sideways and the other turns upwards and down, ensuring the measurement of other points in different directions.

2.4 Operation

In order for the cane to have a dynamic application spanning all people, a startup procedure is done so that the individual holds the cane with the arm stretched down so that the device is pointed directly to the ground, from the moment that the device is turned on, the sensor will begin detecting this interval, as this height is captured, a calibration is made for the individual's height, adjusting the position he found most comfortable using the cane, if there is a bad positioning of the device and the reading range is very large, in this case we work with a variation of less than 1 (one) meter, a distance greater than this being detected the device emits the error signal and continues to measure that the interval is logically appropriate. Once this is done, the code will adjust the angles of the mirrors so that they can always move from the ground to the approximate height of the head.

The method developed for the verification of the environment was a point path forming a 4x3 matrix. The first version of this path is presented below according to Figure 2. However, after some tests it has been verified that certain points become unnecessary, as there is no need to detect obstacles in the sides of the head since they do not pose risks to the handicapped, so it would take more time to read the matrix completely, with the detection of irrelevant obstacles, to solve this problem was redefined the path now going through new points as shown in Figure 3.

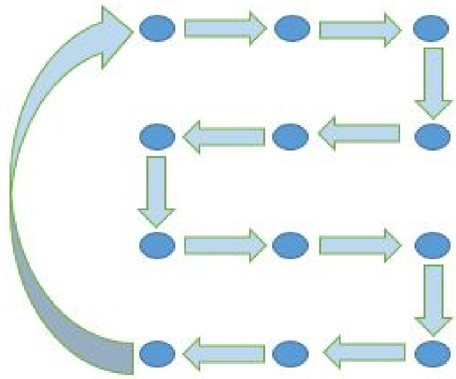


Figure 2 - Initial dot matrix for laser reading

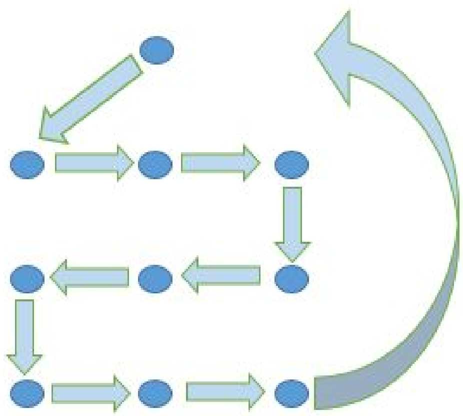


Figure 3 - Final matrix adapted for laser reading

We can more clearly understand the operation of the system according to the flow chart shown in Figure 4 below:

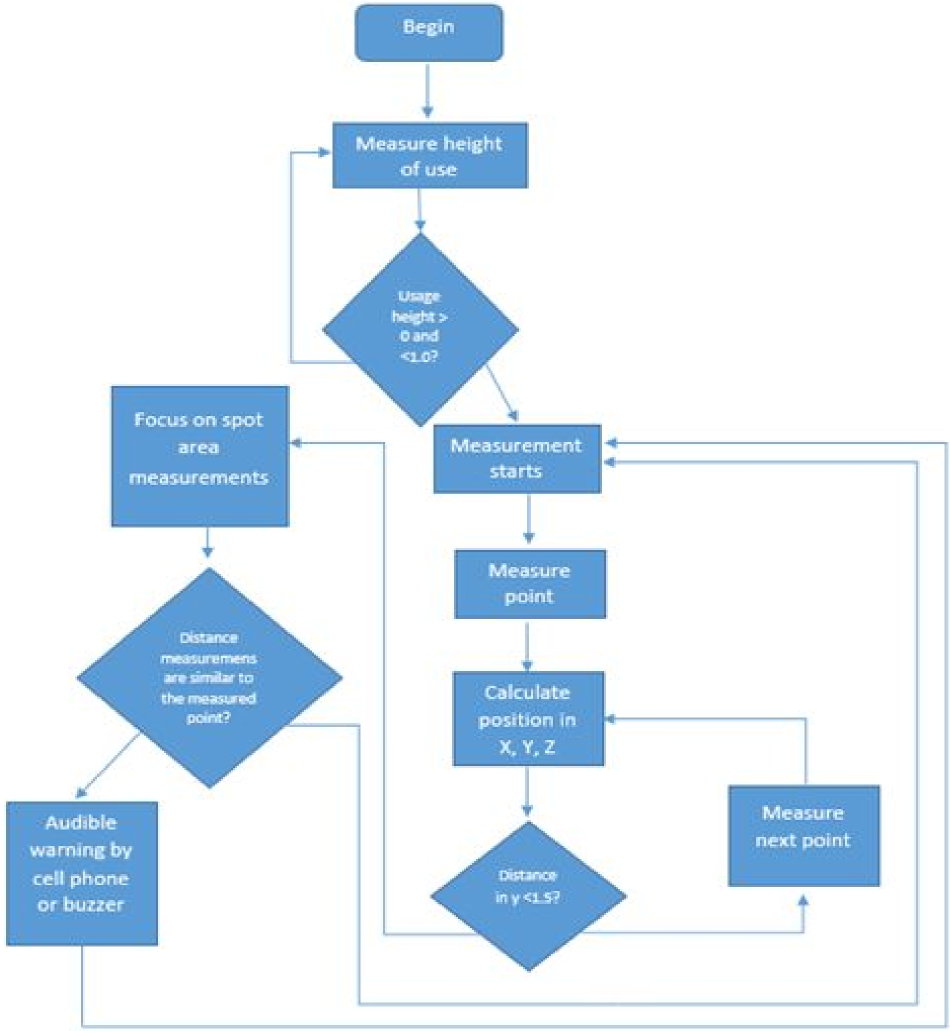


Figure 4 - Operating flow chart of Smart Cane

Chapter 3 System Implementation

According to the description of the system, the development of the Smart Cane system was performed in a way that could efficiently accomplish all the requirements. Treating all possible scenarios for identifying obstacles and their most diverse types. Using the Freedom KL43Z developed by NXP Semiconductors to be used as a prototyping platform for Low-Power projects focusing on IOT (Internet of Things), which is a branch that has been growing and opening doors to various applications of connectivity that serve to make objects more efficient.

3.1 Basic Requirements

However, to map the environment is necessary to move the sensor to capture distances or simply change the angle of the laser beam, for this reason two mirrors were used to move the beam. At the base of each mirror was coupled a servo-type motor. Working based on the control command, depending on the active time of the command, a specific degree will be executed by the motor, the minimum value being 0.6 ms which will reproduce the 0 ° and the maximum value of 180 ° with the active time of 2.4 ms. By using the *Time Active = degree × 0.0001 + 0.0006* formula, it is possible to move the servo motor in all possible degrees of travel.

With the movement of the servos it is possible to go through different degrees that will be used to vary the position of the laser and thus to go through certain points that will be measured by the laser, however, the measured values will be changed by the positioning of the mirrors that will reflect the beam, the distances between the mirrors will be increased in the measurement, being necessary to remove them later.

$$Distance\ Removed = 7.1 + 4.0 + 8.43$$
$$Distance\ Removed = 19.53\ cm$$

Immediately after the measurement and removal of 19.53 cm it is necessary to find the position of the detected object in relation to the X, Y and Z axis based on the distance measured by the laser, which corresponds to the edge D which is the diagonal of the rectangle created by the projection of the laser's beam. As shown in Figure 5.

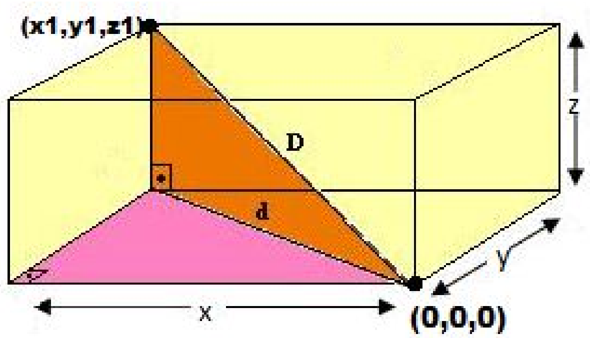
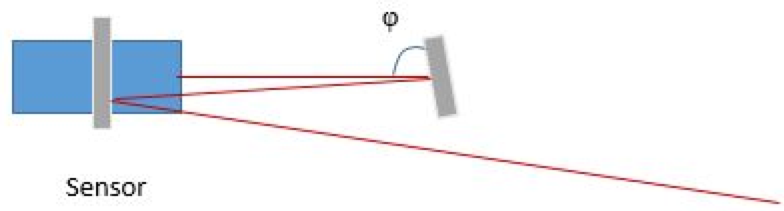


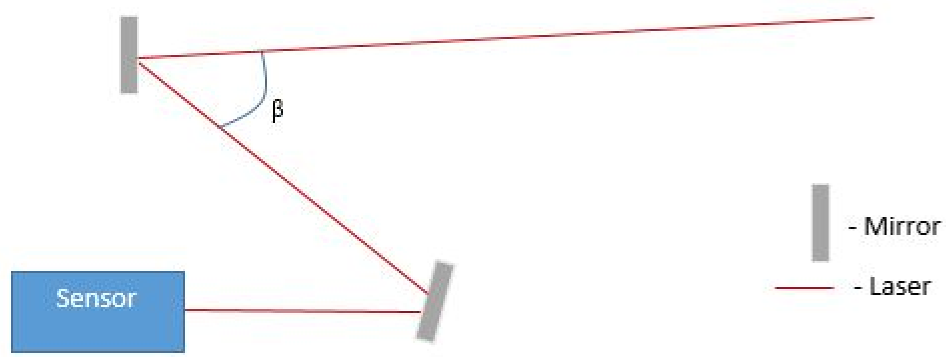
Figure 5 - Projection angle of the laser beam

The only relevant information for calculating the position of the object are the angles of inclination: φ referring to the angle of the mirror 1 which indicates the position in relation to the horizontal of the laser beam and the angle β belonging to the mirror 2 which indicates the position of the beam vertically.

Firstly, the point that centers the beam on the middle of the mirrors was studied, when φ = 90 ° the beam will be focused in the middle of the mirror 2. The mirror 1 has an inclination, causing the beam to arrive with a certain slope in the mirror 2, when β = 40 ° the remaining angles will be equal to 70 °, because with the sum of the angles the value 180 ° will be found and in this case the beam will be aligned to the center.



(a) Upper view



(b) Side view

Figure 6 - Laser operating modes in conjunction with mirrors

Considering the knowledge of the angles for the operation of the cane and applying some mathematical formulas it is possible to find the position of the object in the X, Y and Z axes. Using Figure 2 as the basis for calculating the position of the obstacle in the Z axis, it applies the formula [1] [1] $Z1 = D \times sen(\beta)$ and to know the value of d is used the formula $d = D \times cos(\beta)$. With the value of d uncovered it is only necessary to make the sine and cosine relation to find X and Y, since with the projection of d in the plane (X, Y) a rectangle triangle is formed at points (0,0), (X1,0), (X1, Y1). Since the angle of horizontal inclination of the laser beam depends on the angle $\boldsymbol{\varphi}$, then X1 and Y1 are dependent on this angle. Being:

[2] $X1 = d \times sen(\boldsymbol{\varphi})$
[3] $Y1 = d \times cos(\boldsymbol{\varphi})$

With the use of formulas [1], [2] and [3] it is possible to find the position of the object at any point in front of the visually impaired, thus fulfilling the requirements of the system. In Figure 7 we can see how the components we have just described are arranged in the prototype.

Figure 7 -Front view of Smart Cane prototype

3.2 Smartphone App

In order to improve interaction with the visually impaired, a mobile application was developed for the Smart Cane that is responsible for making the Bluetooth connection between the cane and the cellular device. This application makes the Bluetooth connection from paired devices, so it is necessary in advance to pair the devices. In addition, the application has information returns based on control signals sent by the cane.

In the implementation of the application was used the module HC-06, which makes the wireless network connection in slave mode, in other words, some device with Bluetooth access needs to be the master to start the connection with the cane. The Smart Cane application was developed in MIT APP INVENTOR, an Android application development platform developed at MIT (Massachusetts Institute of Technology). The chosen application is worldwide used for easy implementation of software, integrated development environment and a new development method, we can see according to Figure 4 the development screen.

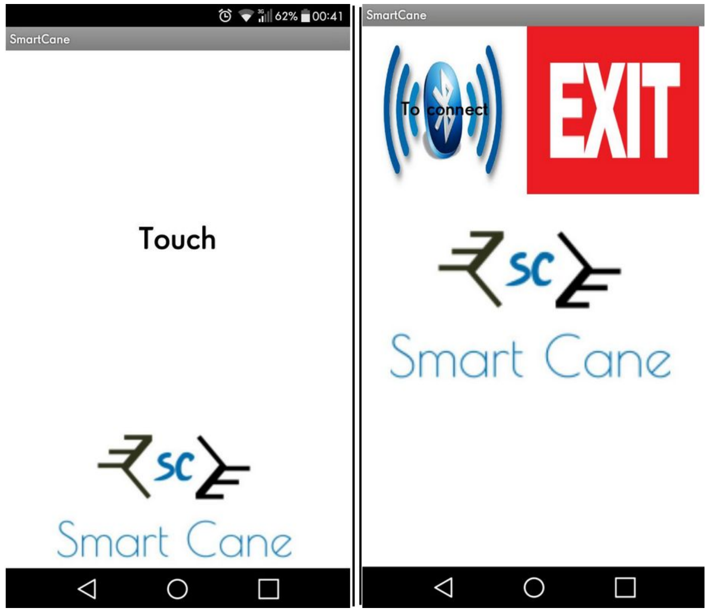


Figure 4 - Smart Cane Android mobile app screen

The Android application developed is based on control signals, so the software makes a constant verification in the communication by Bluetooth, since the cane informs when an obstacle was detected, passing as an argument to the application a number of integer value, according to with the input value the application informs the disabled through a voice application where it is narrated exactly where the obstacle is located. Let's see next the values of entry by Bluetooth, followed by the corresponding texts that are pronounced by the narrator:

· 1, obstacle detected in upper left region;

· 2, obstacle detected in the upper central region;

· 3, obstacle detected in upper right region;

· 4, obstacle detected in the left center region;

· 5, obstacle detected in the center region;

· 6, obstacle detected in the right center region;

· 7, obstacle detected in the lower left region;

· 8, obstacle detected in the lower central region;

· 9, obstacle detected in lower right region;

Chapter 4 Results

Several tests were performed by many individuals in different environments with different obstacles. Related to these tests, we verified in general context of the prototype some positive and negative points in which we could verify the great acceptance of all that tested it, which facilitate the handling for the detection of obstacles, as well as ways of identifying obstacles.

With the test we analyzed some possible scenarios, we defined the scenarios as:

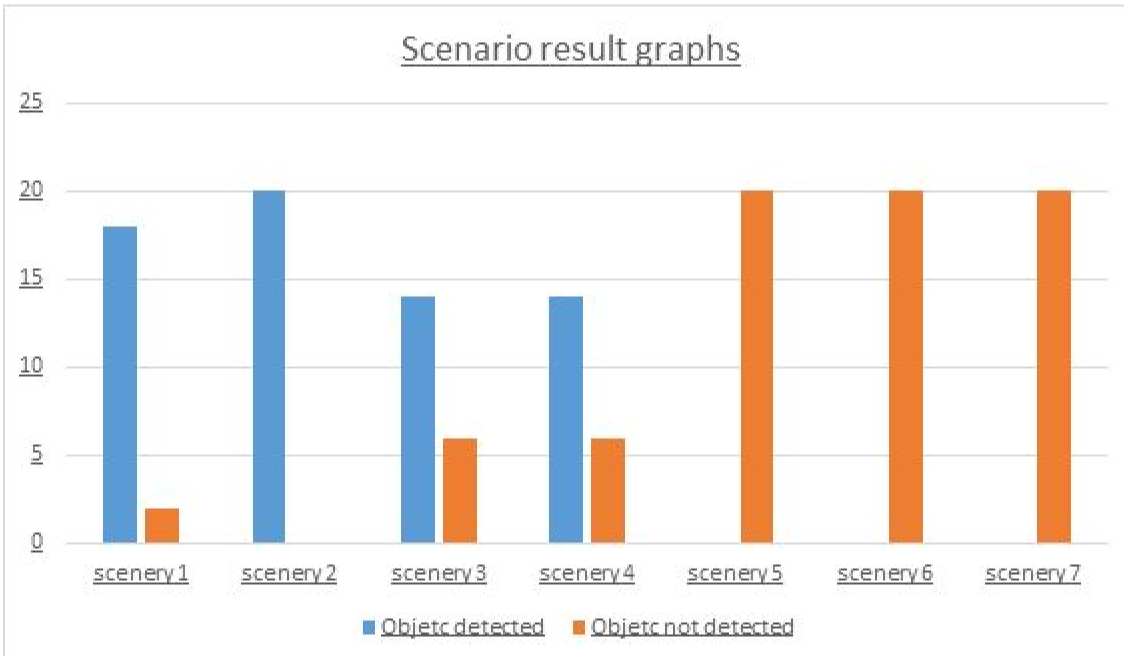
- Large size: Being generally higher than human height. Example: buildings, post, tent, booth, tree, pillars, among others.
- Medium size: Relatively less than the height of a person standing up. Example: furniture, benches, people sitting, low walls, hydrants, etc.
- Small: Or also called low objects, because they are at the height of the feet or below the knees. Example: holes, stops, waste baskets, etc.
- Moving objects: In some cases of obstacles in movement in the frontal region of the handicapped, so the movement of people, animals or any type of mobile obstacle must be treated.

To validate the tests in relation to obstacles, scenarios have been developed that represent everyday environments of the visually impaired. The scenarios described below are as follows:

- ➔ With obstacles:
    - ◆ Scenario 1 - Trees, buildings or public telephones.
        - Description of the scenario: The user walks straight and on the way has a tree, a building or a telephone in front of him.
    - ◆ Scenario 2 - Post or columns
        - Scenario Description: Similar to the previous one, in the path of the user will have a post or column, something with a small width.
    - ◆ Scenery 3 - Table or chairs
        - Scenario Description: The user has something less obstacle than he like a table or chair.
    - ◆ Scenario 4 - Stairs, Hole or Stops
        - Scenario Description: In the user's path has some elevation whether it is a ladder or a stop or has a decline like a hole.
- ➔ Without obstacles:
    - ◆ Scenario 5 - Straight Path
        - Scenario Description: The user walks without any obstacle ahead.

- Scenario 6 - Straight Path with Distant Obstacles
    - Scenario Description: The user walks straight with the obstacle at a great distance from him.
- Scenario 7 - In Motion
    - Scenario Description: The user is walking and the obstacle crosses its path.

Twenty tests were done per scenario, totaling 140 tests with and without obstacles. For ease of view the sample data from the results were grouped into a column chart. On the basis of all cases we deduced from the results that showed positivity in all the tests of the flare.



The graph shows that in scenarios 1, 3 and 4 there were certain objects that were not detected, with a greater number of objects with reflective surfaces, in which it is the greatest difficulty of the sensors that work with the laser. Because the obstacles of mirrored surfaces are the most sensitive of all, for at the moment the laser touches a mirrored object it is unable to return at a distance, reflecting and returning a completely distorted range, thus causing a serious failure or returning. Because of this, when the mirrored object error occurs, the system emits an erroneously detected threat alert signal. In Scenarios 5, 6 and 7, no objects were detected, this being the best case, since they were tests without obstacles.

Chapter 5 Conclusion

Considering the need for safe locomotion of individuals with visual impairment, this is one of the most recurrent problems that, in order to get around autonomously, use tools such as walking sticks, to contribute to this development, we developed a laser electronic walking stick that identifies three-dimensional obstacles from the ground up to the height of the individual, the model was developed with the purpose of innovating the idea of a conventional cane using a laser sensor.

Since, several tests were performed with visually impaired individuals and people without any deficiency, but blindfolded to simulate the deficiency. The tests were carried out in different locations, such as urban environments and controlled environments, to prove the efficiency of the cane with different types of obstacles. In turn, all the people who tested were able to move safely and effectively following the sound guidelines of Smart Cane.

Therefore, it is concluded that we have successfully achieved the goal of this work, since we have developed a small equipment, produced in very light material, the internal system is composed of modern and efficient equipment, organized in a compact way, always seeking a better performance and safety for the user.

For future work we will study other sensors to increase other types of sensors in order to improve the efficiency of the device as well as to ensure greater safety for Smart Cane users in order to solve the errors that we are faced with mainly when trying to identify objects that have surfaces reflective.

References

[1] ALMEIDA, Frederico Borges de. “Reflection of Light in Flat Mirrors"; Brazil School. Available at; <http://brasilescola.uol.com.br/fisica/reflexao-luz-espelhos-planos.htm>. Accessed on August 22, 2017.

[2] CHRISTINE M. Plant physiology:plant biology in the Genome Era[J/OL].Science,1998,281: 331-332[1998-09-23].http://www.sciencemag.org/cgi/collection/anatmorp.

[3] “Capacitive Sensor: What is it and how does it work?”; Citisystems. Available at; <https://www.citisystems.com.br/sensor-capacitivo/>. Accessed on August 22.2017.

[4] Decree No. 5,296. Brazil, Presidency of the Republic of. 2004. Brasília: sn, 2004. Regulation of Laws 10,048 of November 08, 2000, which gives priority to the services it specifies, and 10,098 of December 19, 2000, which establishes general norms and basic criteria for the promotion of accessibility.

[5] Ferreira, Aurélio Buarque de H. 1986. New Aurelian dictionary of the Portuguese language 2a. ed. São Paulo: New Frontier, 1986.

[6] IBGE. Demographic Census 2010. IBGE - Brazilian Institute of Geography and Statistics. [Online] [Quoted in: April 2, 2017.] <http://7a12.ibge.gov.br/vamos-know-the-brazil/our-population-characteristics.>

[7] “Infrared sensor - operation, features and applications”; Electrical Knowledge. Available at; <https://www.sabereletrica.com.br/sensor-infravermelho-funcionamento/>. Accessed on August 22,2017

[8] Page 2 2006. Accessibility for people with disabilities. JUS Navigandi. [Online] November 2006. [Quoted on: March 04, 2017.] <https://jus.com.br/artigos/9167/acessibility-for-personal-carriers-of-deficiencies.>

[9] World Health Organization. Factors regulating the immune response:report of WHO Scientific Group[R].Geneva:WHO,1970.