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DESIGN OF ASSISTIVE DEVICE FOR SAFETY IMPROVEMENT OF VISUALLY IMPAIRED PEOPLE

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Abstract: *The paper analyzes the most current applications for visually impaired people, in order to understand and identify the problems they have, with the idea of creating an application for such a device that includes all the useful functions and reduces the existing disadvantages. The applications presented were tested both day and night, using 2 different phones, both with Android and iOS operating systems. The main needs of a visually impaired person were monitored as follows: following a route to a supermarket; identification of the main food products, pharmaceuticals, money. During the test, several objects were analyzed, but we focused on details that cannot be easily identified by touch. To reduce the acquisition costs of the assistive device and make it accessible to a larger number of users, we modeled and designed a system that can be attached to an already existing white cane. This system can be easily assembled and disassembled, allowing the user to fold the cane, which is then easy to carry in a backpack or even in a pocket.*
Keywords: design*, safety assistive device, mobile applications, visual impairments.*

1. INTRODUCTION

Visual impairment affects an exceptionally large number of people worldwide. In Romania, over 90,000 people suffer from visual disabilities, according to a 2020 report by the National Authority for the Rights of Persons with Disabilities, Children and Adoptions (ANPDCA).

Assistive technology has evolved a lot in recent years in many areas, in the automotive field there are cars that park or drive themselves, robots that prepare meals, the list is long, but for people with visual impairments one of the most accessible assistive devices is the cane. In this paper we analyzed the latest existing solutions to create a prototype that would provide sound information for the purpose of avoiding obstacles, safety and facilitating the activities of a regular day.

Analyzing numerous studies on blindness, conducted over the last 10 years, we realized that at a global level there are still quite significant differences depending on the socio-economic factors or the degree of development of each country, affecting the possibility of diagnosis, prevention or treatment [1].

2. STUDY OF ASSISTIVE DEVICES FOR PEOPLE WITH VISUAL IMPAIRMENTS

2.1 Braille [1]

The Braille reading system has its origins in the early 1600 during the wars in France. A man in the French army was desperately looking for a way to communicate without attracting enemy attention and came up with the idea of developing a system for writing/reading in night type without using a lamp. The system was based on a prominent cell consisting of 2 dots horizontally and 6 dots vertically.

2.2 White cane [1]

Among people with visual impairment, between 2 and 8% use a white cane. Currently, canes can be made of aluminum, fiberglass, or carbon.

White canes have been fitted with ultrasonic devices to detect obstacles at distances of up to nine meters. These devices produce vibrations in the handle to inform the user of possible dangers.

One of the most modern smart canes still being studied is equipped with a 3D color camera, an inertial measurement sensor and its own on-board computer. It can also read the blueprint of a building and can guide the user precisely, as it transmits sensory and auditory signs [5].

The cane form Figure 1 uses infrared light to calculate the distance between an object and other individuals. This function combined with the 3D camera and the computer makes it possible to map the area the user is in. This smart device is still under research due to its weight.

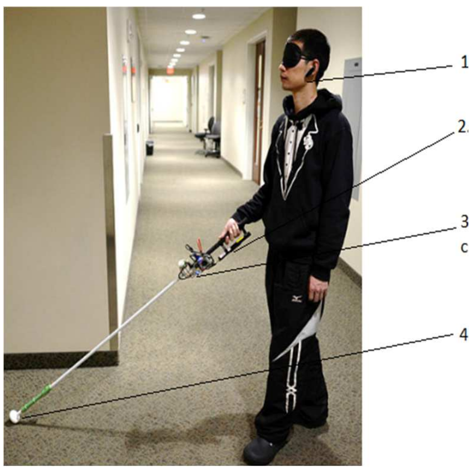

Fig.1. Prototype components: 1. headphones Bluetooth, 2. Baterries, 2. 3D camera with on-board computer, 4 active peak running [3]

Another smart cane that has successfully passed the prototype stage and is already within reach of people with visual impairments is from the company WeWALK (Fig. 2).

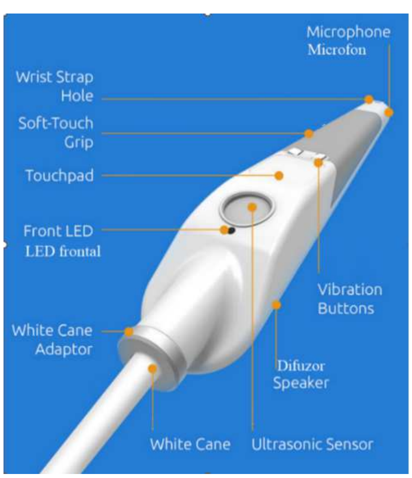

Fig.2. Wewalk components [5]

The conclusions drawn from the comparison of the two types of canes are:

• the walking speed with the electronic cane is significantly slower compared to the traditional white cane:

• 79% of the suspended obstacles that cannot be detected by the white cane were detected by the electronic cane;

• the electronic cane, namely the ultrasonic sensor, has the potential to help visually impaired people who need assistive technology daily by enabling safer navigation [11].

2.3. Echolocation

Echolocation involves the analysis of self-generated sounds from the environment. Figure 3 shows the basic operating principle.

The approximation of distance results from calculating the time elapsed between the production of a sound and the reception of the echo from the environment. Echoes reach the ear at different times and intensities, depending on the position and distance of the object that generated them.

The echo can vary depending on the materials of the objects, the person's location, whether indoors or outdoors, or the geometry of the object [8].

This method is effective, but for a safe journey it is advisable to use it together with a cane, because the quality of echolocation can decrease in crowded, noisy areas or in special weather conditions, such as strong winds.

Also, these devices must be used in conjunction with a cane or a guide dog because they do not transmit information about curbs or other static objects abandoned on the sidewalk.

2.4 OrCam MyEye device

The OrCam MyEye device is a wearable device designed to improve the lives of blind or visually impaired people (Fig. 3). This device is equipped with the latest assistive technology using a smart camera that can be mounted on the user's glasses frame and is connected to a computer the size of a phone.

The advantage is that it can be mounted on any pair of glasses, the device is portable and has the possibility of connecting headphones connected via Bluetooth.

Fig.3. OrCam MyEye [6]

The disadvantage of this device is that it cannot be used by people with hearing impairments, it only increases their independence.

3. ANALYSIS OF MOBILE APPLICATIONS FOR PEOPLE WITH VISUAL IMPAIRMENTS

In this chapter, we analyzed and used all the current applications for people with visual impairments to understand and identify their shortcomings to create an application for a device that includes all the useful functions and reduces the disadvantages. The applications were evaluated both day and night using 2 different phones, with Android and iOS operating systems. The main needs of a person were monitored: following a route to a supermarket, identifying the main food products, identifying pharmaceutical products, identifying money. During the test, several objects were analyzed, but we focused on their details that cannot be easily identified by touch.

A comparative analysis of the existing equipment according to price, weight, shape, safety and operating time was done.

Fig. 4. WeWalk device [9]

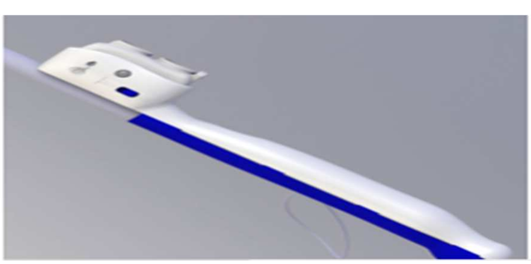

Fig. 5. Smartcane [6]

Table 1

Comparative analysis of existing products

Product name	WeWalk (Fig. 4)	BAWA	Smart cane (Fig. 5)	UltraCane (Fig. 6)
Production year	2019	2018	2014	2010
Senzor type	the ultrasonic sensor	double ultrasonics	ultrasonic sensors	2 ultrasonic sensors
Detection range	80 cm – 250 cm	4.5 m and 45° sensor angular coverage	1,8–3 m, from knee to head level	2-4 m in front of the user, but also detects obstacles at head and chest level
The way it provides information to the user	Audio and vibration	audio	vibration	vibration
Weight	280 g without battery	245g	136g	It is not specified
Dimension	25 mm x 289 mm x 44 mm	It is not specified	240 x 53 x 32 mm	Lengths are available from 105 cm to 150 cm, in 5 cm increments.
Price	2.433,60 RON	3400 Ron	438,10 Ron	2.872,89 RON
Battery life	20 h	48 h	8h	Cannot be estimated as it uses two AA batteries

Fig. 6. UltraCane[6]

4. THE PROPOSED SOLUTION – CASE STUDY

To model the proposed concept, the components proposed in the previous research paper and a comparison of similar equipment were analyzed. For a visually impaired person to learn a new route, they must cover the distance from point A to point B and vice versa approximately 6 times to analyze all obstacles. Considering that not all obstacles are fixed, they can be changed at any time, from a car, the need for a camera being very high. One of the disadvantages of the traditional white cane is that it only detects obstacles through contact, which can be a discomfort on a street or in a crowded building.

The analyzed applications are installed on the mobile phone, which makes the user dependent on them, making it difficult to use both hands.

Designing a device with an integrated obstacle identification camera and audible warning is the best solution.

To reduce purchase costs and be accessible to a greater number of users, we have modeled and designed a system that can be attached to an already existing white cane. This system can be mounted and disassembled, allowing the user to fold their cane, making it easy to carry in a backpack or even pocket.

4.1 Description of the components integrated into the system

The device is adapted with a camera and a sensor to recognize objects and determine the distance to them. It connects Bluetooth to the mobile phone, so the user no longer must use their phone when on the go. Enter the address by voice and receive the orientation information through an audible message. This device can also connect to Bluetooth headphones (see fig.7).

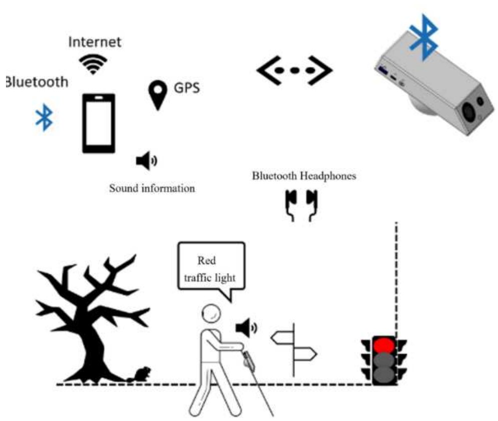

Fig. 7. Device functionality

Device specifications:

- the camera records the images desired by the user, which will be processed by the application to provide sound information,
- TF Mini LiDAR ToF Laser Range Sensor SKU SEN0259.

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- TF Mini LiDAR ToF Laser Range Sensor SKU SEN0259.

TF Mini LiDAR ToF caracteristics:

- Unidirectional laser rangefinder based on time-of-flight (ToF) technology.
- Works both indoors and outdoors, between 0.3 m-12 m.
- Small size, 42mm x15mm x16mm, light weight: 4.7 g.
- Low power consumption, can be powered by standard 5V.
- The average power consumption is 0.6w, the maximum detection distance is 12 meters, compatible with a variety of Arduino controllers.
- Communication interface: UART (TTL).
- Operating temperature: 0°C~60°C.
- Maximum reflectivity range 10%:5m.
- Reception angle: 2.3°.
- Minimum resolution: 5 mm.
- Refresh rate: 100 Hz.
- Measurement accuracy: 1% (<6m), 2% (6~12m).
- Unit of measurement: mm,
- Band: 850 nm,
- requires the use of the following hardware components: Arduino UNO R3, IO sensor expansion board V7.1 x1, Gravity: I2C 16x2 Arduino LCD with RGB backlit display, 7.4V 2500MA lithium battery (with charging and discharging protection board) x1, Serial port: USB to Serial, Dupont threads, - requires the use of the following software components: Arduino IDE, DFRobot TF Mini Library, DFRobot LCD Library.

Considering the elements listed, a diagram of all component’s integration has been made (see fig.8).

A 3D model of it was developed by using CAD system with detailed design of all components (fig.9).

One criterion was to create a device which can be attached to a standard cane and fit with it without changing the dimensions too much (fig.10).

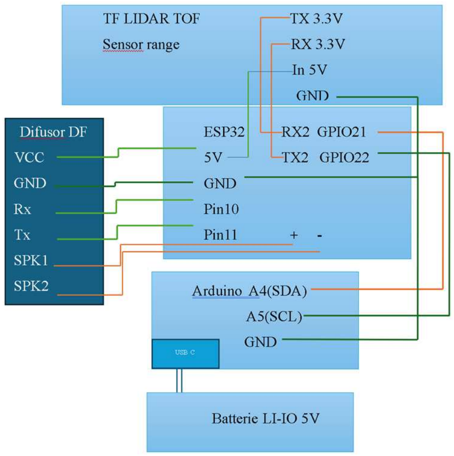

Fig.8. Schematic diagram of electronic components

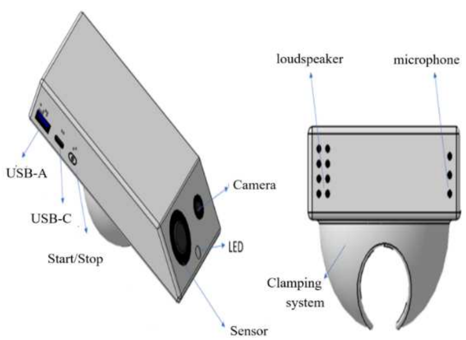

Fig. 9. Detailed 3d model

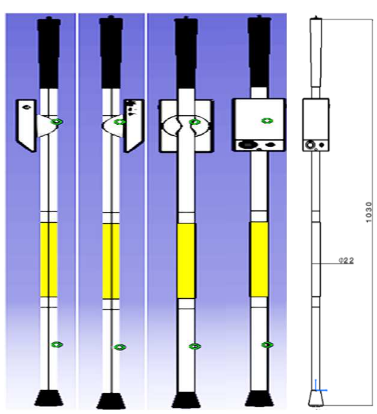

Fig.10. Modelling a traditional cane and attaching the device

5. CONCLUSION

The number of people who have vision problems is constantly increasing, and this aspect can also be associated with the fact that the birth rate is much lower, and the population has aged.

The cane is the most used object by people with visual impairments. Following the tests conducted on today's applications for the visually impaired, the Seeing AI application provides the best details on the environment.

The small size makes the device easy to carry even in pocket. The attachment mode has been designed so that it is easy to attach to the user's cane. The flexible silicone of the clamping system makes it easy to attach to the aluminum rod, thus moving the possibility of slipping.

The device can be used indoors to identify objects, food/pharmaceuticals or to read a book.

The creation of a modern device that automatically benefits from an application with many functions, gives the user freedom of movement.

The paper presents a concept device in design phases. To be available on the market must be done fallowing steps:

Prototype of device - in development.

Test, analysis and validation of the prototype – laboratory test +real environment test – in work

Theoretical and experimental plan for sensor evaluation and validation are in test phase.

The proposed concept device was designed to have a low cost compared with other related products. To achieve this the design includes low-cost sensors available on the market. Another advantage is the integration of this sensor in a stand-alone device which can be use independently or attached to cans, walking frame or other assistive devices.

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Dezvoltarea tehnologiilor de reabilitare pentru persoanele cu deficiențe de vedere

Lucrarea analizează cele mai actuale aplicații pentru persoanele cu deficiențe de vedere, cu scopul înțelegerii și identificării problemelor pe care le au acestea, în ideea de a crea o aplicație pentru un astfel de dispozitiv care să includă toate funcțiile utile și să reducă dezavantajele existente. Aplicațiile prezentate au fost testate atât ziua, cât și noaptea, folosind 2 telefoane diferite, ambele cu sisteme de operare Android și iOS. Au fost monitorizate principalele nevoi ale unei persoane cu deficiențe de vedere astfel: urmând un traseu către un supermarket; identificarea principalelor produse alimentare, a produselor farmaceutice, a banilor. În timpul testului, au fost analizate mai multe obiecte, dar ne-am concentrat pe detaliile care nu pot fi identificate cu ușurință prin atingere.

Pentru a reduce costurile de achiziție ale dispozitivului asistiv și a îl face accesibil unui număr mai mare de utilizatori, am modelat și proiectat un sistem care poate fi atașat la un baston alb. Acest sistem poate fi montat și dezasamblat usor, permițând utilizatorului plierea bastonului, acesta fiind ulterior usor de transportat într-un rucsac sau chiar în buzunar.

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