Assistive systems for subjects with low vision

Mirela Gabriela APOSTOAIE
University Transilvania Brasov, Brasov, Romania
mirela.aposoaie@unitbv.ro

Mihaela Ioana BARITZ
University Transilvania Brasov, Brasov, Romania
mbaritz@unitbv.ro

Abstract. *Low vision is an acute form of impaired visual function due to multiple causes and changes in the patient's functional behavior. At the moment there is on the market of assistive technology products a wide range of such systems that can support patients with different degrees of visual impairment and at the same time can adapt to different activity requirements of these patients. However, the need has been identified to use more efficient and reliable devices in terms of manoeuvrability and to offer "freedom" of movement to patients using such systems. This paper presents some aspects related to the implementation of assistive technologies in the prevention and rehabilitation procedures carried out by the optometrist, in order to improve the activity of patients with multiple sensory and / or locomotor disabilities. The first part of the paper analyzes the prevalence of multiple sensory and motor disabilities in order to identify and develop dedicated and personalized assistive technologies in order to support these patients. In the second part of the paper are proposed two such variants of care systems that offer patients with low vision and blindness the opportunity to move safely to and from the points of interest of its activity. The final part of the paper presents the results and conclusions of the use of these assistive systems and the identification of their future improvement points so that patients become more and more secure in mobility, communication and information transmission / reception.*

Keywords: assistive technology, low vision, information

Introduction

The definition of disability can be considered: a physical or mental condition that limits a person's movements, senses or activities. According to Soder in the work Disability as a social construct: the labelling approach revisited, “a person who uses any assistive device is considered to have a disability” (Soder, 1989).
World statistics report that about 15% of the world's population, representing more than a billion people, live with a type of disability (physical, mental or intellectual) so it can be said that they are the largest and most important minority in the world. This overall estimate for disability is increasing due to an aging population and the rapid spread of chronic diseases, as well as improvements in the methodologies used to measure disability.
Health conditions can be visible or invisible; temporary or long-term; static, episodic, or degenerating; painful or without consequences.
The World Health Organization defines rehabilitation as “a set of measures that help individuals who have or are likely to experience disabilities to achieve and maintain optimal functioning in interaction with their environment.”(Organization, 2011)
Classification of disabilities

https://doi.org/10.2478/9788395815065-032

There are six related concepts in the classification of disability.
(A) Disorders or injuries of certain diseases.
(B) Loss or abnormality of psychological or physiological or anatomical function: due to A.
(C) Restriction or lack of ability in the expected human activity: due to A or B.
(D) Disadvantage that limits or prevents the fulfilment of the expected social roles: due to B or C.
(E) Disadvantage that limits or prevents the fulfilment of the expected social roles: due to F.
(F) Social structure, attitudes and resources: related to A.
The problem is not the concepts themselves, but the labels we attach to them.
Disability dimensions that can be a version of the following list: Locomotion; Fine movements; Personal care; Continence; Hearing; Vision; Communication; Learning; Behavior and social integration; Physical health; Consciousness(Archives of diseases in childhood, 1995)
According to the Law on the Education of Persons with Disabilities (IDEA), multiple disabilities refer to concomitant [simultaneous] disabilities (such as: intellectual disabilities-blindness, intellectual disabilities-orthopaedic disabilities, etc.), the combination of which causes such severe educational needs, which cannot be included in a special education program only for one of the deficiencies.

Methodology

One of the most common combinations of multiple disabilities is low vision with orthopaedic deficiencies, so two systems have been designed that can be used to increase mobility.
The first system is based on the distinct device of visually impaired people, the cane, to which certain modifications are made in order for it to increase mobility. The device can be used by anyone with disabilities as a regular cane, but it is specially designed for climbing and descending stairs.(Andrușcă, 2017)

Figure no 1: The stick with the distance sensors
Source:(Andrușcă, 2017)

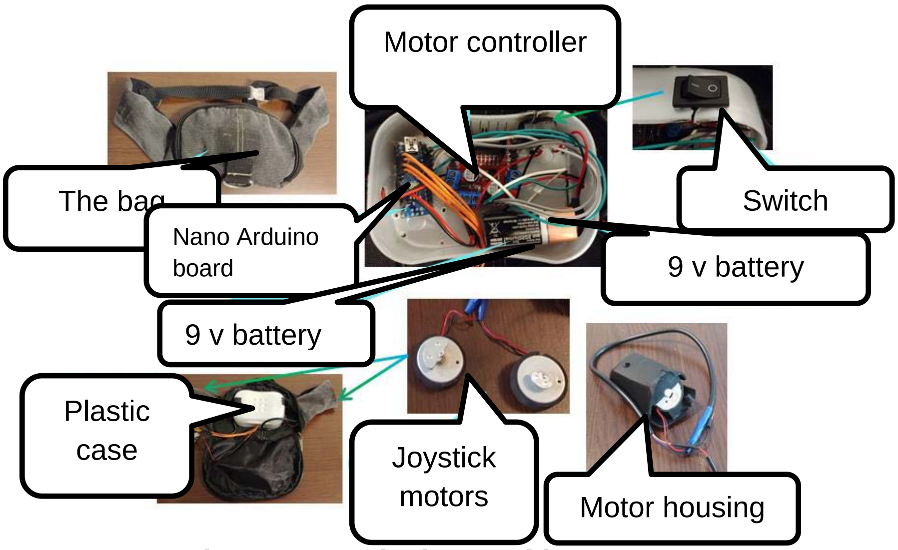

Figure no 2: The bag and its contents
Source:(Andrușcă, 2017)

It is based on a very simple principle, it has an integrated Arduino board which, with the help of motion sensors, drives some motors that will vibrate to warn the user of the

presence of stairs. The 2 sensors are positioned at the base of the stick in order to detect the presence / absence of stairs, they send a signal to a motherboard in a bag that the user will carry. The motherboard will send the information further to the 2 motors that will vibrate.
Detailed tests were performed with it in order to observe the differences in stability and safety. These tests were performed on emetropic subjects whose blindness was simulated by using a pair of glasses created specifically for this test. Space was specially chosen to have different obstacles as well as stairs.
Tests were performed both on the straight road and on the stairs in order to be sure of the autonomy of the device.

Figure no 3: The subject climbing the stairs with the proposed prototype
Source:(Andrușcă, 2017)

Figure no 4: The subject descending with the prototype in hand
Source:(Andrușcă, 2017)

In addition to these tests, tests will be performed on the RSSCAN board in order to compare the 2 instances.

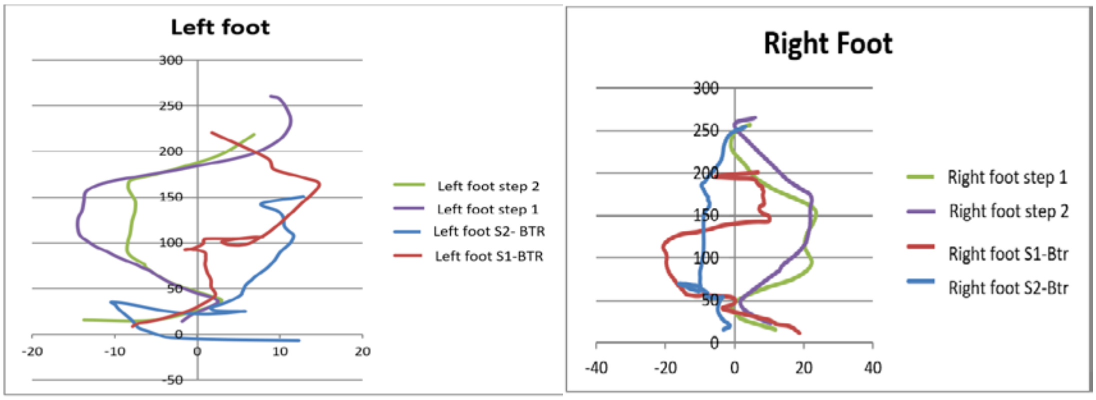

Figure no 5: Comparison - normal gait with blind gait using the cane
Source:(Andrușcă, 2017)

Although the lines of the centers of force resulting in blind and cane walking are quite unstable compared to the lines of the centers of strength of normal walking, they are very close to the ideal axis of the center of force. And this time the deviation of the horizontal axis of the right foot in blindness and cane changes by 1.5 cm from that of the right foot in normal gait.

The second device will be used positioned on the person's waist to give him more degrees of freedom in the use of his hands (than in the case of the cane).
It has been designed to be customized for each person according to the person's height and positioning.

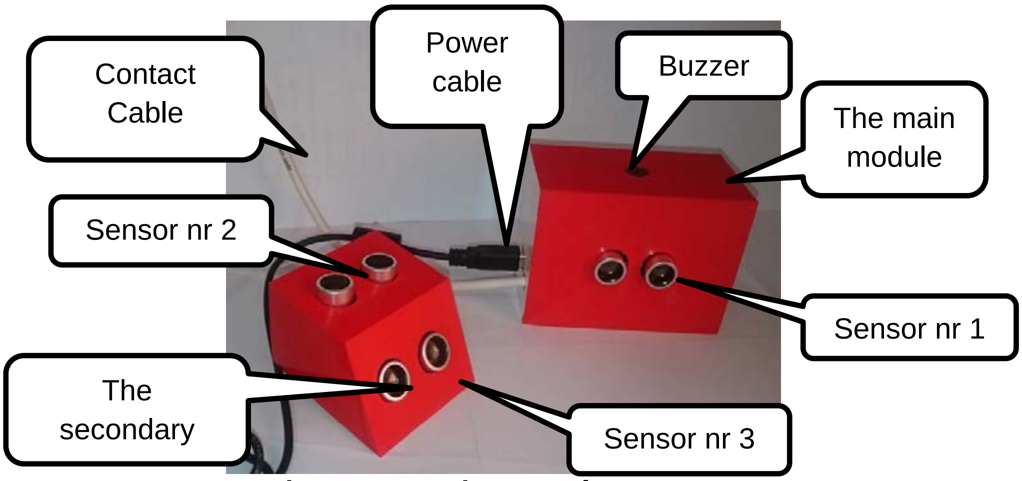

Figure no 6: The complete system
Source:(Apostoaie, 2018)

The device provides the visually impaired person with detailed information about the obstacles that exist from the hip to the ground using the sounds. It has been designed in 2 modules to cover the entire area. For its construction, lightweight materials were used for good portability, an external battery supply system so that it could be changed at any time, and a Velcro fastening system for easy installation. The device housings are 3D printed on the Creality 3D CR-10S-3 printer, and the internal system consists of an Arduino Uno board and 3 ultrasonic sensors. (Baritz & Apostoaie, 2019)
The main module of the system includes: an Arduino Uno board, an ultrasound sensor and a buzzer. The ultrasound sensor will read the distance at the obstacle, the Arduino board will process the information and depending on the program created will send a signal to the buzzer to generate a sound. It will be positioned at the level of the pelvis and can be attached to a belt or even pants.
The secondary module positioned on the subject's foot will include: It will contain 2 ultrasound sensors pointing in different directions. Connecting these sensors to the main module will be done with an 8-conductor cable so that there are not too many wires between these modules so as not to be inconvenient and difficult to use.
Figure no 7 captures the moment when a normal subject is induced blindness by covering his eyes for prototype testing. The subject is rotated around its own axis to be disoriented. The 2 detected areas of the sensors are marked and also the function of the sensor that detects the presence or absence of the earth (as in the case of stairs).
The device must be customized according to the parameters of each user, because each subject may have different requirements on the wishes of the device. This will only be possible at the beginning by the device administrator. The most important parameter, which can be modified, is the distance at which the prototype detects the first obstacle, it can vary between 3m and 5 cm, this being possible for the module located at the hip.
The module attached to the subject's foot can be adjusted according to the height of the subject and the sole of the foot, as they may vary.
The device gives the user the freedom not to use his hands to detect obstacles, he can use other devices while traveling such as: Trekker talker GPS - GPS Speaker - (is a GPS speaker that can be used with one hand thatit verbally announces the name streets, intersections and landmarks while driving, at the touch of a button) or 1.1.4. Victor Reader Trek Talking GPS.

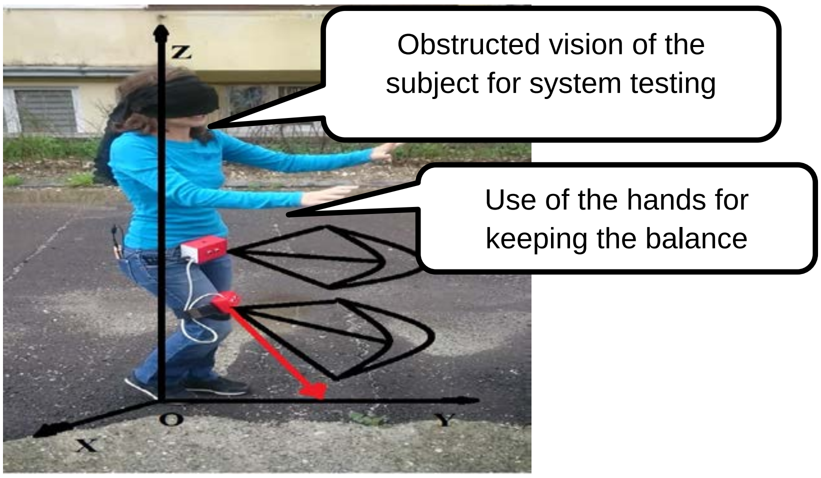

Figure no7: Positioning the 2 modules on a subject with obstructed vision
Source:(Apostoaie, 2018)

Results

The tests performed with the cane on a stepped route took into account several parameters: the average travel time of the subjects in blindness, the correctness of the posture, the number of hesitations.

In addition to improving travel time, there are also improvements in the posture of the back, legs, hands are in a normal position. Subjects feel safe walking thus limiting the number of hesitations and stumbling blocks.

If blind subjects follow a regular training procedure for simple walking and walking, the postural parameters will improve due to the phenomenon of learning, understanding and self-interest.

For the second system, a stepped route was also used, taking into account the same parameters in order to observe the difference between the 2 devices. Following the tests, it was observed that the subjects were much more confident in the device made after using the device for 1-2 minutes to gain confidence in the sounds produced by the buzzer. Subject no. 1 was more relaxed in his movements, encountering all kinds of obstacles and climbing all steps in 1 minute and 14 seconds, while subject no. 2 performed the same route in 1 minute and 40 seconds. It was observed that subject no. 1 had a much more relaxed posture, with his hands closer to his body, while subject no. 2 had his hands fully extended and a more rigid body posture.

The biggest impact of these devices compared to what already exists on the market of dedicated devices for people with disabilities is the price, because they were designated to be affordable.

As Surapol Vorapatratorn presents in his article different prices between $ 700 and $ 3000 for similar devices such as: k-sonar cane and the laser cane, designed devices have a value about 7 times lower than the cheapest device presented on the market. (Surapol Vorapatratorn, 2014)

Conclusion

Following the results obtained with the stick, the following improvements were found:on the RSSCAN board the line of the center of force resulting from the movement in blindness with the auxiliary cane and step approached the line of the center of force in normal gait; on scales the average travel time, both in blindness and low vision, is

lower when using the visual aid device compared to the average travel time without it; in all cases where the visual aid device was used, significant improvements in body posture and correctness of movement were observed.
An important conclusion is the design and development of prototypes that is performed in an accessible programming environment, based on the C ++ language. The program is also friendly in terms of information found on the Internet for the development of applications (tutorials). Software development is easy, the connection to the board is made via a USB port.
The second prototype is an easy one to use without parts that are difficult to assemble or too heavy. It can be used for daily commuting and improves the quality of life by increasing mobility regardless of the environment. The device can be customized for anyone, regardless of height, age or gender. The price for both devices is accessible for majority of the people.

In these experiments we've developed the investigations with equipment from ”Advanced Mechatronic Systems Research Center - C04” and Applied optometric Laboratory at University Transylvania of Brasov, in PhD school Program.

References

Andrușcă, N. (2017). Dezvoltarea aplicativa a sistemelor de ajutor vizual. In *Lucrare de licență.* BRASOV.

Apostoaie, M. G. (2018). 3D printing procedure applied in the design of portable devices for visual aid.

Archives of diseases in childhood. (1995). Retrieved 01 05, 2021, from The Journal of the British Paediatric Association.

Baritz, M. I., & Apostoaie, M. G. (2019). Visual aids based on ultrasonic sensors to increase mobility of patient with blindness or low vision.

https://www.specialeducationguide.com/disability-profiles/multiple-disabilities/. (n.d.). Retrieved 01 05, 2021

Organization, W. H. (2011). *https://www.who.int/teams/noncommunicable-diseases/disability-and-rehabilitation/world-report-on-disability.* Retrieved 01 05, 2021
Soder, M. (1989). *Disability as a social construct: the labelling approach revisited.* European Journal of Special Needs Education.

Surapol Vorapatratorn, K. N. (2014). iSonar: an obstacle warning device for the totally blind . *Journal of Assistive, Rehabilitative & Therapeutic Technologies*, 7.