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Overview of navigation assist devices for visually impaired people

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***Abstract* — This study aims to provide the overview of current assist devices for visually impaired people. The primary objective of this paper is to fully analyze new approaches for the given problematics purposed by different companies and describe the technical solutions proposed by them. A comprehensive analysis was conducted to assess whether the existing solutions fully satisfy the needs of the visually impaired. It also provides novel insights into given approaches and proposes also a novel approach to solving the given issue.**

***Keywords* — visually impaired people, navigation, assistance, wearable devices**

I. Introduction

It has been well established that the development of assistive devices for visually impaired people is not only an expression of solidarity and humanity for the visually impaired, but it is a work whose results are also economically beneficial for the entire society. Providing them with aids for independent functioning takes the burden off the people who must care for them and depend on them. At the same time, visually impaired people are offered a more accessible opportunity for study, work and business. Related to this is the chance to move the society forward.

Intelligent assistive devices for the visually impaired can be grouped into several categories, including portable devices, stationary systems, object detection tools, navigation aids, and mobile applications. Portable devices are those that users can easily carry or wear, allowing them to use these tools in various locations. Portability is an important feature for many assistive technologies, such as navigation systems, obstacle detection devices, or room identification systems. In contrast, stationary systems are designed for use in a fixed location, like large desktop magnifiers. Devices that detect objects help users by either alerting them to obstacles (such as vehicles, stairs, or other pedestrians) or by recognizing things like gestures, faces, emotions, or money. Navigational tools enable individuals to move around safely and independently, helping them stay oriented. Mobile applications provide a wide range of assistive functions. Among the most used are money readers, color detectors, text recognition apps, voice assistants, and screen readers, which help users interact with their surroundings more easily [1].

There is a growing body of evidence suggesting that no current high-quality aid or technology adequately addresses the primary needs of visually impaired people: navigation, spatial orientation, and real-time obstacle detection. This highlights the importance of providing comprehensive overview of current navigation devices to provide new approach to given issue, upgrading current novel devices and develop a functional, useful and reliable device in the future. It remains to be determined which approaches of the current products are suitable to keep and which to replace with a more suitable solution [1].

II. Hardware-Software Integrated Products

The data presented in section below demonstrate that current devices use either distance sensors or cameras with artificial intelligence analyzing the objects in the photo and their distance from the visually impaired person as a source of information about obstacles in front of them. As a form of feedback, two approaches were chosen, which were either implemented separately or complemented each other. Tactile feedback was carried out either through extendable pressure cylinders pressing a certain part of the body surface with a force directly proportional to the distance of the obstacle from the visually impaired person, or in the form of vibrations or stimulation electrodes, where the intensity of the given feedback was again directly proportional to the distance of the obstacle. The form of sound feedback was not directly specified, but we can assume that the specific sound is again assigned to the distance and position of the given obstacle.

The *Lumen* device shown in Fig. 1 (a) integrates a custom camera with AI capabilities to analyze the surrounding environment. Feedback is provided through auditory signals (both verbal descriptions and sounds indicating obstacles) and specific tactile feedback patterns, delivering multisensory input to assist in navigation [2].

ForeSight's haptic vest illustrated in Fig. 1 (b) features a vest equipped with a camera positioned on the front, which is connected to a smartphone. Information captured by the camera is processed and transmitted via Bluetooth to the vest's electro-mechanical components located on the back. Based on the input data, individual mechanical elements apply targeted pressure to specific body areas, providing directional haptic feedback to the user. The haptic vest is still in a prototype state and the product is not available for purchase [3].

The *BuzzClip* device displayed in Fig. 1 (c) employs an ultrasonic sensor to detect obstacles in the user's immediate environment. The data gathered by the sensor is converted into vibrational feedback, which is transmitted to the user, enabling them to perceive obstacles without relying on vision [4].

The *Vision Pro* system, Fig. 1 (d), is a head-mounted device equipped with a front-facing digital camera. Environmental information is translated into electrostimulation impulses delivered via an array of electrodes placed on the user's tongue. This technology allows the user to experience spatial information through tactile feedback generated on the tongue, effectively substituting vision. Company has although recently suspended business and are in the process of selling our intellectual property to a new company. That's why is the *Vision Pro* system not commercially available [5].

The *Sixth Sense* device presented in Fig. 1 (e) utilizes a combination of a proprietary navigation app connected via Bluetooth to external sensors. Although the specific sensors are not detailed on the site, it is known that the device gathers environmental data and delivers outputs through auditory (via headphones) and tactile feedback (via an actuator located on the head, with unspecified additional mechanisms) [6].

The *SuperBrain* device as seen in Fig. 1 (f) is mounted on the head and incorporates a front-facing camera. Information from the camera is processed and transmitted to a pressure actuator, which applies force on the user's forehead, providing tactile feedback as a method of conveying spatial awareness [7].

The *Niira* device shown in Fig. 1 (g) is a head-mounted system featuring a front-facing camera that captures environmental data. The device processes this information and delivers feedback through spatial audio signals, providing users with an auditory-based spatial awareness system. Device is currently available only in Spain [8].

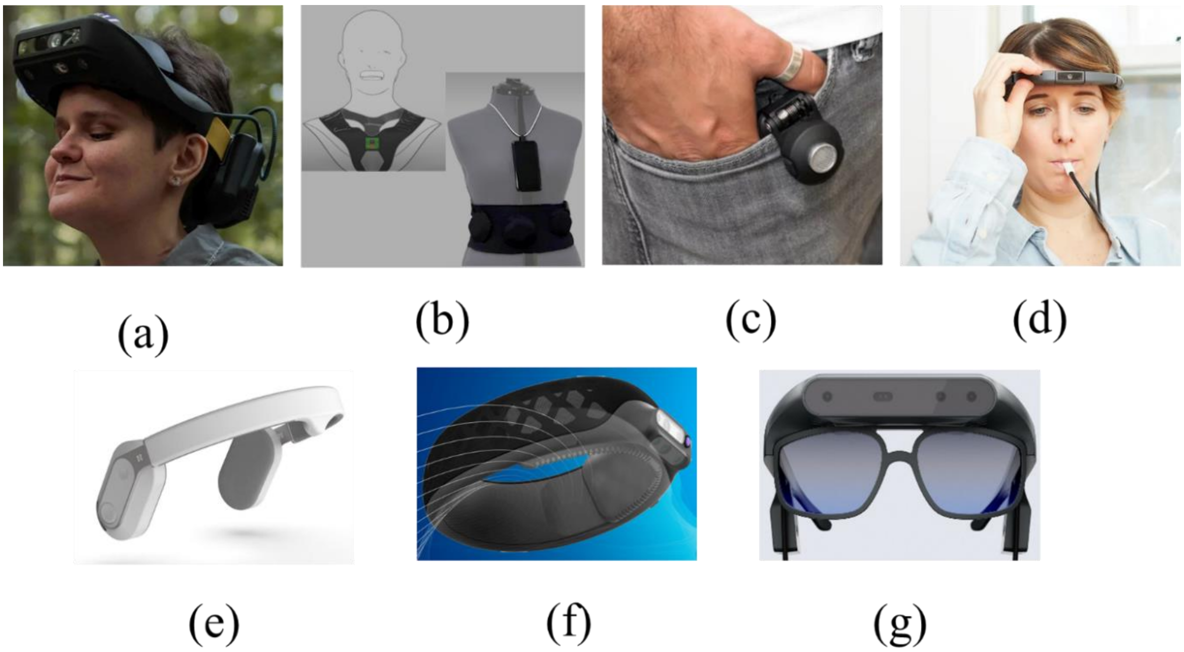

Fig. 1 Navigation assist devices for visually impaired people, (a) - Lumen device, (b) – ForeSight haptic vest, (c) – BuzzClip device, (d) – Vision Pro system, (e) - Sixth sense device, (f) – SuperBrain system, (g) – Niira device

Table 1
Summarization of current assist devices for visually impaired people

Company	Product	Vision compensation	Input data from	Price (€)
.Lumen	.Lumen	Touch and hearing	Embedded camera	under development
Anirban Ghosh	ForeSight	Touch	Smartphone camera	unbuyable
iMerciv	BuzzClip	Touch	Ultrasonic sensor	222,89
BrainPort	Vision Pro	Touch	Embedded camera	unbuyable
HopeTech	Sixth sense	Touch and hearing	Sensors	under development
7sense	SuperBrain	Touch	Embedded camera	9000
Sensotec and Eyesynth	Niira	Hearing	Laser sensor	quotation needed

III. Software-only Solutions

Several GPS-based applications have been developed to assist visually impaired users with orientation and navigation. *BlindSquare*, for example, is a GPS application designed primarily for use in outdoor environments, helping users navigate and orient themselves in space. Similarly, *Lazarillo* offers a GPS-based solution for spatial orientation, also optimized for outdoor use. Another application, *GoodMaps*, takes a different approach by enabling the creation of 3D models of buildings, allowing users to navigate within indoor environments as well. Finally, *Corvus* is a GPS navigation tool tailored specifically for the Slovak environment, providing localized support for users needing spatial orientation in various settings.

IV. Discussion

As mentioned earlier in the paper, there are several approaches to obtain information about obstacles from a visually impaired person. Input obtained to provide feedback via laser ranging has a clear speed advantage over an ultrasonic sensor. However, the question remains whether current laser meters used for mapping objects in front of them will be light enough and dimensionally suitable to be wearable. The camera-based approach has the advantage of size and weight, which makes it a suitable option for a wearable device. However, the question remains whether the analysis of a given input, image/video, by artificial intelligence will be fast and reliable enough.

In terms of conveying feedback, touch has an advantage over sound in that there is no need to analyze the type of sound and associate distance and shape with it. A visually impaired person can therefore react more quickly to a given obstacle. However, the form of pressing the cylinders on a certain part of the body does not seem to us to be an optimal solution, especially due to the mechanical complexity. Stimulating electrodes have the advantage of faster mediating feedback and represent a mechanically less demanding solution. However, their placement on the tongue does not use the potential of a large sensory surface. If electrostimulation electrodes were placed, for example, on the back, we could increase their number and increase the accuracy of providing feedback. The limitation of this approach lies in the maximum possible time of use of the given assistive device, as intense and long-term electrostimulation of the individual's muscles can have adverse health consequences. Further experiments are needed to confirm if the preferred solution is the most suitable for providing feedback.

V. Conclusion

This overview provides new insights into the current state of assistive devices for visually impaired individuals, particularly in the areas of navigation, spatial orientation, and obstacle detection. A key contribution of this work is the comprehensive analysis of both hardware-software integrated products and software-only solutions, highlighting their strengths and limitations. We have identified the potential for improvement in both the feedback methods and the information processing speed of these devices. Touch-based feedback appears more intuitive and faster than sound-based alternatives, but the mechanical complexity of current tactile solutions remains a significant challenge. Likewise, although camera-based systems are lightweight and wearable, further optimization is necessary to ensure the timely and accurate processing of visual data by artificial intelligence algorithms. Further research is needed to confirm the most suitable approach for both detecting obstacles and providing effective feedback. Future work should focus on refining the wearable design and exploring new forms of sensory feedback to enhance the usability and long-term safety of assistive technologies for visually impaired users.

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