Mühendislik Bilimleri ve Tasarım Dergisi
7(4), 913 – 925, 2019
e-ISSN: 1308-6693

Journal of Engineering Sciences and Design
DOI: 10.21923/jesd.482180

Araştırma Makalesi Research Article

ASSISTIVE TECHNOLOGIES FOR INDIVIDUALS WITH VISUAL IMPAIRMENT: CONTRIBUTION OF DESIGN IN THE FIELD OF CLOTHING

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Keywords

Assistive Technology, Visual Impairment, Design, Clothing, Wearable Technology.

Abstract

According to data of World Health Organization, it was estimated that 253 million were visually impaired worldwide in 2017 (WHO, 2017). For those with moderate to total blindness and visual impairment, daily activities such as mobility, communication, education, clothing and shopping cannot be carried out independently. Assistive technologies (AT) offer solutions to contribute to the quality of life of those with visual impairments. Considering the daily obstacles faced by such individuals, as a prior step for design development of alternative ATs, this paper includes an overview of ATs. Since this overview addresses a lack of applications in clothing related AT, the following survey aims to acquire feedback from people with visual impairment, focusing on clothing related issues, with the aim of making improvements in design.

GÖRME ENGELLİ BİREYLER İÇİN YARDIMCI TEKNOLOJİLER: GİYİM ALANINDA TASARIMIN KATKISI

Anahtar Kelimeler

Yardımcı Teknolojiler, Görme Engeli, Tasarım, Giyim, Giyilebilir Teknoloji.

Öz

Dünya Sağlık Örgütü verilerine göre, 2017 yılında 253 milyon insanın görme engeli olduğu öngörülmektedir (WHO, 2017). Orta dereceden toplam körlüğe ve görme engeline sahip olanlar için, hareketlilik, iletişim, eğitim, giyim ve alışveriş gibi günlük faaliyetler, bağımsız olarak gerçekleştirilemeyecek kadar zor olabilmektedir. Yardımcı teknolojiler görme engeli olan kişilerin yaşam kalitesine katkıda bulunacak çözümler sunmaktadır. Alternatif yardımcı teknolojilerin tasarımı ve geliştirilmesi için bir ön adım olarak ele alındığında, bu çalışma, görme engelli bireylerin karşılaştığı günlük engelleri göz önünde bulundurarak, yardımcı teknolojilerin genel bir incelemesini içermektedir. Bu genel incelemede, giyim alanı ile ilgili yardımcı teknolojilerin eksikliği dikkat çekmiştir. Bu sebeple çalışmanın devamında yapılan anket çalışması da görme engelli bireylerden, tasarımın katkısı ile gelişme sağlanabilecek ve giyim alanına odaklanan geri bildirimler almayı amaçlamaktadır.

Alıntı / Cite

Süller Zor, B., Vuruşkan, A., (2019). Assistive Technologies For Individuals With Visual Impairment: Contribution Of Design In The Field Of Clothing, Journal of Engineering Sciences and Design, 7(4), 913-925.

Yazar Kimliği / Author ID (ORCID Number)	Makale Süreci / Article Process	
B. Süller Zor, 0000-0003-0490-6443	**Başvuru Tarihi / Submission Date**	13.11.2018
A. Vuruşkan, 0000-0003-1478-0442	**Revizyon Tarihi / Revision Date**	31.07.2019
	Kabul Tarihi / Accepted Date	10.09.2019
	Yayım Tarihi / Published Date	19.12.2019

1. Introduction

Assistive technology (AT) is a current field, which can contribute to quality of life of people with visual impairment via innovative projects. According to estimates from World Health Organization data, there were 253 million visually impaired people worldwide in 2017 (WHO, 2017). 36 million of them were reported as blind, and 217 million, as moderate to severely visually impaired. In addition, 81% were aged 50 years and above. There are four levels of visual function, according to the International

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Classification of Diseases -10 (ICD – 10, Update and Revision 2006): (1) normal vision, (2) moderate visual impairment, (3) severe vision impairment, and (4) blindness. "Visual impairment" refers to all cases of moderate or severe vision impairment (i.e. low vision) and blindness (WHO, 2017). According to the WHO 2017 report, the major causes of visual impairment globally are uncorrected refractive errors (myopia, hyperopia or astigmatism) with 53 %, and un-operated cataract, with 25% (WHO, 2017).

Over the past 20 years, the social model of disability, in which disability is seen more as a social construction than a medical reality has come to the fore. An individual may have physical disability in a way that requires adaptation in daily life, but most obstacles stem from the attitude of the society and physical/environmental barriers (Kaduwanema, 2016). For these people, mobility, communication, education and other daily activities, such as clothing related issues or shopping can be very compelling. At this point, the medical model and the social model both agree that physical environment and opportunities should be made as accessible as possible for individuals with special requirements (Kaduwanema, 2016). Bringing such people to the collective communication environment, and facilitating their social, educational and the other daily life activities are significant social responsibilities.

This issue particularly interests designers, engineers and urban planners, due to their role in developing a proper design and planning approach to provide wider accessibility considering the needs of all. Related to this, there exist mobile applications, projects and some prototypes. Based upon the daily obstacles faced by people with visual impairment, this research aims to introduce a review of existing examples of uses of AT in daily life based on classification of usage area. The review focuses on major purposes, strengths and weaknesses of current examples, as design research, which leads to an analysis of the potential contribution of design in this context. Both research projects and commercial products are covered in this review.

For the subsequent phase of our design research, a short survey was conducted. The survey aimed to acquire feedback about the general AT usage, and consequently, develop design recommendations in this direction. In our research on existing AT applications, we have observed that current examples, either as research projects or commercial applications, are more related to navigation and object identification functions, while AT research on clothing field is much more limited. Therefore, a section of the survey was allocated specifically for clothing related issues in order to identify the relationship between individuals with visual impairment and the concept of design and clothing. After building a framework with participant perspectives on the use of AT, design recommendations were generated.

2. Review of Assistive Technologies

Constant technological improvement in terms of devices, applications or production systems has changed the nature of interaction amongst people and with environment. These improvements have had positive outcomes for ATs, especially for people with sensory, cognitive, and physical impairments. AT gives those people independence in their daily activities and enhances their overall quality of life. By definition: "Assistive technology (often abbreviated as AT) is any item, piece of equipment, software or product system that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities" (ATIA, 2015).

Table 1. AT Classification According to the Usage Area (WT refers to "wearable technology; App refers to "applications")

ATs for MOBILITY	ATs for COMMUNICATION	ATs for DAILY ACTIVITIES
1-Wearable Obstacle Detection System (WT)	1-Braille Glove (WT)	1-BlindShopping (App)
2-NAVIG Project (WT)	2-Finger Reader (WT)	2-Trinetra (WT)
3-Microsoft 3D Soundscape Technology (App)	3-TalkBack (App)	3-Shop Talk (WT)
4-BuzzClip (WT)	4-BrailleBack (App)	4-Assistive Clothing Pattern Recognition System (WT)
5-BlindSquare (App)	5-VoiceOver (App)	5-LCW Sense (App)
6-Lazarillo (App)	6-KNFB Reader5(App)	6-Give Vision (App)
7-Lazzus (App)		7-OrCam MyEye 2.0 (WT)
		8-Tap Tap See (App)

The review of assistive technologies was classified in terms of their usage area in this study, as *mobility* (e.g. mobility AT/ the batcane, navigation AT/ context aware computing, orientation AT/ blind person's navigator etc.), *communication* and *access to information* (e.g. screen readers, self-voicing applications and speech, text, Braille conversation technology etc.), and for *daily living* activities such as interaction with objects, clothing, shopping etc. In addition, in the main classification of AT examples, a sub-category was added for the initial discussion of research projects, and consequently the inclusion of commercial examples/ applications. Table 1 illustrates the three categories of AT use with the name of examples. Blue indicates research projects, while orange refers to commercial examples/ applications. In addition to guiding the overview in this research paper, this table visually gives a clue about the allocation of wearable technologies and applications, and research projects and commercial examples in this field.

2.1. Assistive Technology for Mobility

The oldest and the best known example of AT is white cane that people with visually impairment still commonly use. However, since this tool can only detect nearby objects, and is intended to detect obstacles in the ground, it gives user limited time to change direction and may not be able to detect objects above ground level. Thus, in this part, we review research projects, technological applications and devices designed to enhance the white cane's function.

2.1.1. Wearable Obstacle Detection System

As an example of one the first research projects in this field, Bahadır (2011), developed a wearable obstacle detection system that warns users about obstacles and hazards, and enables them to navigate safely in indoor environment (Figure 1). The system comprises a wearable garment with sensors, actuators, power supplies and a data processing unit. The challenge in this system is to integrate technical elements in a wearable garment without affecting features such as garment flexibility and weight. The system, firstly, senses the surrounding environment and detects obstacles via sensors, and consequently, it guides the user by actuators through a feedback process interpreted in signal processing unit (Bahadır et al., 2011).

Figure 1. Wereable Obstacle Detection System (https://ori-nuxeo.univ-lille1.fr/nuxeo/site/esupversions/dff23fc1-6f53-4980-9a9a-2fed2e27f8e9)

2.1.2. NAVIG Project

The second research project example on navigation is the NAVIG system (2012), which has been designed and prototyped in order to provide visual information from the environment surrounding people with visual impairment. The system includes head-mounted stereoscopic cameras (Figure 2), SpikeNet Vision object localization algorithm, that identifies the images and even the objects sharing similar shape, and processes them in real-time based on pattern matching. The detection signals are transmitted to the user via 3D audio rendering engine (Kammoun et al., 2012).

Figure 2. NAVIG Project (https://www.sciencedirect.com/science/article/pii/S1959031812000103#fig0020)

2.1.3. Microsoft 3D Soundscape Technology

In addition to research projects, software and technology companies are developing a variety of ATs for people with visual impairment. For instance, Microsoft has developed 3D Soundscape Technology from a research project, which at the first stage, consists of a bone-conduction headset with a smartphone and indoor/ outdoor wireless beacons (Microsoft 2015). The system later evolved into the commercial application which runs on iPhone 5S or later versions or with most wired or Bluetooth stereo headsets. It allows real-time environment tracking with the smartphone's GPS and accelerometer sensors. By creating a 3D sound map, the device listens to the surroundings through sensors, and can determine the direction of the user. The headset, which transmits to the bone next to the ear, can also give information about the places and shops or any points of interest around and additional journey details (Microsoft, 2019).

2.1.4. BuzzClip

BuzzClip is a commercial wearable device by iMerciv, attachable to clothes (Figure 3), which is able to detect nearby obstacles. The working principle of the system is based on sending and receiving sound waves, and then transmitting them to user as intuitive vibrations (Mali, 2015). It has three selectable modes, 1, 2 and 3 meters, and the company suggests selecting 1 meter mode for indoor usage, and 2 or 3 meter modes for outdoors. It works by sending warning vibrations about obstacles in its conical shaped detection area (Figure 3) (Imerciv, 2019). Creators of BuzzClip report that one of the main advantages of the system is that lighting condition or transparency of the object affects neither detection nor distance measurement (Mali, 2015).

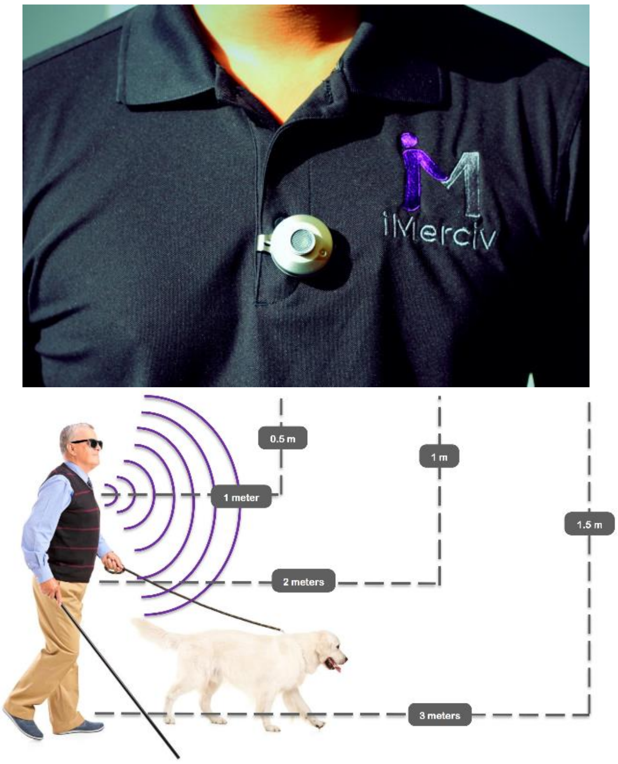

Figure 3. BuzzClip (https://www.imerciv.com/user-guide/index.shtml)

2.1.5. BlindSquare

BlindSquare is a GPS-based application which allows people with visual impairment to travel independently by describing the environment, highlighting points of interest, street intersections and venues through a dedicated speech synthesizer. The app enables users to access the most important functions through an audio menu via any headset or speaker which supports Apple's music controller. Thus, there is no need for the users to touch the phone screen. The app searches a 200 meter radius, and uses iOS-device's GPS capabilities to inform users about their surroundings on Foursquare and Open Street Map. The app is available in many languages (BlindSquare, 2019).

2.1.6. Lazarillo

Lazarillo is another commercial guidance application, which use voice messages to inform users about the current location and nearby services regarding bus stations, cafes, banks, restaurants, street intersections, etc. It can give directions on how to reach your destination by different types of transportation. The application requires a mobile phone with an Android 4.3 operating system or iOS 9.0 (or newer versions), mobile internet and the activated GPS of the Smartphone. Because the application uses the main international databases for its maps, it can be used worldwide. The application is also able to work with the screen readers such as "Talkback" or "VoiceOver" (Lazarillo, 2019).

2.1.7. Lazzus

Another commercial navigation application is Lazzus which gives information on items near the users such as pedestrian crossings, street intersections, stairs and stores, at any given time, by creating an auditory field of vision within 100 meter radius. To provide greater accuracy, it uses two complementary data sources: Google Places and Open Street Map. The app has three modes serving to different types of demands. The first, "Beam Mode", informs the users of items in the current direction. The second, "360º Mode", highlights everything in users' immediate surroundings in every direction. The third, "Transport Mode", is automatically activated when the users travel by bus or car, and informs them about the streets through which they pass (Lazzus, 2019).

Mobile phone navigation applications, such as BlindSquare, Lazarillo and Lazzus are popular and practical tools for navigation and it is expected that the number of similar apps will rapidly increase. Even though their purpose is more advanced than the use of white cane, these apps still can be evaluated under the category of navigation.

2.2. Assistive Technology for Communication

Communication is a complex process that uses different forms as speech, vocalizations, gestures, and facial expressions, to exchange information with a communication partner about one's wants/need, experiences, ideas, thoughts and feelings. Communication can also be in the form of reading or sending text messages as online communication. For people with visual impairment, written communication ways, such as reading mobile phone or computer screen can be challenging, even impossible in some cases. At this point, assistive applications and devices have huge potential for people with vision loss. In the following section, descriptions of some examples of those research projects and commercial applications that make this process easier, and support communication of people with visual impairment (Table 1).

2.2.1. Braille Glove

Braille Glove (2014) is an example of a research project prototype helping to convert the Braille alphabet into text, and vice-versa. The touch sensors, made of copper and arranged like six Braille cells on the palm of the glove, wirelessly transmit texts to the receiving PC/mobile phone (Figure 4). When touching the sensors, the capacitance of the circuit changes, triggering the microcontroller and recording the touch. Tactile feedback patterns provided by small vibrating motors on the back of the glove enable the user to receive regular incoming text messages (English) in Braille. Then, the received data is compared with the entries in a look-up table (Coudhary et al., 2015).

This prototype is an example of wearable technologies with the use of a glove; however, the focus is overwhelmingly on the function, and therefore, aesthetic features and practicality are not the strongest characteristics of this specific product.

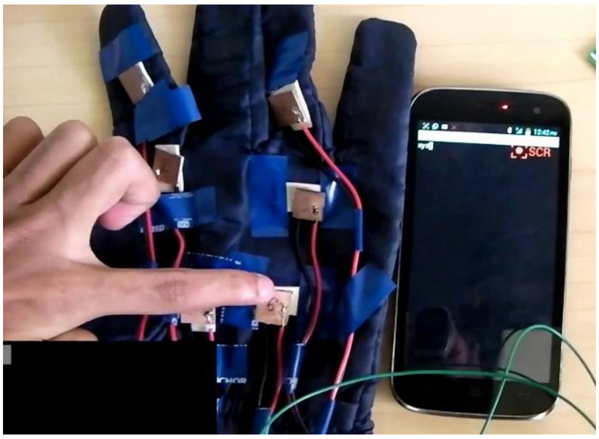

Figure 4. Braille Glove 2014 (https://www.youtube.com/watch?v=ONnZ_HP-dzM)

2.2.2. Finger Reader

Finger Reader is another research project prototype, under development at the MIT Media Lab. It is worn on the index finger and used for assisting in reading printed text, as well as an aid for language translation. The device consists of vibration motors embedded in the ring for tactile feedback, a dual-material case, and a high-resolution mini video camera (Figure 5). Wearers scan a text line with their finger and receive audio feedback of the words and a haptic feed. In addition, Finger Reader's software stack includes a sequential text-reading algorithm, hardware control driver, integration layer with Tesseract OCR and Flite Text-to-Speech feed (Shilkrot, 2015).

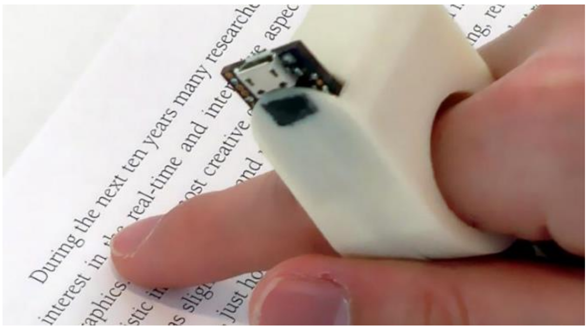

Figure 5. Finger Reader (http://alumni.media.mit.edu/~roys/)

2.2.3. TalkBack

Besides research project prototypes, some services and applications providing easier communication are already on the market. TalkBack is one of those communication applications, developed by Google, installed into Android devices. The application enables users to interact with their devices, informing users about what they touch on the screen. Besides, through a screen reader service, users can access texts including menu names, time and notifications. It can read incoming messages aloud, and send voice and send text messages. In addition, via settings, users can adjust speech volume, start/ stop screen reading by shaking the device, or use a specific voice pitch as a signal to start typing.. (Hildenbrand, 2015).

2.2.4. BrailleBack

BrailleBack is another accessibility service specially developed for the visually impaired, allowing the use of computers and other mobile devices with the Braille alphabet. The application works with the TalkBack screen reader to provide a unified conversation and braille experience, and allows user to pair devices via Bluetooth, and display the text on the screen in Braille alphabet. The users can navigate or interact with their devices using the keys on the display. It also allows text entry using the device's Braille keyboard (Google BrailleBack, 2015).

2.2.5. VoiceOver

VoiceOver is an application for Apple products, while TalkBack and BrailleBack applications are suitable for Android devices. It uses gestures to signal the user's iPhone to speak what is written on the screen, including the description of all screen items, such as battery level, status, cell network, time, date etc. VoiceOver also provides contextual information, such as the adjoining objects or the location of objects on the screen (VoiceOver, 2017).

2.2.6. KNFB Reader

KNFB Reader is another application, which, in real-time, converts the picture of printed text into high-quality audio output. Different from the other mobile readers, the KNFB Reader has built-in image processing technology that allows the users to take photos for accurate results of the things that they want to read or listen to. The system bases on image processing technology (or optical character recognition technology), which identifies the words in the image and allows them to access Braille. KNFB Reader can also provide access to single or multi-page documents, recognize and read printed materials in various languages, and link to Dropbox or OneDrive (KNFB Reader, 2017).

2.3. Assistive Technology for Daily Activities

All assistive technologies, from the most simple to most sophisticated and specialized high technology devices and applications, provide accessibility in daily life. This part focuses on the technologies required for daily living activities in or outside the home environment. AT examples are explained in terms of these activities, with research projects mentioned first, and the commercial examples, subsequently (Table 1).

The grocery shopping, shopping for clothes, and interacting with objects are some of the main challenges for people with visual impairment in daily life. Sighted shoppers can easily find their way around the store, find the products and find out related information, such as the ingredients/ composition and price, and then purchase the items. However, for people with visual impairment, it is very difficult to carry out these processes independently. For this purpose, projects and applications have been developed that will enable independent shopping, recognition of objects and identification of colors, some of which are investigated as following:

2.3.1. BlindShopping

BlindShopping is a smartphone application using entirely off-the-shelf technology, developed as a research project to assist shopping. The application processes the RFID data received via Bluetooth, products are recognized by pointing a QR code reader, and results are transmitted as the verbal navigation commands. The working principle of the system is mainly based on classification of products and environmental elements in the supermarket organization. Thus, with minimal environmental adjustments to navigate the store, search and select products, all products are grouped into different product categories, subdivided into product types, and again into concrete brand products. The supermarket is divided into cells of shelves and passageway cells. Thus, BlindShopping provides product category navigation, product search, product identification, and product selection (Lopez-de-Ipiña, 2011).

2.3.2. Trinetra

Trinetra system as another research project was developed at Carnegie Mellon University (2006), and consists of a Nokia mobile phone, a Bluetooth headset, a Baracoda IDBlue Pen, a Baracoda Pencil, and a Windows-based server. While the system is similar to BlindShopping, Trinetra differs in that it has a headset as a wearable technology item. The system enables people with visual impairments to shop independently. It uses both barcodes and RFID tags; for scanning barcodes, The Baracoda Pencil is used, and for RFID tags, the Baracoda IDBlue Pen. The user scans the product’s barcode with a Baracoda Pencil, providing description of the product. Following this, the data are transferred wirelessly to the mobile phone *via* Bluetooth. The system on the phone first checks its mobile application’s memory for previous scans of the barcode. If the barcode is already in the memory, the information is returned to the phone, if not, a request is sent to the remote server. The server communicates with a generic UPC database to get the necessary information (Lanigan et al., 2006).

2.3.3. Shop Talk

Shop Talk developed by researchers at Utah State University (2009), is a wearable system for people with visual impairments to independently shop in the supermarket environment, which is comprised of a portable computational unit, a numeric keypad, a wireless barcode scanner, base station, headphones, a USB hub, and a backpack to carry them (Figure 6) (Nicholson et al., 2009). The system assists those shoppers in supermarket navigation, product search, and selection.

Shop Talk represents the supermarket environment using data structures as a topological map of movement area, the supermarket inventory management system, and Barcode Connectivity Matrix (BCM). While topological map providing to achieve to the directional labels of "left", "right" and "forward" according to the supermarket floor plan, the supermarket inventory management system creates verbal descriptions of product information. Besides these data structures, the Barcode Connectivity Matrix (BCM) and Universal Product Code (UPC) barcode serve to provide information regarding aisle, aisle side, section, shelf, position, and product description (Jethani, 2012).

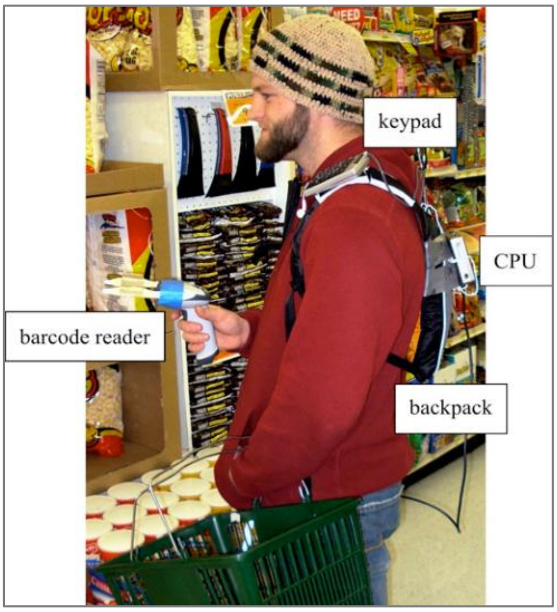

Figure 6. Shop Talk (https://benthamopen.com/contents/pdf/TOREHJ/TOREHJ-2-11.pdf)

2.3.4. Assistive Clothing Pattern Recognition System

Assistive Clothing Pattern Recognition System is a research project output composed of a camera, microphone, computer, and Bluetooth earpiece. This camera-based prototype system can recognize clothing patterns in four categories (plaid, striped, out of patternless, and irregular) and identify 11 colors (Figure 7).

In order to capture clothing images, camera mounted upon a sunglass is used, and to recognize patterns researchers proposed Radon Signature descriptor, which creates 2 or 3 dimensional images by projecting an object from every angle. The system can be controlled by speech input through microphone, and audio description of clothing patterns and colors arrive via Bluetooth earpiece (Yang et al., 2014).

Figure 7. Assistive Clothing Pattern Recognition System (https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6739993)

2.3.5. LCW Sense

LCW Sense is one of the commercial examples, as an application for specifically designed for people with visual impairment by LCW clothing company's RD department, and can be free-downloaded from Appstore or Google PlayStore to mobile phones. The application promises users the freedom to shop alone and provides product information such as color, pattern, fabric type, washing instructions, price, and information about the care label. It distinguishes clothes by scanning the product barcode. If the user likes the product, it can add it to 'my favorites list, and if purchased, to "my wardrobe" list (LCW, 2017). The application was tested by the authors and, and worked partially; product was indentified from the barcode, but after the this step the exact product information was not found. LCW is a clothing popular brand in Turkey, targeting a wide range of customers. This application, therefore, carries an importance indicating that mobile phone apps are becoming more widespread for a variety of purposes, including social responsibility projects.

2.3.6. Give Vision

The Give Vision is a commercial application with a blind-friendly user interface, which was designed by two developers with visually impairment to provide feedback on the environment around the user, via hands-free control of a smartphone. The application aims to assist users during traveling, shopping, reading text, and recognizing places and objects by using image recognition features and algorithms (Munche, 2015).

It can also be integrated with other smartphone applications for messaging and calls. The other innovative solution of the Give Vision Company is SightPlus hands-free and portable wearable headset (Figure 8), that enables users to magnify nearby or farther objects, and change the contrast or apply custom filters. Although the device has a wide area of usage, it is only suitable for stationary activities such as reading, watching TV, recognizing people's faces, sports events, playing music etc., and not for mobility or driving (SightPlus, 2018).

Figure 8. Give Vision, SightPlus Headset (https://www.givevision.net/)

2.3.7. OrCam MyEye 2.0

OrCam MyEye 2.0 is a commercial device consists of smart camera and earpiece attached to the user's eyeglass frame (Figure 9). Working principle of device is through capturing the text or any visual information, and then reading or identifying as directed by the user (OrCam, 2017).

Figure 9. OrCam MyEye (https://www.orcam.com/en/myeye2/)

The device provides real-time identification of previously stored faces in its memory (up to 100 faces), and announces the information in the user's own voice. In addition, OrCam enables the user to shop independently as the device has a database of product barcodes and stores, and it also has color detection features that allows the user to identify product colors (OrCam, 2017).

2.3.8. The TapTapSee

The TapTapSee is a mobile camera application designed specifically to allow iOS users with visual impairment to take a picture of any object by double-taping the screen and to get a description of it in real-time. The application uses VoiceOver to audibly identify the visual information about object. In addition, the application can repeat the previous image's identification, upload images from the camera roll, and share identification via social media, text or e-mail (The TapTapSee, 2017).

3. Survey Results

After reviewing the AT literature in general terms, it was observed that the examples are more related with navigation and text/object identification functions. Even though there are some wearable technology items in the market, the overview reveals that most commercial approaches include mobile phone applications for mobility and communication, while there is limited research and examples of AT in the clothing field. The review addresses a lack of applications, specially in clothing related fields, which defined the focus of our subsequent survey. The survey was designed in order to acquire feedback from people with visual impairment, focusing on clothing related issues, which would lead to design improvements.

The survey consisted of 10 questions including 3 closed-ended and 7 open-ended questions. Comments from 9 participants (5 with total blindness, 1 very low sight, and 3 low) were evaluated and discussed in this section. Even though questionnaire reached many people (i.e. via e-mail to various related associations via surveymonkey.com), and no personal identifiers were sought, few were willing to participate, therefore, evaluations were based on this limited number. The survey consists of 10 questions as follows;

Q1 Which of the following is your age range?
(a-15-24; b- 25-34; c- 35-44; d- 45 and above)
Q2 What is your educational level and occupational status?
Q3 Which of the following is your visual impairment level? (a-Low; b-Very Low; c-Nearly Blind; d-Blind)
Q4 Are design and aesthetic values in clothing important to you? (a-Yes; b-No and comments)

Q5 What are the factors that are important to you in the selection of clothes?
Q6 In your daily life, what obstacles do you face in terms of clothing? (During shopping, during use, etc.)
Q7 Are there any methods you resort to in order to overcome these obstacles? If so, what are these methods?
Q8 Do you have information about the assistive technologies that are designed or produced for individuals with visual impairment or blindness? Do you follow these innovations?
Q9 Are there any assistive technologies (software, application, device, etc.) that you are currently using? If so, what are these?
Q10 Would you like to use an assistive technology product in the clothing field? If you answered yes, what kind of assistive technology would you need, and for what purpose?

The survey results indicated that all participants were able to independently manage their lives, carry out their professions and participate in social activities. However, they highlighted the main obstacles in daily life were caused by the social perception of "having a disability". Most problems they face are not due to the lack of sight, but social misperceptions and inadequate physical conditions, inaccessibility to open and close spaces, and the inadequate implementation of suitable designs. One participant claimed that even though creating spaces for disabilities is shown as a positive discrimination, it might lead to discrimination in other areas of life. Thus, he suggested that it would be more appropriate to create inclusive common spaces for all of society. Even though this is not within the scope of this research, this has been noted as one major complaint from the participants, where design can contribute to resolve such issues/problems. Similar complaints were outlined by other participants, such as the need to share public spaces equally, however, these were outside the scope of this project, therefore, were not included here in detail.

The first three questions of the survey consisted of information about the demographics and visual impairment level of the participants. According to the result of the first question, one participant is between the age of 15 and 24; two of them 25-34; four of them 35-44 and two of them are in the "45 and above" age category. The question regarding educational level and occupational status was answered by eight of nine participants, revealing that one graduated from primary school, seven are either studying at university (2) or have graduated with a bachelor degree (5). The occupations range from housewive to executive (one housewife, one teacher, one executive, one freelancer, 2 civil servants, one lawyer, and one consultant). According to the total data of visual impairment level from all participants , the results include 3 low sighted, 1 very low sighted and 5 totally blind individuals.

Following questions aimed to evaluate participants' relationship with design and clothing, and to gain insight about the obstacles in this field as well as receving their comments on ATs. All survey participants agreed that the design and aesthetic values in clothing are important. Participants frequently stated that being visually impaired does not prevent them from taking part in social life, and that their priority in social settings is "appearance". For this reason, one of them also noted that even if individuals with a visual impairment cannot see themselves, clothing must be appropriate for places and occasions for a good first impression and ensuring proper communication. When participants were asked about selecting clothing, they mentioned a variety of factors. In addition to garment related factors, such as quality, fiber content, price, fit, comfort and colour, another factor mentioned by participants was a supportive shopping assistant.

In addition, one participant commented that for her selection important factors were, first, the color harmony, and followed by fabric texture, ornaments or decorations, which she sensed with her hands. She added that, as a personal opinion, for those who do not see, a visual image on the fabric alone does not mean anything without a pattern to detect and sense with hand. Besides, another participant remarked that, because she/he has a remembrance of colour, and a sensitive touch, matching colours and matching materials by touching are two important factors in garment selection.

When considering obstacles faced by the participants in terms of clothing (during shopping, home use, etc.), one participant noted that for people with visual impairment, "clothing" is not just clothing one's body, but is a rather long process starting with going to a store, choosing a product, combining, purchasing, and even continuing with caring/ washing the product according to the instructions given. Relatedly, one participant mentioned struggling with the washing process. The other answers are commonly about the problems in selection of colors, reaching the garment's fabric, design and price information. The same participant also argued that people whose blindness is not congenital can ask their family members, friends or sales person about the clothing/ product information, and can interpret this advice according to their own visual memories; however, people with congenital blindness have to rely on others' tastes and suggestions. On the other hand, one participant commented it was not always possible to trust sales people, because sales-oriented person can mislead, or their design taste can be very different, adding "I don't know if a garment looks good on me. In daily life it is very difficult for me to adjust the color matching of my clothes by myself without anyone seeing." Another participant had a similar problem, in that when she/he goes shopping with a relative or friend, the most difficult and distressing occurance is when they showed her/him the style that they themselves prefered. Thus she/he experiences the most trouble in finding a garment in her/his own style, or what she/he likes. The other person will often give various reasons for not liking it. The participant continued that just as sighted people can decide their own clothing by themselves according to their own style, people with visual impairments but who have not congenital vision loss should also be able to select their own style, or a service should be provided by a Professional (e.g. professional stylist, fashion designer etc.) in general.

Following on from the 6th question, in the 7th, participants were asked if they have any methods to overcome obstacles. Regarding this, one participant referred to LCW Sense application (given in Section 2.3.5), even though he had never tried it himself. On one hand, participants noted that some just ask for the salesperson's opinion or ask friends/relatives for the help, especially for color combinations, while one participant tried to read garment information on the smartphone zoom application. In addition, one participant prefers to go shopping with relatives familiar with her/his taste, and who are unbiased. On the other hand, one of the participants approached to the question in terms of the domestic use, i.e., she/he sorts clothes by colours - blue at the top and green at the bottom, but she/he doesn't find this method very effective because of the risk of confusion, which undermines self-confidence.

Following the examination of participants' relationship with clothing, the last three questions were asked in order to examine their approaches to the ATs. One of the participants stated that she/he has no idea about ATs designed or produced for individuals with visual impairment or blindness, while another reported knowing a few examples but was not well informed on these technologies. However most of the participants have knowledge about assistive technologies, follow the innovations and actively use them, especially the applications. Some participants commented as "I'm very interested in technology. I follow the innovations closely, of course there are new works for us. We are also pleased with them and we are expecting from the experts working on this subject, more productive, improving innovations for us.", "Yes, I use technology. I like to use technology at every point which makes my job easier." Considering the comments of the participants, a more widespread information and outreach system should be established on assistive technologies and their uses. For active and technology conscious users, the designs of ATs should be updated with innovative approaches and a design-technology integrated understanding should be adopted in the production process of ATs.

In addition, most of the participants stated that they use smartphone including text reader and/or navigation applications. One participant gave as examples the TapTap See application that she/he used to reach information, such as reading books or newspaper columnists, watching films in the cinema, etc. However, only two participants mentioned any AT for clothing. These two participants indicated that they used only applications for identifying colors, and these were not always accurate, and do not work with nuances (Q9). Relatively, in the last question (Q10), it was asked whether they would like to use an assistive technology product in the clothing field, and what kind of assistive technology they would need. 8 participants answered "yes", and they would most like to use an AT giving color, pattern, design and price information of a garment. Also, one participant would like to use an AT offering an easy-to-use identification for clothing items.

4. Discussion of Results and Contribution of Design

As seen with the survey outcomes and the review of AT examples, many AT examples exist for mobility, reading, and for getting the product information via barcode reading. An increasing number of mobile applications is one of the directions in terms of such ATs, but not all of the applications are convenient to be installed in both iOS and Android. Besides, the operating speed of the application, the image quality (for image processing-based apps) and the accuracy of the information transmitted to the user may depend on the performance of the user's mobile devices. Installing different apps for different purposes can slow down the mobile devices' performance after a while. These can be mentioned as the negative sides of the applications.

Another aspect in ATs are the systems described as wearable technologies. It is believed that ATs in the form of wearable technologies are so roughly designed that they lack aesthetic and functionality. The main problem is the failure to fully integrate electronic and technical materials into clothing and textiles. The technical materials' weight and size are also two important factors that affect the mobility, comfort and aesthetic appearance of wearable technologies. Regarding these problems, contribution of design and innovations in textile and material field come into the prominence. Thus, these innovations may allow scaling -down in size of technical materials, even to nano size, reducing their weight, and give them flexibility. For instance, the use of a flexible battery or 3D printed tactile sensors allows the production of a more aesthetically pleasing and lighter BrailleGlove prototype as seen in Figure 4. The interfaces of these wearables and the applications should be designed as user-friendly, uncomplicated, and should feedback the data correctly.

On the other hand, in terms of clothing, there are very few examples (i.e. mostly as just color identifier), and when the input from participants in the survey are evaluated, it is seen that selecting proper clothing might be an issue for people with visual impairment.

Investigating users' necessities, demands, abilities and restrictions will add value for such research and applications. Therefore, design products should focus on this problem without discrimination. Relatedly, when designing an assistive technology in the field of clothing, it is necessary to address this area as a whole, from shopping to domestic/ in-house use. Considering the participants' comments , the most troublesome issues are that they cannot perceive garments' colors or create suitable color combinations during shopping, and have difficulty washing the garments. In addition, they demand easy access to the price, fabric content and care instructions information. Here, technology integrated design solutions can contribute. One design solution could be labels including garment information and care instructions printed in Braille, which can be standardized across brands. The important point is that they should be produced in the size and with the material which do not discomfort the user. Secondly, Barcode or QR code reader apps designed with user-friendly interfaces should become widespread in the clothing field. This can be implemented by individual brands such as LCW Sense example (i.e. section 2.3.5), or a group of companies (e.g. Inditex, H&M etc.) can design an app that include a common barcode/ QR code pool for their brands. In addition to the apps, wearable technology is an up-and-coming area. Therefore, the technologies used in ATs for the other fields can be adapted to the wearable technologies for clothing field. For instance, an AT in the form of wearable technology can be designed using micro/ nano materials, and including image processing and recognizing features (i.e. features can be adapted from 2.3.7. OrCam MyEye example).

The important point is that for both app and wearable technology directions, designers should focus on comprehensiveness. In both directions, the ATs designed should be able to apply the steps of color and pattern recognition, price and fabric content information to the people with visual impairments, and should be able to offer garment combinations ideas in the shopping process. Relatedly,relying on others for selection of clothes was noted as a common problem in the survey results. Combination suggestions prepared by experts, such as stylists or fashion designers, can be stored in a data pool, and integrated into the wearable systems, or designed as an online service app serving as a supportive sales assistant. Intelligent fashion styling and recommendation systems could offer solutions for users with visual impairment, where artificial intelligence can learn the taste of the user and provide style recommendations accordingly as a shopping assistant (Vuruşkan et al., 2015)

5. Conclusion

In this paper, assistive technology examples for people with visual impairments were reviewed according to their usage area, and a short survey was conducted. Some of the examples in the review were commercial, while the others were conducted as research projects. Thus, there was an examination of firstly, AT for mobility, and then respectively, AT for communication, and for daily activities. In terms of mobility, the selected projects and applications offered solutions for safely navigation in indoor and outdoor environments. Communication was not only regarded as being among individuals, but also as communication with devices, and for accessing information. Following this, AT examples for daily activities were examined, according to their functions, for shopping, clothing and interaction with objects.

In conclusion, considering social perspective, in order to improve the physical environment and facilitate daily activities, designers need information and tools that could improve the design and production processes, from design concept to final product or service. In addition, through constantly improving technologies in terms of devices, applications or production system, it is possible to reveal positive outcomes from the perspective of assistive technologies for people with visual impairments, ranging from moderate level to total blindness. Thus, those applications or devices allow people to live independently and enhance their overall quality of life. In terms of the design perspective, a crucial point in assistive technology design is the need to effectively analyze the needs of individual users. The user's ability, restrictions and needs, context of use, the technology itself and its features are important parameters for investigation and development.

Further work will focus on more ATs as a form of wearable technologies for people with visual impairments, and in the clothing field. In this direction, in order to develop a wearable technology design, firstly context of use will be determined according to the survey analysis and literature on the obstacles in the clothing field. Following this, a wearable technology item will be designed considering full-integration of system to the surfaces, and maximum user-friendliness.

Conflict of Interest

No conflict of interest was declared by the authors.

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