Toward designing efficient application to identify objects for visually impaired

Lamya Albraheem, Hessah AlMotiry, Hind Abahussain, Lama AlHammad, Masheal Alshehri, Reem AlDosari, Sara AlKathiri.
Information Technology Department, College of Computer and Information Sciences
King Saud University
Riyadh, Saudi Arabia
lalbraheem@KSU.EDU.SA

***Abstract*—There is an increasing interest in developing technologies that attempt to help visually impaired people in their daily lives. However, it is shown that the object identification task is still the major difficulty for visually impaired people. Although there are many applications that can be used for this task, there are still obvious limitations that require more improving. For this reason, this paper provides an analysis and evaluation for the technologies that used in the object identification task. As a result of this evaluation, it is shown that the best technology is the human computation. Moreover, a comparison between the applications that use human computation is provided in order to identify the best features that can be considered in designing efficient application to identify objects for visually impaired.**

Keywords— human computation ; blind; identification; visally impaired

I. INTRODUCTION

Nowadays, with the rapid development in the field of mobile technology, different IT-based assistive technologies have been developed in order to provide a better quality of life for people who have special needs such as visual impairment. These technologies have contributed mainly to helping blind people to interact efficiently with social activities and increasing their ability for having independent lives. This is can be seen through different applications that used for path guiding, obstacles detection, searching and identifying objects [1].

There are a lot of challenges that face visually impaired people in performing their daily tasks especially accessing information about surrounding objects. For this reasons, there is an increasing interest in developing effective solutions that can help them in recognizing any objects. These solutions were designed using different technologies such as image processing, which includes optical character recognition (OCR), color identifiers, brightness identifiers and objects recognitions algorithms. Furthermore, barcode, RFID (radio-frequency identification devices), tactile signs and Braille have been used for wide range of applications. However, there are still some limitations of these techniques which present the need for designing a solution that attempt to address these issues [2] [3] [4]. For example, image recognition algorithms can fail in recognizing an object's image if it's not exist in the database or if there is any different in the orientation. The limitation for using barcode and RFID readers is that objects have to be attached with special tags otherwise the objects cannot be identified [4]. This show that the automated software are not accurate for identifying objects for visually impaired people and usually work with different restrictions [5].

According to the mentioned problems, this paper provides a survey for the assistive technologies that can be used to help blind people in identifying objects. It presents their advantages and disadvantages and makes an evaluation in order to find out the best assistive technology that can be used for designing an efficient identification application. Furthermore, it makes a comparison between the mobile applications that use human-powered technology to find out which are the limitations that require more improving and research. This can be a starting point for research that investigates the development of efficient assistive application that can help visually impaired people in identifying surrounding objects.

This paper will be organized as follows: Section 2 present taxonomy of different technologies that used to identify objects for visually impaired people. Section 3 provides a comparison and evaluation of object identification technologies, while section 4 provides a comparison between mobile applications that use human-powered technology for object identification. Finally, section 5 contains the discussion and findings while section 6 present the conclusion and future works that suggested from this research.

II. OBJECT IDENTIFICATION TASK FOR BLIND PEOPLE

Object identification is an essential and important task in our daily lives; as well, it is play as an initial state for completing any sophisticated tasks. Even though blind people are able to identify objects by tactual features but there are some differences between objects in optical appearance, for example, two objects with the same size and tactual features but with different labels. Although visual impaired people can ask for help from any sighted persons to differentiate between objects, this is can affect blind people independency [6]. In addition, it is shown by previous study that the most common visual challenges for blind people is the need of help to identify an object [2].

There are many assistive technologies that can be used to help blind people in identifying objects. These technologies can be classified into two classes (as shown in Fig.1) : the first class is automatic services which include image processing, Barcode and RFID (Radio Frequency Identification Devices)

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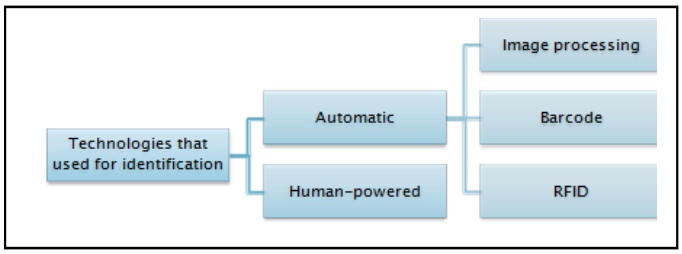
while the second class is based on human-powered services. In this section, different research and applications that conducted and developed to identify objects for visually impaired people will be presented.

Figure 1 : Classification of technologies that used for object idenitification



A. *Automatic services*

1) Image processing Module: In 2013, Matusiak, et al. developed an object recognition tool for android smartphones. This tool has three image processing modules: a color detection module, a light detector module and an image recognition module. The color detection algorithm works based on the basic RGB color images of pixels. It converts these components to evaluate the average value of the color and compare it with a predefined class of colors. This module is suitable for the smallest resolution possible of the photos taken with an automatic flash. There are two different approaches, HIS color space (Hue Saturation Intensity) and special color histogram. The color detection application running on Sony Xperia S. and the detected color will be read using text to speech technology [4].

The light Detector module: this application operates in real time and is based on the content of the camera's preview image. It is performed in two steps: Calculating the average brightness of the image central part and generating an audio signal.The image brightness is directly proportional with the frequency which means the brighter the image the higher is the frequency of the generated sound. Robust localization of light sources such as streetlights or a lamp in the room is the most proper usage of this module [4].

Image recognition module is a composite task that includes many steps such as key points detection, calculation the description, and comparing the resulted description with other image description in the database to recognize the object [4].

Currently there are various applications for image analysis in mobile devices available on the market. One example is a real time iOS recognition system dedicated to visually impaired or blind users developed by LookTel. It scans the object taken by the camera and recognizes it based on a pool of images that is previously stored by user in a local database. LookTel Recognizer App will make the object recognition come in handy for visually impaired. This powerful object recognition technology is also featured with a barcode scanner that extends the diversity of identifying object methodology. Moreover, the user is able to backup and export their created database so they can restore it whenever they need. Although this application is dedicated to the people with severe visual impairments or blindness, it still requires a sighted person assistance to capture the object while considering the orientation for creating the initial image library before the application can be used [4].

Furthermore, another application that designed for visually impaired people which called the EyeRing. It is a finger-worn device that connects with an android phone which responsible about speech processing algorithms and all computer vision algorithms. The current functionalities implemented in the device are detection of banknotes, recognition of colors and distance calculation. However, this solution is expensive and requires an external hardware device to be worn by the blind person [4].

Another real-time identifying object iPhone application that enables visual impairments to scan object quickly and accurately by using only their mobile camera is Scan Search. This application scan the object that a blind user wants to identify using the camera, then it generate very good quality frames from it and send them to the IQ Engines' web service. As defined by Zhong et al , IQ Engines is a cloud-based visual search engine with a large public dataset containing million images. Instead of fully processing each frame, Scan Search can intelligently determines only specific frames.
Based on the study of Zhong et al, there are several features of Scan Search:

- Scan Search does not have a photo taken button.
- Scan Search does not need the user to figure out right position to take high- resolution image. So it can save time for the blind user.
- Scan Search allows blind user to identify a food product with a success rate of 91.7% as opposed to a photo-snapping interface with a success rate of only 62.5% with the same image recognition mechanism.
- Scan Search application is efficient on computational and networking resources on the iPhone.

The required bandwidth was below 50 KB/s. Therefore it can be deployed on a large range of smart phones as long as they have a camera with reasonable resolution [6].
In addition, there are some other systems which use image processing technique to identify what an impairment/blind user needs to recognize. Reading-assistive system can help the visually impaired to read texts and labels. Some examples are pen scanners and camera-based assistive text reading framework. Such systems use special algorithms to isolate the object from cluttered backgrounds and extract the moving object region. An efficient and effective motion based method is ROI (region of interest), it automatically localize the region of interest. Then it integrate a OCR (Optical Character Recognition systems) software that scan and recognize the text [7].

2) BarCode:

Barcode is a simple data carrier which is most widely used in marketplace. Is printed on items in clear manner and used for many different reasons, but the most prevalent reason is to

make the process of de termination the object easier. Barcode was used for assisting visually-impaired persons to obtain verbal information from product. The person can scan the barcode of the item by scanner unit, then listening to its information's through speech synthesis [8].

There are various systems have been developed to identify products like Trinetra, is a system aims to develop assistive technologies for the visually impaired people to make them more independent in grocery shopping. The system is built and designed by using different hardware, such as Nokia's 6620 smart-phone, Bluetooth wireless headset, Baracoda's IDBlue RFID-scanning pen, Baracoda's barcode-scanning BaracodaPencil and RFID tags. This system on the cell phone has an input and output, the input is created by scanning the barcode or by user keypad-events, and the output is a voice message that received by the user to describe the name and type of the item, or maybe to tell the user that an item does not exist in the database. This message will be generated by the TALKS text-to-speech software in the form of synthesized speech. The user have then to close the application or continues scanning more items [9].

ShopTalk, is also another system that designed for blind shoppers to find and identify specific item. It contains a set of headphones (for pronunciation route instructions), a barcode scanner, a numeric keypad, and a computational unit. This way depends on a barcode connectivity matrix, where product information (e.g., aisle, aisle side, shelf, section, position, description) is stored built-in from the store's inventory database [10]. The barcode scanner used by the shopper. It has simple change to take features of the shelves in supermarkets that have curl down and a small lip at the bottom. When the shopper want to scan the barcode have to attach plastic stabilizers to the front of the scanner that rest on the shelf lips. The stabilizers used for reducing the time that needed by the shopper to finish the task of scanning successfully. It achieved by making the process of scanning easier for the shopper to align the scanner with shelf barcodes [10].

3) RFID (Radio Frequency Identification devices):

RFID is wireless Radio Frequency Identification technology that can help people with different purposes. This technology can be used for identifying the objects and navigation in unknown environment. RFID system contains tag chip and reader device. The reader device use radio frequency to transfer data from tag chip, and the tag chip has information about its objects. This information stored in tag's memory in binary representation. The passive tag do not have any source of power, for that it required alternative way to get the power like a power that generated by reader device [3].

Varpe and Wankhade (2013) design a system for help blind people to navigate through undefined place and to identify objects. Usually blind people try to identify objects by tangible contact. However, RFID technology is used for the presented systems to help blind people in identifying objects in addition to the navigation. In this system, the RFID electronic tags are placed under specific objects and the database is installed in remote computer which maintains information of electronic tags. The RFID reader that embedded in the user cane will generate radio Frequency for transfer data from tag chip, and the chip will send back unique tag's id, and this tag's id is transferred and processed in remote computer by taking the related info based on the tag's identity code. The blind people have wireless headset and it is connected with the computer and RFID reader. Therefore, the computer will provides the information in a voice representation to the blind person [3].

In 2013, Mathankumar and Sugandhi designed a shopping facilitator for visually impaired people. They used RFID technology and PIC microcontroller in the supermarkets. The system using two Tarang-F4 versions of zigbee transceiver modules, which is protocol for communication on wireless networks used to transfer the information between devices. One of zigbee modules is to interface with microcontroller and the other one connected with PC for transfer data. The goods are organized in shelves with passive RFID tags which have unique waves of radio frequency that's generated by RFID reader and the RFID reader reads and sends unique code to microcontroller. For each unique code there is unique audio file recorded to identify goods by using APR9600 IC, which is interfaced with the microcontroller. The microcontroller receives the unique goods identification code and matched the code with related audio file. Then the matched audio file will be played. When the blind person purchases goods, they have to push the switch in the module. Then the goods information is sent to system through zigbee [11].

In 2011, Kornsingha and Punyathep developed a system for reading medicine labels for visually impaired people. This system is implemented using the RFID technology and microcontroller. The architecture is used in this system is "A Pipe and Filter Model". First step to build this system is recording descriptions of the medicine by voice recording software, and then storing this information into an SD memory card. After that the SD Memory Card is connected to the microcontroller MCU. Then the microcontroller MCU will be ready for processing the data. When RFID reader read tag label then the information of tag label transfer it to microcontroller MCU, then it will processed the received data and choose the suitable encoded data from SD Memory Card, then transferring the suitable encoded data to the MP3 Decoder, which converts the data into voices by the speaker [12].

B. Human Powerd Services

The human-powered technology, which also called human computation, can be defined as "a new research area that studies the process of channeling the vast internet population to perform tasks or provide data towards solving difficult problems that no known efficient computer algorithms can yet solve." [Chandrasekar et al. as cited in 13]. This technology has been used to solve different problems that need human skills such as language understanding and visual recognition. Therefore, there is a recent interest in using human-powered technology to provide assistance for people with different disability to solve many real accessibility problems. This is actually called a Human-Powered access technology [14].

There are many principles that should be considered in designing any system that use Human-Powered access technology. These principles will be presented below [14] :

- **Initiative:** This is mean who will provide the assistance: end user, workers or organizations.
- **Source of Human Workers:** There are different source of workers, they could be experts, friends, crowd workers who are recruited to perform different tasks, volunteers, and organized volunteers who are belonging to an organization.
- **Motivation**: The people usually have different reasons to provide help:
  Intrinsic: some people want to use their time in something useful without anything in return.
  Status: some people motivated by announce about their help to public and giving awards.
  Financial: some people motivated by money.
  Enjoyment: the system can make providing help to other enjoyable. For example, using games to perform a task.
- **Financing:** Financial support can be obtained according to the source of human workers. It could be public fund or private by the user personally or through his or her workplace, or it can be free.
- **Worker Competence:** Different people have different skills and qualifications even if they work in the same place. The type of workers actually depends on the provided services. Different services need to be provided by experts. On the other hand, some services need the amateurs who take their work as a hobby and they don't take money for it. Moreover, some work doesn't need qualifications and can be done by non-expert.
- **Latency:** Some people have patience and could accept the delay of human assistance even if they have to wait, others can't and they need help immediately. The expected latencies can be interactive, short delay and undetermined. For example, some services should be given right away like real time language interpreting; other may be delayed for unlimited time like reading your mail by volunteer.
- **Reliability:** Getting assistant from human could be difficult sometimes, because they aren't available or unable to use Internet. Some human assistance can be always available, while other assistance can be assumed available by hiring workers to services. Also, there are some services that have undetermined reliability where the people may participate in providing services and maybe not.

After reviewing the applications and research that used human-powered services as assistive tool in identification task, we found the following applications: MySmartEye, LendanEye and Vizwiz. The features of these applications will be presented and.

MySmartEye application is available for iOS and Android platform. It is designed to associate visually impaired people with the answers to their needs using the human-source mechanism. It will help both users blind and volunteers, in which the volunteer can contribute anytime and anywhere conveniently, and the visually handicapped will get the volunteer's contributions in just seconds. By using the accessibility features in smartphones, it will make capturing photos for visually impaired easy. Then, this picture will be shared among micro-volunteers waiting for their answers. Once a volunteer replies, it will be then converted to speech for the visually impaired individual [15].

LendAnEye is a mobile application that works as a guide to help visually impaired people in their daily live. This software is actually two separate Android application versions; one is intended to the volunteers *LendAnEye (Volunteer)*, and the other one is *LendAnEye (Visually Impaired*) which is for the blind users. The blind users have to double tap the phone to contact a volunteer to guide him via a live video call wherever he is [16].

VizWiz is a smart phone application designed for both iOS and Android visually impaired users. This application allow the blind users to capture picture of any surrounding object and send it tagged with an audio question asking about what they want to know about the taken photo. The answers are received quickly then read by using the smartphone screen-reading software. VizWiz offers the blind user different options to get the answer. First option is crowd-sourcing mechanism using IQ Engines or collecting the answers from workers on the Amazon Mechanical Turk. However, based on the users' comments, the workers option is not available currently. The other option is friend-sourcing including Twitter, Facebook and Email. It also can be a combination of the two mechanisms [17, 18].

III. COMPARSION AND EVALUATION OF OBJECT IDENTIFICATION TECHNOLOGIES

In tabular format, we give a summary for the Advantages and Disadvantages of the technologies that can be used for identification task (see Table I in APPENDIX). Moreover, we make an evaluation between them according to different criteria such as: Cost, Accuracy, Response time, Performance, Scope and Easy to use (see Table II in APPENDIX).

IV. COMPARISON BETWEEN MOBILE APPLICATIONS THAT USE HUMAN-POWERED TECHNOLOGY

As a result of the evaluation, it is shown that the best technology that can be used for the identification task for the visually impaired is the human-powered technology. Therefore, in this section, a comparison between the mobile applications that use this technologies and our suggested application will be presented (See Table III in APPENDIX).

V. DISCUSSION AND FINDINGS

Based on our evaluation for the object identification technologies (as shown in Table I and II it is obvious that helping visually impaired people using the human-powered technology or human computation is superior to all the other technique. This is due that the human powered technique solved some of the other technique weak points. Human-powered technology provides higher/high performance and

effectiveness to identify any surrounding objects/objects around without any restrictions as in other technologies .For instance, human-powered services are not so much affected by quality and light conditions. Moreover, this technique does not need a reader or special tags. For these reasons, we constructed a comparison between mobile applications which used to identify objects through human powered technology to prevent falling in the same mistakes that others made and develop a more efficient assistive application that can contribute identifying objects around the visually impaired.

According to our comparison (as shown in Table III), we are planning to develop an iOS mobile application,"BeMyEye", that have different features assisting the visually impaired individuals. BeMyEy will enable the blind users to add pictures or videos tagged along with an audio question. Our mobile application will be different from all other applications that it will be dedicated the Arabic users. The motivation for the volunteers is their feelings to achieve something meaningful and helpful. Furthermore, by making the identification task as a "game", people are more likely to participate. BeMyEye system will be unlike LendAnEye and MySmartEye systems that it allow the visually impaired to ask the help not only from any random volunteer in the crowd source but also their family and friends, this will enhance the trustworthy, privacy and confidentiality in our application in addition to make the reply faster.

VI. CONCLUSION AND FUTURE WORKS

This paper provides many important contributions. It presents a survey of the assistive technologies that can be used by visually impaired people in identification task. Moreover, it presents a comparison and evaluation for these technologies in order to get the best one. According to the presented discussion, we conclude out that human-powered services technology would be the winner due to its convenience, effectiveness and high performance. For this reason, this paper makes a comparison between the mobile applications that use this technology to find out which are the limitations and issues that require more research and improving.

For future works, we are working to develop and implement a mobile application that helps blind people in identification task to any surrounding objects. This is will be achieved using human-powered technology in addition to accessibility features in smart phones. Furthermore, in order to design easy to use and accessible application, different usability and accessibility guidelines that focusing on visually impaired people should be considered.

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APPENDIX

TABLE I. ADVANTAGES AND DISADVANTAGES OF OBJECT IDENTIFICATION TECHNOLOGIES

	Advantages	**Disadvantages**
Image processing	Unlike RFID and Barcode, it does not require any special tags to recognize the object. Faster response time and better availability [6].	The performance can be affected with the quality of the built-in camera and the lighting conditions [4]. It may need predefined database of images to compare the taken photo with it. Complex (it is not easy to implement) . Limited in scope and error-prone [6]. low recognition rates [6]. The difficulty for blind people to take a high-quality photo that required for image processing. [6].
RFID	RFID is the simple and efficient technology which can be used for object detection and identification in many applications [11]. Easy to implement [11].	It requires attaching special tags to the objects. Consequently, they can be costly, since such systems need to be regularly maintained to keep them up to date [4]. Unlike Barcode, RFIDs are not yet commonly attached with objects. Therefore, this technology can identify only the objects that contain RFID tags so it cannot be used for any objects [9]. Removal of exposed tags: RFID tags can be removed easily because they are exposed for removal [19]. Reader collision: The signal from one reader can interfere with the signal from another where coverage overlaps. This is called reader collision [19]. Tag collision: when the readers read a lot of tags in the same field, there is a high possibility for tag collision. This is happen when more than one chip reflects back a signal at the same time which confuse the reader [19]
barcode	Bar codes are inexpensive and effective [14]. It does not required any hardware instrumentation of the store and leads to low installation and maintenance costs [14].	it is very hard for blind users to find the position of the bar code and to correctly point the bar code reader at the bar code [7]
Human powered	Characteristic of hardware or software will never be better the human brain. (Humans can provide services that are still too difficult to provide solely automatically). More flexible and economical than computer vision powered services (Automatic Approach) [6] . This technique is much easier and simple than automatic techniques because visually impaired won't need a reader to get the help they need. It's much better and detailed when a human describe things around to other human. Has lower requirement of image quality [6]. Can work with a wider range of objects [6]. Only need a mobile camera Simple	The availability oh humans help is undetermined unless we use a worker to do the job. The provided assistance may sometimes be not as useful as expected due to the helpers' misunderstanding of what they are asked to do. lower availability of online users [6]. it may take several runs for a blind user to take a photo with necessary information inside [6]. However, the user can capture a video which will be easier to include all necessary information. Not as fast as computer algorithms [6].

TABLE II. EVALUATION FOR THE OBJECT IDENTIFICATION TECHNOLOGIES

	APPLICATIONS			
	Image processing	**BARCODE**	**RFID**	**Human-powered**
Criteria				
Cost	**Implementation**	**Low cost.**	**Cost of Hardware (RFID readers and tags)**	**Economical**
	1	3	2	4
Accuracy (recognition rate)	Not accurate	Accuracy may be affected it the user cannot correctly scan the code.	Accurate	Accuracy may be affected if the image/ video not clear for users.
	1	3	4	3
Response time	Fast.	Fast.	Fast.	Depend on the online users
	4	4	4	Undetermined
Performance	Affected by image quality and light conditions.	Affected by the availability of the database that contains the products information.	Tags may be removed. Tags collision and reader collision.	Best performance
	1	3	2	4
Scope	Only the image that exist on the database /training set	It is exist in most products in supermarket and pharmacy but not all of objects	Not commonly used	Can be used for any objects
	1	3	1	4
Easy to use	Difficulty in taking high quality image	Difficulty in correctly point the bar code reader	Easy to use, but RDIF reader have to be with the user all the time.	Difficulty in Taking a photo with necessary information. However, to be easier he can use video.
	1	1	3	3
Total	**9 / 24 = 37%**	**17/24 = 70 %**	**16 / 24 = 66%**	**18 / 24 = 75%**
The point given in range from 1 (lowest) to 4 (highest) .				

TABLE III. COMPARISON BETWEEN HUMAN-POWERED TECHNOLOGY MOBILE APPLICATION

	APPLICATIONS			
	MySmartEye	**LendAnEye**	**VizWiz**	**BeMyEye**
DESIGN PRINCIPLES				
Platform	**Android +iOS**	**Android**	**iOS + Android**	**IOS**
add photo	✓	✓	✓	✓
add video	X	X	X	✓
record a voice question	X	X	✓	✓
Live-call	X	✓	X	✓
(Text comments) text-to-speech	✓	X	✓	✓
Voice comments	X	X	X	✓
Arabic Language	X	X	X	✓
Initiative (end User, Worker, Organization)	U	U	U , W	U
Source (Experts, Crowd, Friends, Volunteers, Organized Volunteers)	V	V	C , F	F , V
Motivation (Intrinsic, Status, Financial, Enjoyment)	I	I	I , F	I , E
Financing (Public, peRsonal/pRivate, Unpaid)	U	U	U	U
Worker Competence (Expert, Amateurs, Non-experts)	N	N	N	N
Latency (Interactive, Short delay, Undetermined)	U	U	S	S
Reliability (Always, aSsumed, Undetermined)	S	S	S	S