



The Review of Raspberry Pi Based - Systems to Assist the Disabled Persons

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ABSTRACT

As people, eyesight is one of the most significant and depended upon in acquainting ourselves with where we are and what is around us. Freedom in exploring our new environment has to do with our capacity to survey these new environments, distinguish impediments as well as distinguish between objects in these environments. This task as simple as it may seem is one of the many problems encountered by the blind in their daily lives. Which hinders their ability to freely move about and carry out their day-to-day activities. Many types of research have been carried out to develop systems to assist the blind and the deaf. Some of these researches were developed with microcomputers as their central component. This study seeks to investigate the literature for studies that utilized raspberry pi to develop systems to assist the blind and the deaf. It as well attempts to define future research perspectives on the subject by addressing the research questions stated in this study. The finding of this study would enlighten researchers to be guided for future researches, as well as enable them to see the flaws in the area of study in other to solve such problems.

Key words: visually impaired, Raspberry pi, Home automation, Smart devices, object detection

1. INTRODUCTION

As people, eyesight is one of the most significant and depended upon in acquainting ourselves with where we are and what is around us. Freedom in exploring our new environment has to do with our capacity to survey these new environments, distinguish impediments as well as distinguish between objects in these environments. This task as simple as it may seem is one of the many problems encountered by the blind in their daily lives. Which hinders their ability to freely move about and carry out their day-to-day activities [1]. Having eyes to acquire and relay sensory information to the brain is a critical feature of human physiology. Also, 83% of awareness of our surroundings is accessed through the eyes and therefore it is essential for human survival as was

reemphasized by [2]. Many people around the world are however incapable of vision. Although technology is currently growing at a fast pace, people living with these disabilities cannot benefit from these technologies. Blindness can be described as a disorder in which the person is unable to see or has no sense of light. In other words, it is a condition in which a person is forced to utilize his or her other senses for vision[3]. Thus, whether an individual suffers from a total or partial vision deficiency, such a person is deemed visually impaired.

Internationally, visual deficiency amounts to almost a billion of the entire global population. Most of these individuals either suffer from total or partial vision deficiency of which most are over the age of fifty years. Uncorrected refractive defects and cataracts are the primary sources of vision deficiency and blindness according to a 2020 report [4]. The majority of blind people are poor and have low incomes or in some cases no income at all. Most of them are found in Africa and Asia. According to new estimates, vision impairs are projected to rise to 115 million by 2050 [4].

The challenges the blind and deaf encounter daily in carrying out their activities has necessitated the inventions of systems to ease their burdens. With the improvement in technology in recent times, researchers have tried to develop systems to alleviate their challenges. Shiyam (2016) in their study developed a system that included an IoT module comprising of accelerometer sensors and raspberry pi. The sensors capture real-time data related to the hand gestures of the user. Raspberry pi is used as a computing module that transfers data to the cloud and is embedded with Python Script with functionality to produce the desired output. The output is expected to be an E-mail and voice output. The accelerometer sends the data to raspberry pi in support of the Wi-Fi module. The Python Script on raspberry pi has the `adxl` libraries to accommodate and understand the sensor's data. Raspberry pi 3 controllers are used for interface and image processing purposes. The Voice recognition module is used for converting audio to text with the help of models of neural networks that convert text into various sign gestures. In this way, complete communication takes place on both sides.

Sign Language, is the basic form of gesture for the deaf and dumb. By using sign language, they can convey their message. Bhagat-Thakre (2020) said the existing system has various disadvantages which are listed below. The researcher developed a Braille system and disclosed that harm can be induced to the surface. Such inductions could be caused by writing with a spot of indelible ink on the surface of the system, as well when a blind person injures the fingers, it would be difficult for such person to read from the system. The braille device is therefore more prone to problems and inhibits reading. The main defect in the Finger reader is that it can only process the English language and could not able make out for the deaf and dumb Sign language is frequently used, but it cannot be easily understandable by those who do not understand the language.

Raspberry pi 3B+ is a less expensive computer but with a sizeable amount of memory space with the size as small as a credit card. It utilizes USB and HDMI to connect to keyboards, mouse, and monitors to operate the input-output device of the device. It is easy to operate and program. One doesn't need a deep knowledge of it to use. Raspberry pi acts as a controller to control and monitor various operations like the processing of images and generating the appropriate words. Raspberry pi takes as input images of hand gestures or various signs from a camera and compare the input to a stored database and generate appropriate text [7].

In recent years, many new solutions have been designed for the elderly, the physically impaired, such as the blind and the deaf as well as patients living on their own to give them a sense of independence. Controlling unautomated devices may be a challenging situation popular among disabled persons [8]. An IoT or smart home is interconnected to devices and sensors which provide information on home activities and help users monitor these devices. These homes are fitted with cameras, actuators, and wireless networks to establish communication between the smart home and the devices [8]. A great way of achieving IoT is to utilize speech recognition to control and coordinate devices and sensors. Many developers in their studies have utilized microphones for connectivity in smart homes and while some others have added various already made products to submit speech commands to their systems for the same purpose [9], [10]. Jain, Nandakumar and Ross (2016) in their study, however, emphasized that developed systems that use speech recognitions have various challenge such as proximity, security as well as noise which ultimately affect the accuracy of these systems.

Despite developments in this area of studies, it was found that no systematic literature review carried out to assess and investigate the literature for studies that utilized raspberry pi to develop systems to assist the blind and the deaf. This has been a major gap for current developers to assess the advantages and disadvantages of the use of raspberry pi to

develop such systems for both the users and the developers. Furthermore, for researchers to know what has been done so far and the directions in which future research should be encouraged? Additionally, the study seeks to investigate the literature for studies that utilized raspberry pi to develop systems to assist the blind and the deaf. This study seeks to define future research perspectives on the subject by addressing the questions below.

RQ1 What are the advantages, disadvantages of using raspberry pi systems for disabled users?

Q2 What are the advantages, disadvantages of using raspberry pi systems for developers?

RQ3 What are the limitations of the current research on raspberry pi projects?

2. METHODOLOGY

PRISMA is one of the commonly used systematic literature review methods in most academic research. This method of literature review guides the researcher in acquiring knowledge especially in terms of previous research, makes the research gaps more visible, and guides the researcher on how to improve existing knowledge in the current area of research. A literature review has to be systematic and must follow a routine analysis for it to be exact or close to being exact [12]. This research is therefore consistent with the application of a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method [13], [14].

As a method of reviewing the literature, PRISMA helps researchers to make guided decisions with regards to the selection of their research questions, as well as the selection of their variables. PRISMA also helps the researchers in the selection of the right data that would help them to make guided research [15].

With the help of meta-analysis and the PRISMA method of collecting data, this research intends to acquire resources that would be beneficial in developing a system with the raspberry pi to aid visually impaired and deaf persons [15].

2.1 Data collection and search process

The study utilized two databases, which are Web of Science (WOS) and Scopus because both databases are rich with the information required by researchers. The knowledge from these databases covers scholarly articles that support one another in material, method, and strategies in most cases.

Table 1: Data collection and description

Data collection	Description
Database	Journals and articles were obtained from Web of Science (WOS) and Scopus
Search string	SCOPUS: TITLE-ABS-KEY ((raspberry AND pi) AND ("disabled" OR "deaf" OR "visually impaired" OR "physically disabled")) WOS: ALL FIELDS: (raspberry pi) AND TOPIC: (disabled OR deaf OR visually impaired OR physically disabled))
Publication dates	The research is restricted to articles and journals published between 2016 and 2020
Language of publications	The research is restricted to articles and journals published in English
Included criteria	<ul style="list-style-type: none"> The research was focused on Raspberry pi projects to assist the blind and deaf. The research was focused on studies published from 2016 to 2020. The research was focused on studies published only in peer-reviewed journals/Articles. Only English Language articles were considered. Articles with a special focus on raspberry pi projects to assist the blind and the deaf in titles and keywords were considered. Only articles were considered in this study.
Excluded criteria	<ul style="list-style-type: none"> Studies developed using systems other forms of microcomputer. Studies that are not published with full

	texts were excluded. <ul style="list-style-type: none"> Studies outside the period of 2016 to 2020. Studies that are not peer-reviewed journals.
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2.2 Alternative use of the keywords

The search for the study was conducted based on the following approach to answer the research questions in this manner. Alternative use of the keywords as shown in Table 1 were used to collect relevant studies on the research question. Concatenating those alternative words, the search strings were formulated and were used to search the various databases

Table 2: Alternative use of the keywords

Blind/deaf	Raspberry pi
Blind	Raspberry pi
visually impaired	
physically challenged	
deaf	

The string was however slightly modified when used on the individual online databases according to their interface requirements while keeping the logical order consistent for preliminary searches. Full-text journal articles will be examined to select those to be included in the study and the articles which will not meet the inclusion criteria were excluded.

2.3 Study selection criteria

When the findings have been reached, the filtering criteria are used to screen out the unrelated studies. Papers retrieved from SCOPUS and WOS were independently sorted for inclusion and excluding criteria, by the two researchers. Paper was considered only if two or all the experts approved its inclusion. 74 articles were obtained from the basic search totally. Out of that number, 13 were excluded due to duplication of these articles for the two databases. The use of raspberry pi to develop systems to assist the visually impaired and deaf was the focus of this study, therefore studies that were not exactly related to this focus were excluded upon reading the titles, abstracts, and keywords. Consequently, 17 of the articles were further excluded resulting in 44 articles for this study. After both researchers examined the suitability of the full texts separately, 20 articles that had access to the full text and fit the purpose were selected for in-depth analysis.

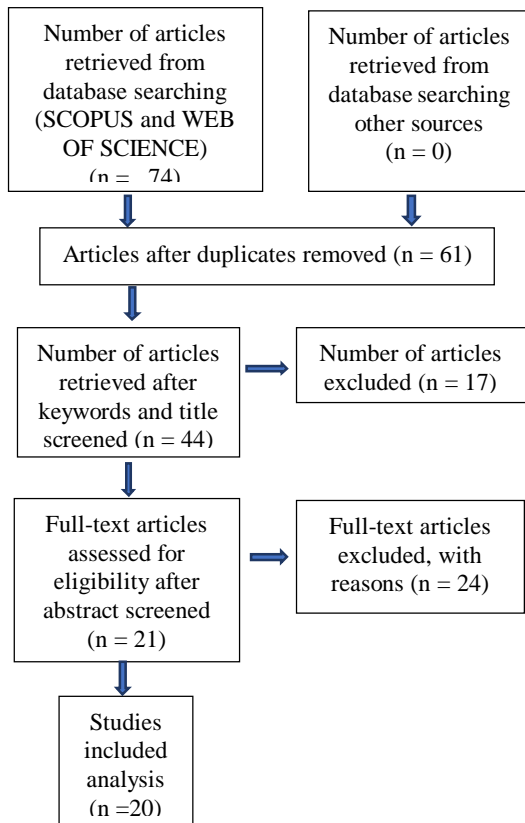


Figure 1: Figure 1. Flow diagram of the publication selection process

3. SOME COMMON MISTAKES

This paper reviews past literature to determine the advantages and disadvantages of raspberry pi to develop systems to assist disabled people for users and developers. The table below summarizes the studies from each of the 20 papers used in this research.

Table 3: Summary of Related Studies

Research	Research title	Aim of Study	Findings
Zubov (2018)	“A Smart City Assistive Infrastructure for the Blind and Visually Impaired People: A Thin Client Concept”	To use the smart city assistive structure obtainable for B &VI to aid interaction with additional subsystems through IoT procedures	The new improved Voila-Jones face sensor with other features such as eye and nose was recommended to aid in the image processing speed. This can only be applied with the use of HOG+EDC since the rate of detection is not 100%
Anandan, Manikandan & Karthick	“Advanced indoor and outdoor	The provision of assistance for the blind to	There is a good detection result with the use of

(2020)	navigation system for blind people using raspberry-Pi”	detect objects and navigating	this method as it removes shadows. This aids the blind to move freely
Bin Shahrman et al., (2019)	“An architecture improvement of electronic Braille Quran based on Raspberry Pi”	To improve existing architecture with modern technology which is the Raspberry Pi 3B+	Raspberry Pi can carry out projected functions of e Braille Quran. There is a reduction in battery consumption as well by 1.2% /hour
Vasanth, Macharla & Varatharajan (2019)	“A Self Assistive Device for Deaf & Blind People Using IOT”	To assist mild deaf and blind persons to work successfully in their surroundings	The system can use network protocols with the help of Google API servers that provides affordable aids for people living with impairment
Latha et al., (2019)	“A smart reader for blind people”	To provide a smart bot that will aid visually impaired persons.	Findings show that the smart read for the blind has a positive outcome as the openCV is easier to use in comparison to the PC platform. It aids in accessing data in different forms.
Rajyashree, et al. (2019)	“Communication assistant for the deaf, dumb and blind”	To attain the finest technology that is directed at aiding the blind to hear the text that is converted to sound.	The model enables the deaf, dumb and blind to interact with their surroundings through the use of a handy device that gets rid of all interferences in communicating. This helps in developing them. The system is powered by Raspberry Pi to support the deaf, dumb and blind.
Sahoo, Lin & Chang (2019)	“Design and implementation of a walking stick aid for visually challenged people”	To provide an aid that will assist with obstacle detections	The lifestyle of VCPs will be improved drastically as they will be able to live on their own with the use of this device thereby making them self-assured in the environs, they find themselves.

			The use of the APP as a tracking device for parents and also help in emergencies. This gives both the user and parent some form of security
Sharath, Muthangi & Premananda (2020)	“Development of self-assisted voice module for visually impaired”	To enable facial recognition and text apprehensions by the use of Local Binary Pattern Histogram (LBPH)	This system has a high accuracy rate of face recognition where blind people are unable to see properly. As well as read tests accurately. The LBPH system is portable and can be carried anywhere by visually impaired people. The system can be improved upon to include other languages as well as navigation systems.
Ismail A., Abdlerazek S., El-Henawy (2020)	“Development of smart healthcare system Based on speech recognition using support vector machine and dynamic time warping”	To provide the aged and people living with disability to have speech recognition that is a budget-friendly system and can have access to the internet easily to be used in homes and hospitals.	The system was able to assist patients and the aged to have control over IoT devices, through their compatibility to aid in speech recognition. It provided designed to provide privacy in managing patient devices in hospitals and at homes for the elderly. There was a 97% level of accuracy higher than previous systems that were 79% by the use of DTW with SVM that was able to differentiate sound segments. There is a system that is unable to detect voices that are not clear.
Meera, Sharmikha Sree & vvalarmathi (2019)	“Effective shopping method for visually impaired people using	To make movement in an urban shopping environment easy for the blind with the	The system can provide smart shopping for the blind with no form of assistance. This facilitates

	optical character recognition ”	use of artificial intelligence and OCR	shopping through the use of L293Ddriver, optical character recognition, and Raspberry Pi.
Hapsari, Mutiara & Tarigan (2019)	“Face recognition smart cane using haar-like features and eigenfaces”	To provide a smart cane that has facial recognition function with the use of Haar-like features and Eigenfaces	The device serves as a tool aid that will assist the blind to recognize other people that have a distance of 0.25 to 1.5 meters. This smart cane has a 91.67% accuracy if the face to recognize is a straight position to the camera
Zeineddine et al (2020)	“Low Cost Electronic Braille”	The provision of a budget-friendly LCE Braille will vocalize and convert typed characters to alphabetical characters. To aid in interactions among students, teachers, and parents when learning.	The findings showed that the design is low cost and effective and users were satisfied with it. No errors were experienced is using the control buttons which worked accordingly.
Akour et al (2020)	“Mobile Voice Recognition Based for Smart Home Automation Control”	To develop a system that uses an Android mobile phone to control home appliances with a voice command from the user.	Their research was able to detect the vocal command with high accuracy. It with mentioning that their system was cheap to develop and proposed that future research could be made to include the system helping the elderly and disabled persons as well.
Baskaran & Balachander (2019)	“Real Time Object Detection System”	To develop a system to would assist in locating misplaced items. As well as assist the visually impaired with face recognition.	Their system could accurately detect objects with the use of a high pixel camera and could as well adjust to new situations because of the learning algorithms used. Moreover, their system could be controlled remotely as well.
Prabhu, Ruban	“Smart Glass for	To develop a smart glass to	They found from literature and

Thomas, Senthil Kumar (2019)	Visual Impaired People”	assist the visually impaired, the deaf and the dumb.	their project that, sound-based assistance device was most suitable for the visually impaired. They as well utilized a servo engine to produced touch for the deaf and dumped person. The researcher stresses that their developed system was affordable to produce.
Latha et al. (2019)	“A smart reader for blind people”	To develop a system, assist visually impaired to read in developing countries	Their system was able to inform the visually impaired to read the text and proposed to eliminate the limitations of their current system.
Habib et al. (2019)	“Staircase Detection to Guide Visually Impaired People: A Hybrid Approach”	To detect a staircase and ground by utilizing already trained models and ultrasound sensors	The developed system could detect the staircase with high accuracy in the illumined environment using RGBD cameras and with higher accuracy with the use of ultrasonic sensors. They however mentioned a future development of the system into a more user-friendly device for industrial production would be necessary. They also mentioned their system would be expanded to detect other forms of obstacles in the way of the visually impaired.
Venkateswarlu et al (2017)	“Text to speech conversion”	To develop a cheap system to help users to listen to the content of a text and image	Their developed system was able to convert text to speech with an average processing period of not more than 3 minutes for the

			size of an A4 paper. The developed system did not require internet connectivity to operate. Their proposed system can be used to assist the editing eBooks and web pages.
Dunai et al (2017)	“Euro Banknote Recognition System for Blind People”	To develop a handy system to enable the blind to identify and differentiate Euro notes	The researcher found out that, due to the infrared laser camera, their system was able to detect banknote even with less illuminated environments. They as well used algorithms that could be trained which made their system more effective. They however realized difficulties in identifying crumpled banknotes. In their study, it took a relatively long time to train the algorithms, whereas it took 11 seconds to recognize an already recognized note. They intended to improve the algorithms for accuracy in note detection in their future researches and as well to be able to detect fake banknotes. They also intended to utilize memory usage judiciously in their future research.
Rajbongshi et al. (2020)	“Bangla Optical Character Recognition and Text-to-Speech Conversion using Raspberry Pi”	To extract Bangla text from Bangla images and further change the extracted text to speech	Accuracy of 97% was attained in the image to text conversion since the image capture range of raspberry pi is not of high quality. And was almost impossible to capture images

			at night. They also found noise in the speech due to algorithms used for the text to speech conversion. The researcher, therefore, decided to enhance the algorithms, you high quality pi cameras, and expand the research to the capture of handwritten scripts in their future study.
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3.2 Advantages and disadvantages of using raspberry pi systems for disabled users

Throughout literature, most authors have mentioned the advantages of using raspberry pi to develop systems to assist the blind in various ways. Zubov (2018) in his study found the raspberry pi-based system to be very useful to visually impaired persons, in the sense that such systems are cheap to develop. The author as well mentioned the portability of a raspberry-based system for easy carriage of visually impaired persons. Venkateswarlu et al (2017) also mentioned the portability of the device and how it makes the systems portable to be easily carried around by the blind, as well as it cheap and it not depending on the internet making it comfortable to be used anywhere by the blind without the internet connectivity. Additionally, Hapsari, Mutiara & Tarigan (2019) spoke about the portability of the raspberry pi-based system. The fact that raspberry pi is a credit card size device with the capacities of a full computer makes it easy to be used to implement IoT, an assistive and portable server-based system to help the blind, the deaf, and the elderly.

In the production of prototypes and development of the assistive system, it is important to ensure the overall cost price is not expensive. This it is because, most of the disabled person go through financial challenges, especially those in the third world countries. Dunai et al (2017) noted the need for a cheap and simple assistive system for the blind because of their constant use-dependent of such systems, therefore a raspberry pi-based system is appropriate for such designs. Venkateswarlu et al (2017) additionally in their study mentioned the efficiency and cost-effectiveness of developing a system based on a raspberry pi to convert text to speech to assist blind persons. Sharath, Muthangi & Premananda (2020) also emphasized the cost and security of raspberry pi as one of the main advantages of using it to develop a system to assist blind persons. Because it ends up coursing the total cost price to be low thereby making it affordable for the poor

disabled persons. The literature revealed that it is affordable and advantageous for the disabled person when raspberry pi is used to develop systems for such persons.

Akour et al (2020) wrote about the comfort users attain for a home automated system build with raspberry pi to control their home appliances with a voice command. They as well said it is beneficial to use this device to develop a smart lighting system in a museum by combining it with smart thermal sensors to feel the presence of tourists. In their view, most of the recently developed systems with this device are robust and able to withstand the variance in accents in languages and noise. These systems are easy to use thereby being very helpful and accessible to the blind, disabled persons as well as the elderly. they are additionally secured by being able to validate and verify the voice of owners of the systems. A monotonous task performed by humans can easily be replaced by systems developed with raspberry pi. They further mentioned that activities carried out in dangerous environments by humans can safely be replaced by these systems. They also estimated a low cost of systems produced with raspberry pi. In their view, it would be cheap but accurate of the functions the systems are designed for, there would easy for disabled persons in third world countries to afford.

Habib et al (2019) also complain about the low quality of the image produced by the raspberry camera during their test. This is their observation affected the overall accuracy of the performance of the entire system during testing. They however mentioned that it was advantageous using a raspberry pi to develop a real-time image processing system for identification. Hapsari, Mutiara & Tarigan (2019) in their study mentioned that raspberry pi has been one the most popular devices used for face recognition for classroom attendance checking, as well as the development of security doors.

3.3 The advantages and disadvantages of using raspberry pi systems for developers

Currently, there are several microcomputers on the market for the development of systems to assist the disabled person. Some of the devices are UP2 Squared, Huawei HiKey 960, ODRROID-XU4, and Arduino Uno just to mention a few. However, most of them are either expensive or have a lower processing speed and fewer functionalities as compared to a raspberry pi. Raspberry pi 3B+ is a less expensive computer but with a sizeable amount of memory space with its dimension as small as a credit card. It utilizes USB and HDMI to connect to keyboards, mouse, and monitors to operate the input-output of the device. It is easy to operate and program. One doesn't need a deep knowledge of it to use. Rajbongshi et al. (2020) reiterated in their study that, raspberry pi is a Linux-based system, which makes it easier for project

development. They mentioned that most of the libraries for text-to-speech conversions are compatible and easily installed on Linux systems. In their study, they emphasized the use of high pixel cameras to intensify the accuracy of text captured by the raspberry camera, in their opinion has been a limitation. The researcher also mentioned the use of advanced text-to-speech algorithms in other to reduce noise during the process. Latha (2019) said one of the advantages of using a raspberry pi based system to assist the blind in banknote recognition is that it has a short processing time as compared to other microcomputers. Dunai et al (2017), reiterated that the less expensive nature of systems developed with raspberry pi. They, however, wrote about the camera quality which brought a difference in the quality of the captured image in an illuminated area and a dark area.

Venkateswarlu et al (2017) in their study emphasized that raspberry pi has a fast-processing speed. It usually took approximately three minutes to convert text to speech when used in their project. They found it very tolerant with accuracy above 98% in converting the text of an A4 sheet size document to audio. One major advantage they mentioned in their study was the fact a raspberry pi system can be a standalone system; in that, it accurately works without internet connectivity. Akour et al (2020) described the raspberry pi as a server to which other components can be connected as a central point in the development of smart systems. Raspberry pi can be then connected to the cloud, this forms the core of the internet of things and smart automation and control of devices and sensors. On the side of the production of raspberry pi-based systems, they also estimated a low cost in the systems produced with raspberry pi. In their view it would be cheap but accurate of the functions the systems are designed for, there would be affordable for developers for experimental and implementational purposes. Baskaran & Balachander (2019) said the price of raspberry pi makes it suitable for experimental purposes, developers would not be afraid to experiment with it because it is cheap as compared to a personal computer which has the functionalities of a personal computer. This they said would encourage innovation and novelty in the development of systems to assist the blind and the disabled as a whole with the aid of technology. The scalability of development is very essential, Ismail et al (2020) in their study mentioned that systems developed based on raspberry pi are easily scalable. Thus, more sensors and devices can be added to the system for more functionalities as and when needed.

Conversely, Hapsari, Mutiara & Tarigan (2019) complained about the processing speed of raspberry pi devices used to implement image processing systems. The image processing algorithms process involving and need very fast computational speed for such activities. They further criticize the memory space.

3.4 Limitations of the current research on raspberry pi projects

Despite the researches carried out in this area of study, there are still some setbacks in the development of these systems. Rajbongshi et al. (2020) observed that there was no system developed to read the handwritten text, this they predicted should be an area future researches should be undertaken. [31] Dunai et al (2017), for detection of fake banknote for the visually impaired, there is a missing gap in the area of research and they proposed, this should be researched further in the future to assist visually impaired to be able to identify and differentiate fake banknotes as well as other documents. Habib et al (2019) said systems that would be able to detect obstacles such as stationary and motion objects should be developed to assist the blind. They further mentioned the need to develop a single unit raspberry pi-based system. Whereas research in the area of developing systems to assist the blind and deaf in other parts of the world is increasing, little has been done in regions like the Middle East and Africa. Akour et al (2020) mentioned that future researchers should invest time into the development of systems that would aid the deaf, system that would take prompts and commands from them.

4. DISCUSSION and CONCLUSION

This study conducted systematic literature on developed projects that were based on the raspberry pi to fundamentally assist the blind and the deaf. It considered the advantages and disadvantages of using raspberry pi to implement these projects. It additionally considered the merits and demerits of implementing projects based on these devices from the perspective of the developers. Moreover, the research highlighted some noticeable missing gaps within these kinds of projects. It was evident that most of the projects are carried out by researchers from India. It is therefore strongly recommended that academicians from developing countries or third world countries, as well as developing regions, should make more investigations into the subject matter in order to enhance their knowledge in the subject area, improve on the existing system and advance the currently used algorithms employed in the types of development. These would go a long way to assist the blind and the deaf in such geographical areas who are poor and cannot afford the expensive assistive products on the commercial market but have challenges in the autonomous execution of their regular activities.

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