Studying Data Analysis on the Need of Sign Language Recognition Technology for Deaf & Mute Students

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ABSTRACT

Since there are more than 300 different sign languages in the globe, it can be difficult for persons who have hearing or speech disabilities to communicate successfully. 34% of disabled Omani persons have hearing impairments (Oman Observer, 2021). An interesting and crucial field of research is the use of sign language recognition software to assist students with speech and auditory impairments in academic settings and the workforce. The goal of the study is to examine the demand for sign language recognition technology among students who have speech and auditory impairments by giving a thorough analysis of the communication hurdles that a Sign Language Recognition System (SLR) can eliminate. With an emphasis on Arabic Sign Language (ArSL), it offers a methodical comparison of various existing SLR systems. A more thorough grasp of the research issue is provided through the use of a mixed-methods technique that combines surveys and interviews. The study's conclusions point to a pressing need for sign language recognition technology in both education and employment for children with speech and hearing impairments. The results of the study have significant ramifications for the creation and application of sign language recognition software in academic and professional settings. There is certainly room for more investigation into the applications of sign language recognition technologies. In order to promote the employability of deaf and dumb persons in Oman, the study is anticipated to contribute to the development of essential frameworks and standards.

Introduction

Sign language has greatly improved the lives of hearing-impaired and mute people, helping them achieve milestones in life that they previously thought were impossible. Yet, due to the complexity and redundancy of the nature of sign language to normal people, they are often not motivated to learn. One way to break this obstacle is by having sign language interpreters, but the availability depends on multiple factors like cost and time. Sign Language Recognition Systems (SLRs) provide a solution in terms of sign language being translated into text or audio form of the local language (Suharjito et al., 2017). This type of enhanced assistive technology can significantly change the lives of deaf and dumb people.

Assistive technology uses hardware and software to improve the functional capabilities of disabled people (Times of Oman, 2016). Inclusive education involves the participation of society in making sure that people with auditory disorders can benefit completely in learning environments (Oliver, 1990). An example of assistive technology for deaf students can be software that assists them in lectures, making audio converted into written information on smartphones (Santoso et al., 2020).

The idea of Sign Language Recognition Systems has been a popular research topic worldwide, but one that is filled with too many variables during its development. While researchers aim for perfect success in parameters of accuracy and precision during testing, they use different methods for experimentation according to budget, data, and time constraints. This can be due to the availability of datasets, image acquisition methods, or different machine learning techniques for classifying or training datasets. In addition, most of the comprehensive studies are done based on isolated sign language recognition where sign gestures such as alphabets and numbers were recognized one at a time,

the nature of this system being static (Papastratis et al., 2021). But it is more beneficial to have words or sentences recognized in a continuous manner for real-life applications. This uses a continuous sign language recognition system which has its own challenges (Ibrahim et al., 2019).

Noteworthy amount of research has been done in the Arab world in the field of sign language recognition systems which use Arab Sign Language (ArSL). It's been observed through the study of reviews on this subject by Ibrahim et al. (2019) that only 13% of the systems were sensor-based and 57% of the research for ArSL used dynamic signs. This gives room for discussion on how SLR systems for ArSL could be improved.

The purpose of this paper is to explore how assistive technology could be enhanced in Oman by finding the need for sign language recognition systems for deaf and mute students through a thematic analysis conducted via questionnaires and qualitative information taken from interviews with people directly involved in the deaf community. Developing such technology would directly contribute to Oman Vision 2040 goals of social well-being and protection, increasing labor market growth and inclusive education (Oman 2040, n.d).

The Deaf Student Community in Oman

According to the Times of Oman report, there were 518 students in special education schools, of which 214 were deaf and dumb students (Times of Oman, 2016). According to the Oman Association for the Hearing Impaired (OAHI), Oman has the second largest population of hearing-impaired people with only six sign language interpreters to help them (Times of Oman, 2016).

In addition, Al Rayes (2012) noted in their study that when it comes to education for the deaf, the mainstream curriculum, the assigned teachers, and equipment weren't suitable for their learning styles and needs. There was a gap between the general curriculum content and linguistic challenges of these students. Deaf children are also confined to classroom environments which halts creative thinking and innovation. Teachers aren't adequately skilled to deal with such students with few learning materials that include training and teaching techniques (Darwish et al., 2022). This presents much needed attention which should be given to the deaf community in Oman in terms of government investment, training, and awareness to the public.

Related Work

To learn about what makes up a robust, well-functioning and accurate sign language recognition system, we study different SLR systems developed all over the world. We aim to study the different parameters such as data acquisition methods, datasets, recognition techniques and feature extraction methods, AI algorithms being used, isolated or continuous systems, and recognition accuracy rates. These are then compared using a table. There are lots of variables that affect the accuracy and recognition rates of any SLR systems. By narrowing down and choosing few of the most popular and well-tested methods involved in each process of creation, this can contribute to gathering better ideas for future improvement in this area.

Here, four literature reviews of four different languages are compared. Saggio et al. (2020) used sensory gloves which obtained gesture input and their SLR system used k-Nearest Neighbor as their classification algorithm. Most of these systems are isolated systems, with only Hienz et al. (1999) attempting to use the continuous form of sign recognition. All of the discussed studies were able to receive 90+% recognition rates.

Table 1. Classification of Different Language Sign Language Recognition Systems

	Image capturing	**One-handed/Two handed signs**	**Feature extraction method**	**Classification technique**	**Accuracy rate**	**Isolated/ Continuous system**

Saggio et al. (2020) (Italian Sign Language)	Sensory gloves	Two-handed	Dynamic Time Warping (DTW) and Convolutional Neural Network (CNN)	k-Nearest Neighbor (KNN + DTW) CNN	96.6% ± 3.4 (SD) 98.0% ± 2.0 (SD)	Isolated
Muthukumar, K.et al. (2017) (Indian Sign Language)	Images	One-handed	Local Binary Patterns (LBP)	Support Vector Machine (SVM) with LBP	92.14%	Isolated
Hienz et al. (1999) (German Sign Language)	Video camera	Two-handed	Self-built algorithm model for feature vector	Hidden Markov Models (HMMs)	Bigram model 95%	Continuous
Yang, S. & Zhu, Q. (2017) (Chinese Sign Language)	Video dataset	Two-handed	Pre-Training Convolutional Neural Network (CNN)	Convolutional Neural Network (CNN)	99%	Isolated

Since Modern Standard Arabic is the official language of Oman and other Arab nations (Al-Mahrooqi, 2020), we focus on Arabic Sign Language Recognition Systems (ArSLRs). Different literature papers are discussed using a table, like we did previously for different sign language systems to draw up comparisons based on various parameters.

In the six literature reviews studied, two reviews used images to form their dataset, Kamruzzaman (2020) and Zakariah et al. (2022) and at the same time included one-hand signs. Data gloves were used by Mohandes (2013) and Tubaiz et al. (2015), which needed gesture-based input and sensors. Two-handed signs were popularly used in most of the systems, proving how sign languages need both hands for signing words or sentences. Different methods of feature extraction were used, and all the reviewed studies explained their reasonings for choosing their methods, such as extracting geometrical features (Ibrahim et al., 2018), Principal component analysis (PCA) for analyzing larger datasets (Mohandes, 2013). Most of the reviewed studies were developed for isolated recognition systems as continuous systems are harder to develop with lower accuracy rates. The classification techniques used also differed in each study since the authors wanted to find efficient and different ways of classifying compared to already existing research in this field. The accuracy rates for each of the studied system were consistent with one another, except for a few that had reduced accuracy rates compared to the others due to factors such as occlusion (Ibrahim et al., 2018) and continuous sign recognition (Assaleh et al., 2008).

Table 2. Classification of Arabic Sign Language Recognition Systems (ArSLR Systems)

	Image capturing	**One-handed/Two handed signs**	**Feature extraction method**	**Classification technique**	**Accuracy rate**	**Isolated/ Continuous system**
Ibrahim et al. (2018)	Camera	Two-handed	Geometric features in spatial domain	Euclidean distance	83%, Total Error Rate (TER)=0.08%	Isolated

Mohandes, M. A. (2013)	CyberGlove	Two-handed	Principal component analysis	Support Vector Machine (SVM)	99.6%	Isolated
Tubaiz et al. (2015)	DG5-VHand data gloves	Two-handed	Window-based statistical approach	Modified k-Nearest Neighbor (MKNN)	Sentence recognition: 98.9%	Continuous
Assaleh et al. (2008)	Vision-based video dataset	Two-handed	Two-tier spatial-temporal extraction	Hidden Markov Models (HMMs)	Sentence recognition: 75%, Words: 94%	Continuous
Kamruzzaman, M. M. (2020)	Raw images	One-handed	CNN-convolutional layer and filter	Convl.Neural Network (CNNs)	90%	Isolated
Zakariah et al. (2022)	Raw images	One-handed	ImageDataGenerator by the Keras API	EfficientNetB4-CNN	Training accuracy-98%, Testing accuracy-95%	Isolated

Research Methodology

For our methodology, we performed a statistical analysis from the data that was taken from a survey made using a Google form. We have used the data that was automatically generated through the Google form. This is done to collect statistical information from our sample group in Oman to know about the state of the current assistive technology for deaf students in Oman and their involvement with the deaf community. Through this survey, we also wanted to know about their opinions of sign language technology to benefit deaf students in their education.

In addition, we conducted online interviews with people directly connected and involved with the deaf and mute community and their education. The aim through collecting such qualitative data was to find out their opinions on how sign language technology could help their deaf students and to know about how assistive technology could be improved in Oman. We also wanted to know through these individuals how inclusivity can further be improved and achieved, so that the deaf community doesn't have a hard time adjusting to society.

Reviews related to Arabic Sign Language (ArSL) were also reviewed and studied to get a better understanding of different types of sign language recognition systems, so that we can implement suitable systems in Oman as well.

Analysis

Quantitative Data Analysis

In order to understand the current use and knowledge of assistive technology in Oman, we performed a survey on a sample group consisting of the general public.

The survey had 26 participants. It revealed that only 15.4% of the participants had family members who suffered from auditory or speech disorders.

The statistics in Figure 2 for the types of assistive technology that the participants had knowledge of showed that 96.2% of them knew about speech-to-text software and 73.1% of them knew about hearing aids. But only 26.9%

of the sample group knew about assistive technology such as closed captioning software or graphical aids such as smartboards.

In the group, Figure 1 showed that 46.2% of the people expressed strong interest in being involved with the deaf and dumb community. According to Figure 4, 65.4% of the group believe that learning sign languages is a moderate level of complexity. Figure 3 showed that 53.8 of the participants were interested in learning sign language and it also showed the types of sign languages people wanted to learn.

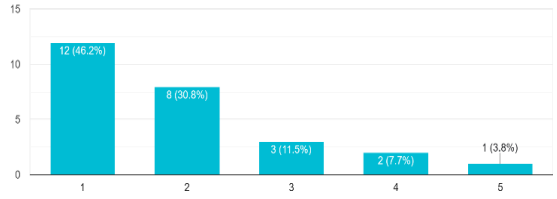

Figure 1. Level of interest in being involved with the deaf and dumb community.

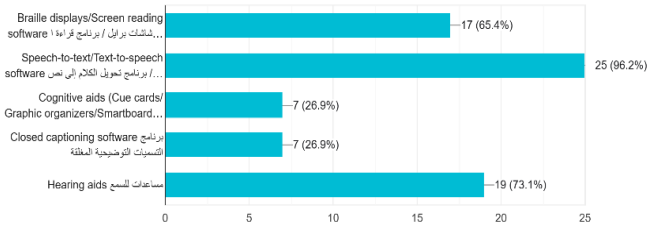

Figure 2. Knowledge of assistive technology by the public.

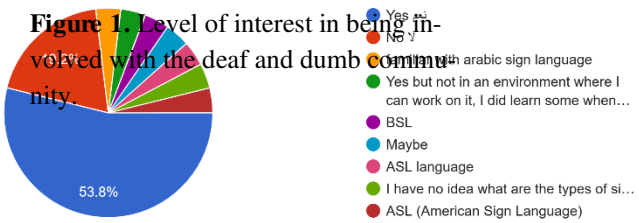

Figure 3. Interest in learning sign language and the types they want to learn.

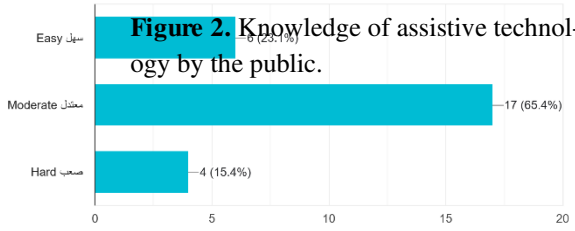

Figure 4. The level of complexity needed for learning sign languages.

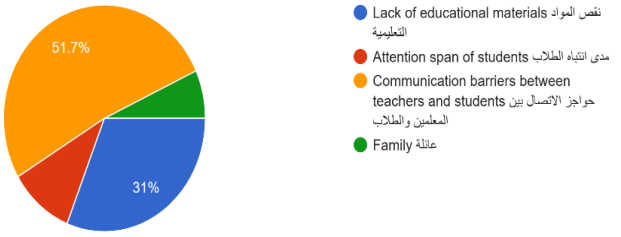

Figure 5. The barriers that prevent deaf students from their educational goals.

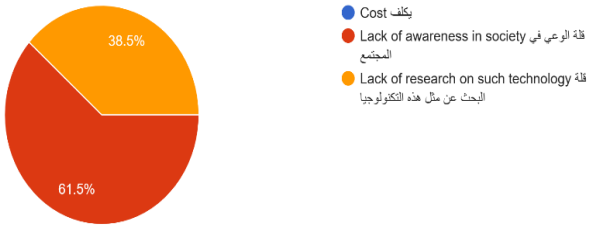

Figure 6. The barriers that prevent assistive technology from being accessible to disabled people.

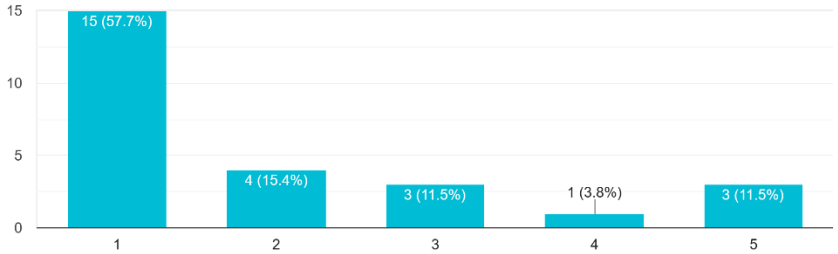

Figure 7. Statistics for how many people think sign language technology could be beneficial for deaf students in education.

As shown in Figure 5, 51.7% of the participants believed that communication barriers between teachers and the students prevented them from achieving their educational goals, while 10.3% blame the attention span of students and only 6.9% of the people think family becomes an obstacle in education for deaf students. 61.5% of them also thought that assistive technology wasn't being utilized due to the lack of awareness in society regarding the disabled community, which is illustrated in Figure 6.

When it came to asking about whether sign language technology could be useful for deaf students in education, 57.7% of the participants strongly supported the development, implementation, and use of such technology (Figure 7).

Qualitative Data Collection

To achieve a deeper understanding of the deaf community in Oman, interviews were taken with people directly involved in helping the deaf community, such as specialized teachers, psychologists and board members of schools and organizations that help the deaf. The interviews were conducted online through meetings such as the 48th Arab Deaf Week with various supervisors who teach deaf students, and correspondence through email and social media.

The common questions that were asked to the interviewees included asking them about: 1) the struggles that deaf people faced, 2) how deaf students struggled to communicate with their teachers during lectures, 3) what was the level of interest these students showed in the field of information technology, 4) the interviewees knowledge and opinions about sign language recognition systems, 5) how they think deaf students can communicate with people who didn't know sign language, and 6) ways to increase sensitivity of normal people towards their community.

Through the interviews, we found that the current assistive technology used by the deaf students included hearing aids, educational technologies such as smart screens, videos, YouTube, and apps like Kahoot and Wordwall. The deaf students at Al-Amal school for the deaf get electronic booklets that teach the basics of sign language and grammar. According to specialized teachers who teach sign language, for normal people to get a comfortable level of fluency in sign language, it takes 3 months. Deaf students face barriers such as lack of vocabulary or languages during the learning process, but they can learn at the rate of normal students. Most of the assistive technology used by deaf students is portable and on devices like mobiles, laptops, and tablets, but some interviewees also mentioned that some sign language technology devices fail due to the requirement of specific sensors and software for recognizing body language and facial movement. Whether a student is being homeschooled and continually accessing different e-resources or is attending school full-time and using them as supplemental material, online platforms can help students with special needs understand the course material. Handwritten homework may be a better option for some students with learning issues than interactive games, activities, and movies. Education is becoming more and more digital every day. As a result, there are currently more resources available online than ever before. As greater knowledge of these children's needs is discovered, a number of these online tools are being created to serve students with special needs (Al Hosni et al., 2023).

It was also found that Arabic Sign Language (ArSL) had differences amongst the different Arab nations, being connected with a help of a unified dictionary for commonality. In Oman, a dictionary for Omani Sign Language

is being developed. Most schools still teach Arabic Sign Language to students due to its broader popularity, significance, and usage.

One important thing noted by most of the interviewees is that they believed that even in the deaf community, the level of external help needed through assistive technology varied for every individual.

Through interviews conducted with psychologists who deal with deaf and dumb students, they convey that social isolation is a main factor that prevents deaf people from feeling included in society. There is a disconnect between teachers and students where both parties cannot be understood to a big extent due to communication differences. They stress creating inclusive learning environments for students, as well as sensitivity training for teachers, administrators, and students to help raise awareness on their unique needs.

Results

Analysis of Results

Through the data collected from the survey and interviews, we can infer that assistive technology is an important field that needs further research in Oman.

Lack of awareness in society: The statistics from our sample group of 26 people showed that around half of them believed lack of awareness in society to be the main cause that prevents deaf students from achieving their educational goals. This presents a gap in the inclusivity of deaf people in integrating with society. From the interview information collected, it can be found that normal people didn't really put in the effort to integrate with their community by learning sign language and exhibited some lack of sensitivity towards their needs. This can be solved through workshops, educational pamphlets, and campaigns that advocate for the deaf.

Educational barriers: From the data taken from Fig.5, it is found that over half of the sample group believed communication barriers to be the main problem that prevents the deaf community from their true potential as students. This is further supported by interview data from psychologists who have noted that students with auditory disorders needed captioning facilities on digital lectures and help in notetaking and classroom discussions. Thus, a more interactive network is needed to be constructed in the educational field to help the disabled.

Portability of technology: Deaf people have a convenient niche in assistive technology in terms of portability. This can be attributed to the various technologies that have been developed on mobile devices, laptops, etc. Thus, the information technology field is crucial in being a key player for improving the lives of the hearing-impaired. Fig. 2 shows the various types of assistive technology currently available for hearing-impaired and mute people, which all happen to be portable. The results from Fig.2 show that most people are only slightly familiar with assistive technology, especially only 26.9% aware of educational assistive technology such as graphical or cognitive aids. There seems to be a crucial need to educate people on all types of assistive technology that could be utilized. But at the same time, this leads to positive responses when it comes to the development of sign language technology in Oman, with 57.7% strongly agreeing (shown in Fig. 7). This shows that there is a significant need for the development and implementation of a sign language recognition system in Oman.

Complexity of sign language: As specialized teachers have mentioned in our interviews, there is a learning time of 3 months to get a level of fluency that makes conversation easy with the deaf and mute. From Fig. 3, it is observed over 53% are interested in learning sign language and only 19.2% were averted to the idea. The rest mentioned the variety of sign languages they want to learn. Fig. 4 shows that most participants (65.4%) believed that sign language was only moderately difficult to learn. Collecting all this data leads to the conclusion that implementing sign language courses in schools and colleges would be positively received by most people and lead to much better incentives in terms of inclusivity and understanding. This would also push the need for assistive technology such as SLR systems as more people become aware of it.

Interest for learning about new assistive technology: In collecting personal responses from authorities working on education for the deaf community, they have also expressed the interest of students as well as teachers and supervisors who are invested in learning new technology and their applications. Hence, the contributions and talents of such differently abled students should be taken into consideration for the development of sign language technology.

Through the various literature reviews compared in this paper, we come across Arabic Sign Language Recognition Systems (ArSL SLR systems). This was to get an overview on different methods used in those systems which could be used to implement such a system in Oman.

Conclusions

This paper discusses how sign language technology could be a form of assistive technology for deaf students. An extensive amount of research has been done on sign language recognition systems (SLRs). These types of systems are created in all types of sign languages. Arabic Sign Language (ArSL) was given special focus as Arabic is Oman's national language and similar systems can be developed for Oman by taking ideas from ArSL SLR systems. Assistive technology is a field which many people are not aware of in Oman. A statistical analysis was performed by taking a survey with the public as the sample group. Interviews were also conducted with psychologists, specialized teachers, and board members of organizations for the deaf. The results from the statistical analysis showed that 46.2% of the people expressed strong interest in being involved with the deaf and dumb community. From the various assistive technology currently being used by people, 96.2% of them knew about speech-to-text software. 57.7% of the participants strongly supported the development, implementation, and use of such technology. The primary sources of research conducted for this work reveal that there is a significant need for sign language technology. Specialized teachers who teach the deaf are deeply interested in learning about new types of assistive technology. They also mentioned that the deaf community is very keen in knowing about developments in IT. Inclusivity is an important factor that is needed in Oman, so that Oman's Vision of 2040 goals such as the well-being and social protection of such people are ensured, and it leads to the development of a well-rounded, aware, and more educated society in Oman,

Recommendations

The development of sign language technology is a popular field that has been studied around the world. Yet in Oman, research regarding this field is limited which is due to the lack of awareness. There is a need for inclusion of deaf and dumb people through campaigns, social activities, and educational materials.

Through spreading awareness on the need of sign language technology, the public can contribute funding and ideas to create better sign language systems. By developing and implementing such technology, it increases the inclusivity and communication between normal people and the deaf.

As deaf students have passion in the field of information technology, they can also aid in the development of SLRs with new perspectives and ideas that might get overlooked by normal people.

Sign language takes three months to be learned by normal people from scratch. By making the public more educated on various forms of assistive technology, they won't be as discouraged in participating and volunteering in activities that target the deaf and dumb. The data found through our research suggests that there is an area that brings much needed attention to the disabled community that is often very overlooked.

Through studying various literature that we have encountered in this paper, some data acquisition methods have been favored globally, such as computer vision-based image capturing. Sensor gloves which take in gesture inputs aren't focused as much due to factors such as budgets, operational and technical feasibility. This is an area which can be explored for future research, to develop ways to make sensor-based approaches more economical, accessible, and technically feasible by majority of the people. When it comes to machine learning algorithms, Support

Vector Machine (SVMs), Hidden Markov Model (HMMs) and especially Convolutional Neural Networks (CNNs) have consistently provided more accurate results. This helps us narrow down what classifiers we can focus on in terms of future research. Continuous sign language recognition techniques aren't much explored due to reduced accuracy rates and inability to gather large datasets to make them work, but future research which heads in this area could massively benefit the people.

Acknowledgments

We would like to thank Mr. Yasser Abdelgaber Ahmed Moustafa, English supervisor for special education schools and programs in Oman and Ms. Badriya Al Hosni from Student Success Center, Middle East College for their valuable insight into Oman's deaf student community.

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