Survey of Sensor-Based Arabic Sign Language Datasets

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Keywords: Arabic Sign Language Dataset, Deaf Community, Sign Language (SL), Gesture Recognition, Sensor-Based Recognition.

Abstract: Sign language is the primary means of communication for the deaf and hard-of-hearing community, representing a linguistic bridge that connects them to society and enables them to express their thoughts and feelings. However, Arabic Sign Language (ArSL) still suffers from a distinct lack of scientific research and documented digital databases. This limitation hinders the development of automated recognition systems and weakens their integration into modern artificial intelligence applications. This research aims to review and analyze previous studies related to the use of various databases and sensor technologies in Arabic Sign Language recognition. The study focuses on identifying shortcomings in previous research efforts and proposing methodological approaches to improve data collection and unify standards among researchers. This study relied on an analytical review of scientific literature to extract conclusions and evaluate the effectiveness of previously developed systems in terms of accuracy and efficiency. The results reveal that available databases lack diversity in vocabulary and grammatical structure, which reduces the ability of models to accurately recognize signs. The findings emphasize the importance of developing comprehensive and standardized databases that support the training of intelligent systems, thereby contributing to the integration of deaf individuals into society and improving their educational and social opportunities.

1 INTRODUCTION

Researchers Researchers recognize that the primary mode of communication for those who cannot hear is through sign languages, which rely on movements in all types of human interaction, whether purposeful or incidental [1]. A person who is deaf can truly exercise their rights by learning and using sign languages to receive an education in both sign and spoken language and by helping others understand sign language. To ensure that the deaf community can participate fully in life and learning, it is essential to provide sign language interpretation [2]. According to the World Health Organization, one billion people, or 14% of the world's population, live in Arab nations and utilize the Arabic alphabet [3]. Several Asian and African languages and dialects including Kurdish, Punjabi, Sindhi, Balti, Balochi, Lurish, Urdu, Kashmiri, Somali, and Mandinka, as well as the inhabitants of Arab nations employ Arabic alphabets [4]. Since almost 25% of the global population utilizes Arabic alphabets, their significance is evident.

Despite the growing need for Human-Computer Interaction (HCI) driven by advancements in sensor technology, Arabic Sign Language (ArSL) has not advanced as much as other sign languages such as American Sign Language (ASL), British Sign Language (BSL), Vietnamese, Chinese, and various others. Additionally, little is known about the Middle East's classification and translation of sign language with the goal of using contemporary technological tools to assist those with impairments. Arabic computer programs designed to assist individuals with impairments in their education also possess flaws. Despite the great diversity of sign languages, where each has its own syntax and rules, the only similarity is that they are all visually perceptible [5]. Furthermore, outside of the deaf population, knowledge of sign language is not very common. Many deaf children are born to hearing parents; thus, even within the family, there is a linguistic barrier. Deaf individuals are often taught to be multilingual in reading and writing because there are no established protocols for sign languages [6]. Additionally, there is a vast array of sign languages. The employment of facial expressions, head movements, and hand

gestures to transmit meaning constitutes the linguistic features of sign language [7]. Studies on recognizing hand movements began with gloves equipped with multiple sensors and trackers as part of a sensory method. These gloves provide accurate information about hand position and finger movement, which aids in recognizing Arabic Sign Language [6]. Other initiatives employ different sensor types, such as cameras like the Microsoft kinect [8]. The goal of these systems for recognizing Arabic Sign Language is to create a method to occasionally replace human interpreters by converting sign language shown in videos or images into Arabic text. Additionally, this method aims to encourage better and more inclusive communication by enhancing exchanges between deaf and hearing individuals.

2 CLASSIFICATION OF ARABIC SIGN LANGUAGE RECOGNITION

Creating a structure for recognizing Arabic Sign Language (ArSL) necessitates collecting a substantial dataset of sign language, which must be accurately labeled with the corresponding signs. This collection can be utilized to educate and evaluate models in the classification phase of machine learning. Information regarding the recognition of Arabic Sign Language can be obtained through two approaches [9]: the first is a sensor-based strategy [10], and the second is a vision-based strategy, as seen in Figure 1.

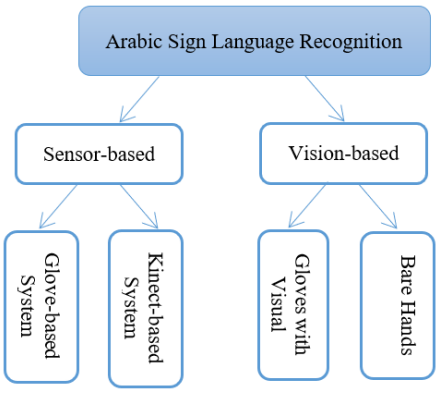

Figure 1: Approaches for recognizing sign language [11].

The method of recognizing Arabic Sign Language through visual means focuses on the analysis and interpretation of sign language gestures captured in images or videos with the help of computer vision methods. The sensor-based method for recognizing Arabic Sign Language employs sensors to identify and record information related to sign language gestures. This technique can be utilized either as an alternative or as a complement to visual methods, presenting several benefits and drawbacks. One benefit of utilizing sensors is their ability to yield more precise and dependable data compared to visual methods, particularly in situations with low lighting or obstruction. Additionally, sensors can capture data that may not be visible to the human eye, including signals from electromyography, as well as measurements of force and pressure. There are two primary types of systems: glove-based systems [12] and Microsoft Human Pose Estimation-based systems [13]. Gloves can be used in systems that read hand gestures (see Fig. 2) because of their mechanical and electrical components [12].

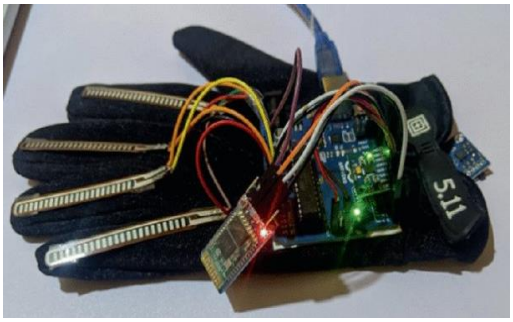

Figure 2: Smart glove with sensors.

Even though this approach can produce beneficial results, using a glove linked to specific sensors (Fig. 3) that capture data may pose difficulties for individuals who rely on sign language and have speaking or auditory impairments [14].

Figure 3: Microsoft human pose estimation sensor.

This can be accomplished through either a vision-centric or a sensor-centric method. A method for identifying the ArSL alphabet involves regarding each letter as a unique gesture and applying machine learning strategies to categorize the gestures

according to visual or sensory characteristics. Typically, a fixed state and a limited vocabulary are employed to convey letters. While the Arabic alphabet consists of merely 28 letters, the Arabic Sign Language contains 39 symbols [15], [16]. Instances of basic symbols that consist of a pair of letters include eleven extra symbols. For instance, these two letters resemble the English word "the" and are exceedingly prevalent in Arabic [17].

Isolated word identification, unlike the recognition of alphabetic symbols, centers on a collection of movements that relate to individual words, each carrying its own meaning and significance. It treats every term in Arabic Sign Language as a distinct gesture and categorizes gestures based on the established system built around them.

On the other hand, the method of continuous sign recognition presents greater challenges when discussing execution. The challenges linked to this approach include tracking hand movements, recognizing motion, identifying features, and handling an extensive vocabulary. Once the appropriate feature vector is acquired, classification is simplified because of the various methods that the system can utilize.

3 ARSL RECOGNITION CHALLENGES

Sign language does not have a standard form. Regional and dialectal differences set Arabic Sign Language apart from spoken languages. The great majority of Arabs can understand Arabic Sign Language, and it is the focus of our interest in this study [18], [19]. Learning the deaf community's language and creating Arabic Sign Language learning models are necessary to improve the Arab community's comprehension and integration of the deaf community. To make it possible for a larger portion of the population to interact with deaf and mute people in an efficient manner, and to partially replace human translators, a system that can interpret sign language should be created. To encourage more inclusive and smooth encounters and enhance communication between the deaf population and others, the complexity and diversity of sign language movements must be addressed. This complexity is one of the biggest obstacles to creating a framework for Arabic Sign Language detection. A variety of hand gestures, body postures, facial emotions, and body movements are all part of sign languages, which are intricate visual languages. The distinct grammar and syntax of Arabic Sign Language, in particular, make it difficult to model and recognize using traditional machine learning methods. To solve these challenges, various techniques for recognizing sign language have been employed by researchers. A significant factor to keep in mind while creating a framework for sign language recognition is the availability of an extensive database that researchers can depend on to advance their research. This is the primary emphasis of the current study [20], as the lack of availability of a data set or the existence of only small sets that do not meet the researcher's needs hinders the development of projects and progress within the framework of Arabic Sign Language recognition. The availability of pre-made data that meets necessary requirements eases the workload and time commitment for researchers, which raises interest in this language as a study subject; consequently, findings, development, and outcomes improve. In contrast to other languages, there are not many databases accessible in Arabic Sign Language, per earlier research.

4 TRAINING DATA SETS

There are a number of ways to capture gestures in sign language; however, studies suggest that the focus on gloves is more comprehensive and broader. People are drawn to the sensory glove because of its capacity to capture the data required to depict the hand's structure and motion in order to identify the motions of the source language. Although there are many positions in the source language, much of the research has focused on a small subset of these positions, which may be as few as several letters of the alphabet [21] - [23]. Additionally, researchers use the most common word positions in the source language [24] - [28], using a mix of words, numbers, and alphabets [29] to carry out their research and create an SLR system. The collection of gestures has been expanded by others with the intention of creating a system that can differentiate between them. Some datasets contain whole alphabets [30] - [33], others utilize numbers between 0 and 9 [34] or include both in the same system [35] - [37]. In addition, other researchers contributed by differentiating between certain words, phrases, and even phrases chosen to depict a range of real-life scenarios, such as family, shopping, school, sports, etc. [38] - [41].

Table 1 provided information on the Arabic Sign Language dataset studies using sensor-based

recognition utilized in the majority of the earlier research. This information includes the kinds of gestures used and how frequently they are used. The Table 1 also shows the number of performers and the creators of the signs. The total number of samples used in the trials is also provided.

5 CONCLUSIONS

This paper has provided an outline of the Arabic Sign Language recognition systems that are currently accessible in the public domain, specifically those that include databases and use sensor approaches to detect Arabic Sign Language gestures. Many aspects related to Arabic Sign Language have been explored and investigated. There is a sign language for almost every country; however, sign language studies have not yet satisfied the needs of each language. Despite the importance of this topic, published scientific research on Arabic Sign Language recognition is limited, especially regarding articles that use sensor approaches. In addition, techniques for recognizing sign language have been reviewed in this work.

Table 1: Arabic sign language dataset using sensor-based recognition.

Author	Language	Components	Gesture	Sample per Gesture	Gesture Performer	Sample Size
[42] 2021	Arabic Sign Language	Six IMUs sensors	28Arabic alphabets	25 samples per gestures.	Seven young volunteers (three male, four female)	4900 samples
[43] 2020	Arabic Sign Language	Two Glove each have 5 flex and (MEMS) module MPU-6050	30 words and 15 expressions	One time	Two users	45 tested
[44] 2021	Arabic Sign Language	Microsoft Kinect V2 Sensor	502 signs	50 times, each signer repeats	Three professional signers	75,300 samples.
[46] 2024	Arabic Sign Language	five flex sensors, MPU6050, An accelerometer gyroscope, MAX30102 sensor.	12 Alphabets, 8 words	One time	One user	20 tested
[47] 2019	Arabic Sign Language	Five flex and one-accelerometer sensors	five Arabic letters	Four times	Four user	80 Samples
[13] 2018	Arabic Sign Language	Kinect Sensor	30 isolated words	40 times	10 different signer (four women and six men).	1200 samples
[48] 2021	Arabic Sign Language, English Sign Language	Five flex and one-accelerometer sensors	29Arabic alphabets 26English alphabets	20 times	One user	580 Samples Of ArSL
[49] 2023	Arabic Sign Language, English Sign Language	Five flex and one-accelerometer sensors	28Arabic alphabets 26English alphabets	200 examples of each letter in both ASL and ArSL. (except J and Z)	One user	5600 Samples Of ArSL
[50] 2014	Arabic Sign Language	Two CyberGloves	(100) two-handed signs.	20 times	An adult deaf community volunteer	2000 samples
[51] 2023	Arabic Sign Language	potentiometer for each finger, MPU6050	40 ArSL words	One time	10 deaf people	400 Samples
[45] 2015	Arabic Sign Language	DG5-VHand data gloves	40 sentences 80-word lexicon	Ten times	Right handed young female	800 samples

The findings show that there are currently three methods in the field of sign language recognition. The first approach is vision-based systems; the second approach, widely used in this field, relies on sensors as the primary source of data capture; and the last approach is a hybrid technique combining the first and second approaches. Many researchers have proposed ways to recognize Arabic Sign Language and have provided reported datasets. However, for testing and evaluating their systems, researchers are unable to access any standard Arabic Sign Language datasets. A number of datasets have been promised for public release. Although they have not yet reached the status of "reference datasets" among Arabic Sign Language recognition researchers, they are considered promising solutions to motivate researchers. There is a need to stimulate efforts toward enhancing digital documentation to facilitate more in-depth research and expand the body of knowledge on Arabic Sign Language. Investment in scientific research is crucial, as is increasing cooperation between academic institutions, organizations for the deaf, and government agencies. Addressing the problem of limited access to data due to intellectual property rights or regulatory restrictions is vital. Furthermore, launching joint research initiatives between Arab countries and academic institutions would contribute to unifying efforts and encouraging institutions to provide Arabic Sign Language databases openly and freely to researchers and developers. All of this will contribute to increasing interest in Arabic Sign Language and its documentation, which enhances communication with the deaf community and contributes to increasing educational opportunities and social integration.

6 FUTURE WORK

There are several future aspirations that will improve the standard and strengthen the scientific foundation of this field. One is the potential for developing a single, all-inclusive database that can be used for research and development, encompassing all dialects in Arab nations while accounting for regional linguistic variety in signs. Advanced technologies, such as those that track hand positions, facial expressions, and body movements, can also be used to improve the database's quality and comprehensiveness. This is in addition to expanding scientific collaboration both worldwide and within the Arab world to promote advancements in this area.

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