Saudi sign language Translation Companion System

1. Preface

In the following I will present the details of my work in Arabic Sign Language (Ar-Asl) and Saudi Sign Language (SSL). As the director of Center for Smart Robotics Research (CS2R) we were conducting research in a system for translation between the deaf and normal people. We were able to build such system. The system consisted of speech to sign system and sign to speech systems. For better user interaction we put the system on a robot that we design and built specific for the system. This work on the Arabic Sign Language uses artificial intelligence and machine learning. It is directly related to computerization of Arabic language and services not only the Arabic speaking community but contributes to Sign Language recognition in general.

Due to our expertise in the speech processing group, which became part of CS2R, the speech to sign system was not a big challenge, the sign to speech was more challenging. To conduct research on sign recognition we built a sign database that contained 80 signs performed by 40 signers in 5 repetitions. The signs were recorded in an unconstrained environment which makes recognizing the sign difficult, nonetheless we conducted research using it and got excellent results that we published in ISI journals. Due to our expertise in SSL we were able to secure fund for a project titled “Saudi sign language Translation Companion System”, where I was the PI of the project. This project is currently running.

As a further work in the area I am supervising a PhD thesis with the title “Sign Language Recognition using Transformer Technique with Multi Modalities Input” with my colleague in the center Prof. Abdulwadood as a co-supervisor.

I am also doing research in an essential point for practical sign translator. The Arabic sign language structure is different from the Arabic language; hence this need a translator between them. Currently I am supervising a Master thesis with the title “A Deep Neural Machine Translation System from Arabic Text to Sign Language” with my colleague in the center Dr. Yousef Alohali. The Arabic sign language is different from the Arabic language and has its own structures and rules. It is not possible to directly translate word by word from an Arabic text into a sign. Rather, the sentences and phrases in the Arabic texts must be converted into their equivalent in sign language, text which is signed text and is known as Gloss. In this research, the student built a database of children's stories containing the Arabic text and the corresponding sign text, which was translated by certified sign language translators. The student is now applying the latest

machine translation techniques, which rely on deep learning methods, and the experiments have given good initial results and are working to improve them.

Many parts of the first year report about the project are not published yet, hence in the following I will present the letter from National Science Technology and Innovation Plan (NSTIP) for funding the project, brief description of the project, followed by a list of or publications in the area.

Letter of National Science Technology and Innovation Plan (NSTIP) about funding the project

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إفادة

تفيد الخطة الوطنية للعلوم والتقنية والابتكار بجامعة الملك سعود بأن سعادة الدكتور / منصور بن محمد السليمان الأستاذ بكلية علوم الحاسب والمعلومات، رقم وظيفي (١١٩٦٢٣)، هو الباحث الرئيس للمشاريع المبينة بالجدول ادناه، وهذه المشاريع ممولة من برنامج التقنيات الاستراتيجية بالخطة الوطنية للعلوم والتقنية والابتكار:

م	رقم المشروع	اسم المشروع	المدة
١	08-INF167-02-	التعرف على المتحدث العربي ARABIC SPEAKER RECOGNITION	٢٠١٠-٢٠١٢
٢	١٢ MED2474-02	تقييم الامراض الصوتية بالحاسب Automatic Voice Pathology Assessment	٢٠١٣ - ٢٠١٥
٣	3-17-09-001-0003	نظام حاسوبي لتعليم اللغة العربية لغير الناطقين بها Computer-Aided Pronunciation Training System for Non-native Learners of the Arabic Language	٢٠٢٠-٢٠٢٢
٤	5-18-02-001-0003	نظام ترجمة محمول للغة الإشارة السعودية Saudi Sign Language Translation Companion System	٢٠٢٠-٢٠٢٢

وقد اعطيت له هذه الإفادة لسعدته بناء على طلبه لتقديمها الى من يهمه الامر ودون أدنى مسؤولية على الوحده.

مدير وحدة العلوم والتقنية والابتكار

ا. د. أحمد بن عبد الله الخازم

رقم الملف ١/٣/٢٨٦٧٤
التاريخ ١٤٤٣/١١/١٢
المرفقات

2. Technical Brief of the first year work in the project

The presented work is a collaboration between the Center of Smart Robotics Research and the Higher Education Program for Deaf and Hard-of-Hearing at King Saud University. This is part of the funded project supported by National Science Technology and Innovation Plan (NSTIP) in King Saud University under grant number 5-18-03-001-0003.

Recently modern societies are trying hard to be inclusive of disabled individuals by ensuring equal opportunities for the disabled through ease of access to social services and daily human needs. This project is designed to enable two-way communication of deaf individuals with the rest of society, thus enabling their migration from marginal elements of society to mainstream contributing elements.

Over one billion people, globally, experience disability according to the WHO (World Health Organization). This accounts for one of seven people who suffer from disability [1]. The Demographic Survey 2017 [2], issued by the General Authority for Statistics – KSA, states that 1810358 Saudi residents suffer from disabilities, i.e. 7.1 % of the population are disabled. FIGURE 1 shows the Saudi Population's cause of disability and type of difficulty [2]. Saudi Vision 2030 [3] emphasize on providing all the facilities and tools required to put the disabled people on the path to receive the education and job opportunities that will ensure their independence and integration as effective members of society[4][5][6].

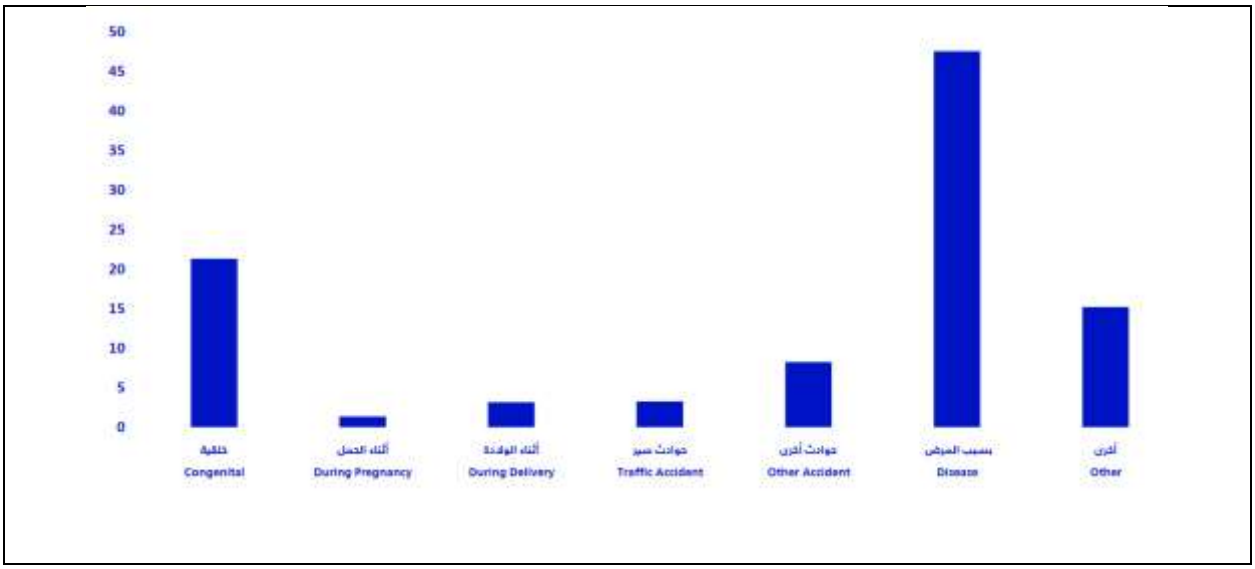

FIGURE 1, SAUDI POPULATION CAUSES OF DISABILITY

FIGURE 2 and FIGURE 3 present the Saudi Population with disability by age and educational status for one and multi-difficulties[2], From both figures, we can see that: 33% are illiterate, 12% can read/write, and only 11 % are university and higher. These statistics indicate that there is a correlation between disability and education status.

360 million people over the world have a hearing disability, 9 % of them are children, as stated by the WHO [1]. In KSA, the number of deaf is about 720,000 [4]. Deaf persons have great difficulty in communicating with other people in the society. Only a small number of them know and use sign language to communicate with others.

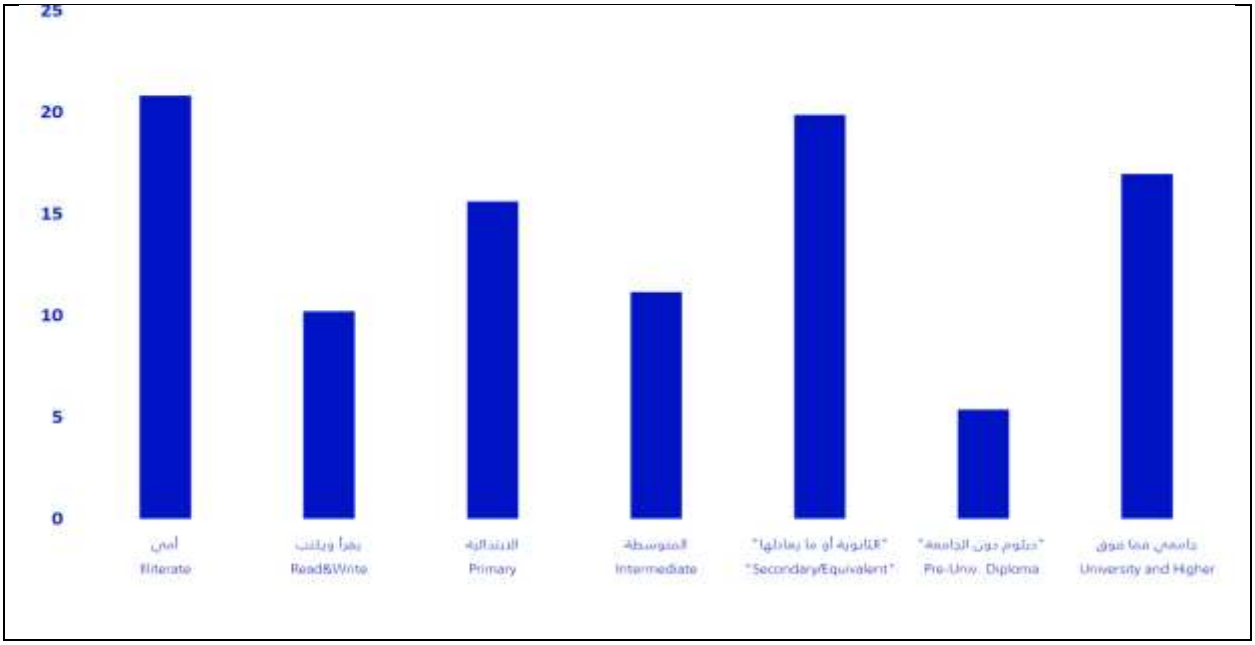

FIGURE 2, PERCENTAGE DISTRIBUTION OF SAUDI POPULATION (10 YEARS AND OVER) WITH DISABILITY BY EDUCATIONAL STATUS – ONE DIFFICULTY

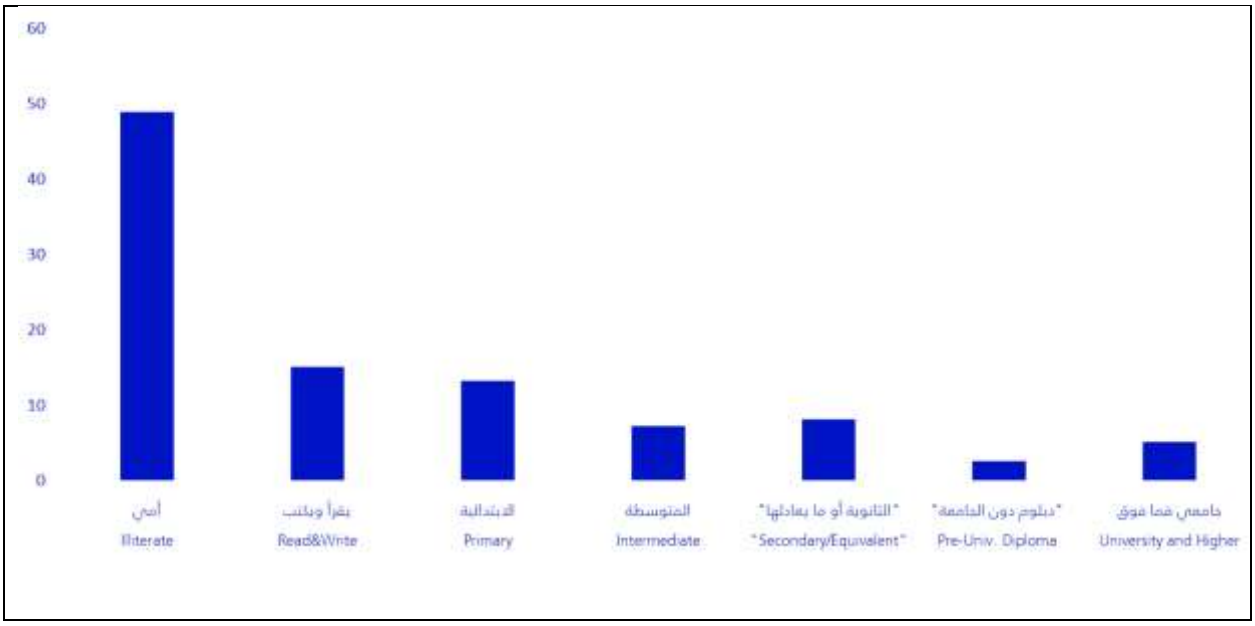

FIGURE 3, PERCENTAGE DISTRIBUTION OF SAUDI POPULATION (10 YEARS AND OVER) WITH DISABILITY BY EDUCATIONAL STATUS – MULTI DIFFICULTIES

FIGURE 4 shows the percentage of Saudi males and females using sign language. The lack of sign language interpreters [7][8][9] amplifies the difficulty of the deaf in communicating with the rest of society, especially in the government services, specifically in healthcare as stated by this study [10].

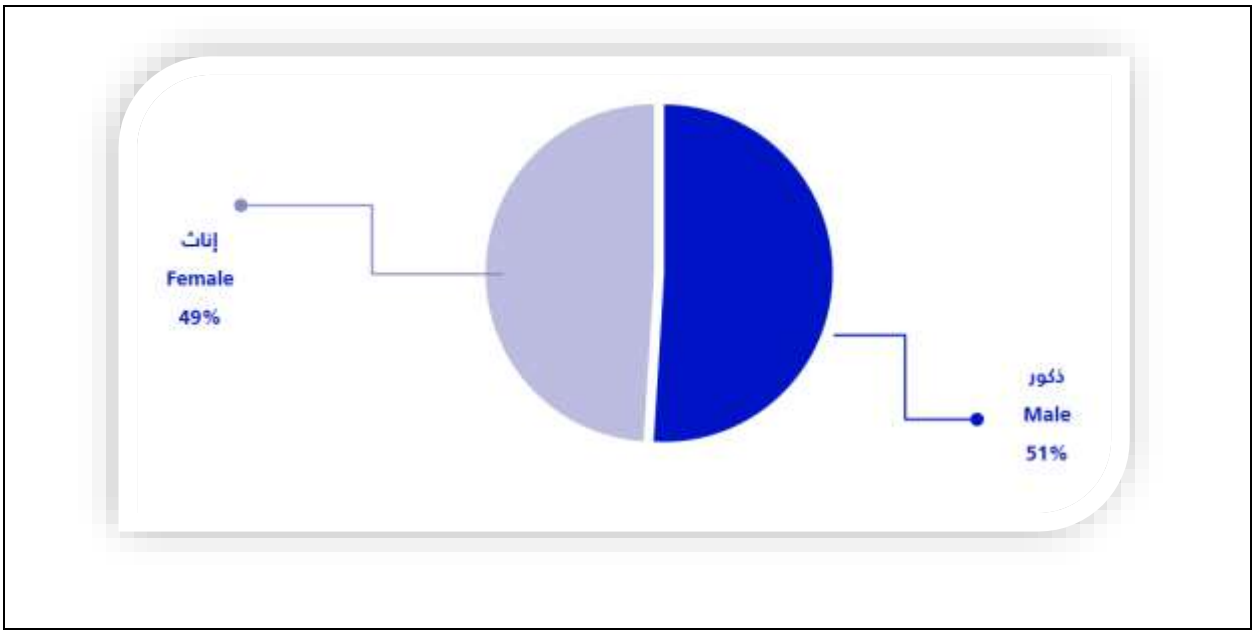

FIGURE 4, PERCENTAGE PER SEX OF THE SAUDI POPULATION USING SIGN LANGUAGE

As a contribution to help the deaf people get involved in the society and integrate with it, we aim to develop a system for a two-way translation of Saudi sign language based on Avatar. This system will be implemented in a carry-on electronic device (laptop, tablet, or mobile) and integrates four basic functions:

1. Recognizes the speech of the normal person and produce the corresponding text.
2. Converts the recognized text of the normal person to sign language and performs this sign by the Avatar. This allows the deaf person to understand the speech of the normal person.
3. Recognizes the sign performed by the deaf person and produces the corresponding text.
4. Converts the text of the recognized sign that the deaf person performed into speech. This allows the normal person to understand the sign of the deaf person.

This system will help the deaf in two ways. First, they can carry with them anywhere they go and use it to communicate with the rest of society. Second, it can be used to teach the deaf the sign language, especially the children.

FIGURE 5 and FIGURE 6 show the proposed two subsystems, the sign language recognition system and the Avatar sign language displaying system respectively.

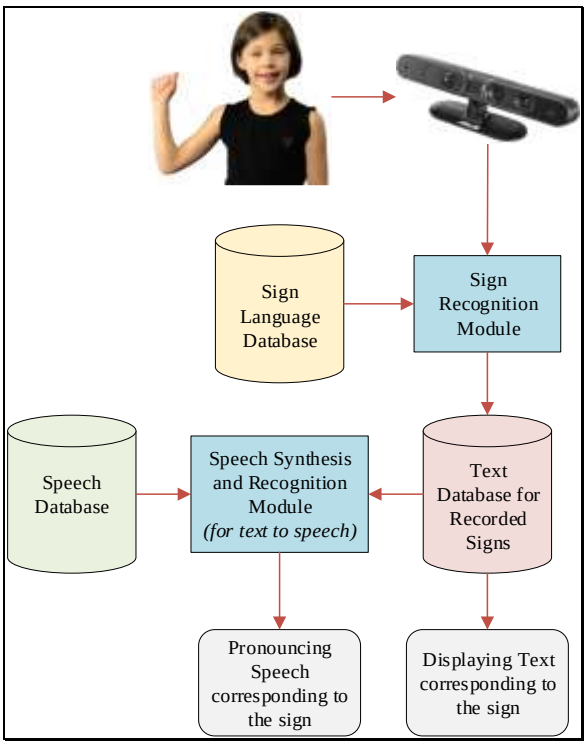

FIGURE 5, PROPOSED SIGN LANGUAGE RECOGNITION SYSTEM

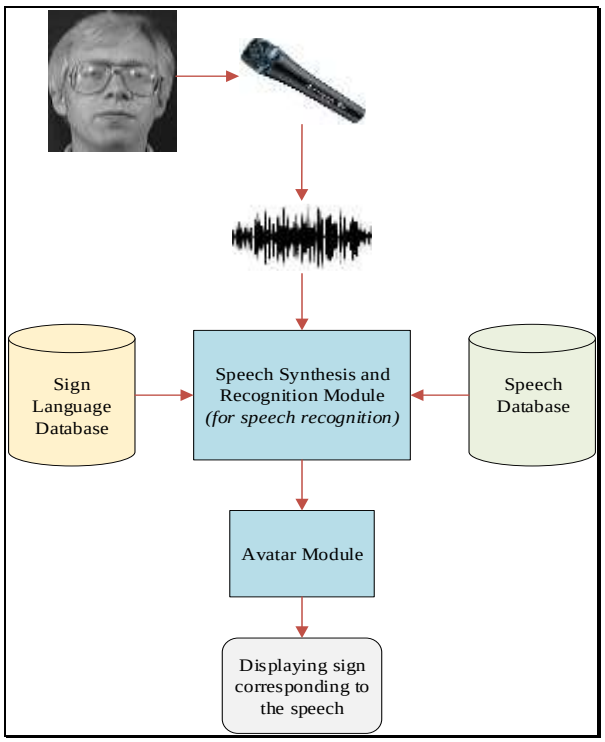

FIGURE 6, PROPOSED AVATAR SIGN DISPLAYING SYSTEM

To build the desired system the project has the following technical objectives:

- Design and development of a Saudi sign language database (SSL).
- Design and development of sign recognition module.
- Design and development of speech synthesis and recognition module
- Design and build of the Avatar module
- Integrate the developed modules

Till now we accomplished the following: built the sign database, built an excellent sign recognition module and published the results in 2 ISI journals developed, built a high-performance Arabic speech recognition module, and designed the Avatar of all the needed signs.

2.1. Objectives accomplishments

As we have presented project has five technical objectives, namely:

- Design and development of a Saudi sign language database (SSL).
- Design and development of a sign recognition module.
- Design and development of speech recognition module.
- Design and build the Avatar module
- Integrate the developed system

In the following section, we will briefly present our accomplishments in each of these objectives.

2.1.1. Design and development of a Saudi sign language database (KSU-SSL)

We designed and are developing a very useful database of Saudi sign language. Great efforts were put in making this database. We can summarize the main characteristics of the database in the following:

- The signs adhered strictly to the Saudi sign language dictionary.
- The selected signs cover most of the signs used in daily life and a selected application field to show the usefulness of the system.
- The selected field is the medical field for its importance and need by the deaf.
- Each sign was recorded in 4 repetitions plus one with painted hands. We started with wearing gloves in both hands then switched to painted hands and fingers.
- Constructed suitable studio with 3 cameras: High speed RGB camera with high fps, IR, and mobile.
- We Recorded deaf, hard-of-hearing, experts, and non-deaf.

- Recording approved by expert attending in person in most cases while in few cases the recording of some part of the signs were attended by remotely by zoom and similar applications.

2.1.2. Design and development of a sign recognition module.

Recording of KSU-SSL allowed us to build the sign recognition module and investigate the best techniques and suggest new techniques. We also used a sign database that we developed before the project, KSU-ASL. Our investigation gave excellent results for dynamic signs, and published the results and the findings in a Q1 journal. We accomplished the excellent results though KSU-ASL which is hard because it was done with few restrictions (distance, height, low FPS, lighting). This work presents a novel system for dynamic hand gesture recognition via a combination of multiple deep learning techniques. The proposed system represents the hand gesture using the local hand shape features as well as the global body configuration features. This way of representation is very efficient for the complicatedly structured hand gestures of sign language. Openpose framework was utilized in this study for hand region detection and estimation. A robust face detection algorithm and the body parts ratios theory were utilized on the other hand for gesture space estimation and normalization

We also did an investigation using the database developed in the project, KSU-SSl, and got excellent results that we published in an ISI journal. The research utilized a latest technique in machine learning which is graph neural networks.

2.1.3. Design and development of the speech recognition module

In this objective, we have developed an Arabic speech to text engine (STT) that is able to convert speech to text. We got excellent results with part and the complete Gale, which is a large speech database containing approximately 1000 hours of recording of Arabic speech. The STT has been tested on the pronounced speech for the signs selected for the project and gave very accurate recognition rate. Further investigation will be conducted to improve the performance of the recognition system.

2.1.4. Design and building of the Avatar module

In this objective, we have developed a functional mobile app Avatar, two virtual characters (man and woman) were designed. Further enhancement is being tackled, for a better character gesture movement.

2.1.5. Integration of the different modules

After finalizing the different modules, we will first integrate the modules for each direction of communication. We will integrate the speech recognition module with the Avatar module to display the signs of the recognized speech. We will integrate the sign recognition module with the speech synthesis module to vocalize the recognized signs. The next step will be to integrate the whole modules in the desired sign translator system. Initial tests were performed and gave very satisfactory performance.

2.2. Publications Impact

The project has significant impact on the lives and communication needs of deaf and hard of hearing in the Arabic speaking world. Due to the similarities between the different sign languages of the world, other researchers from around the world are also using our work to make advances in their respective sign language recognition systems. This is clear from the citations we receive for our work.

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List of Publications

1- Al-Hammadi, Muneer, Mohamed A. Bencherif, Mansour Alsulaiman, Ghulam Muhammad, Mohamed A. Mekhtiche, Wadood Abdul, Yousef A. Alohali, Tareq S. Alrayes, Hassan Mathkour, Mohammed Faisal, Mohammed Algabri, Hamdi Altaheri, Taha Alfakih, and Hamid Ghaleb. 2022. "Spatial Attention-Based 3D Graph Convolutional Neural Network for Sign Language Recognition" Sensors 22, no. 12: 4558. https://doi.org/10.3390/s22124558.

2- Bencherif, Mohamed A., Mohammed Algabri, Mohamed A. Mekhtiche, Mohammed Faisal, Mansour Alsulaiman, Hassan Mathkour, Muneer Al-Hammadi, and Hamid Ghaleb. "Arabic sign language recognition system using 2D hands and body skeleton data." IEEE Access 9 (2021): 59612-59627.

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4- Al-Hammadi, Muneer, Ghulam Muhammad, Wadood Abdul, Mansour Alsulaiman, Mohammed A. Bencherif, Tareq S. Alrayes, Hassan Mathkour, and Mohamed Amine Mekhtiche. "Deep learning-based approach for sign language gesture recognition with efficient hand gesture representation." IEEE Access 8 (2020): 192527-192542.

5- Muneer Al-Hammadi, Ghulam Muhammad, Wadood Abdul, Mansour Alsulaiman, Mohamed A. Bencherif, and Mohamed Amine Mekhtiche, “Hand Gesture Recognition for Sign Language Using 3DCNN,” IEEE Access, vol. 8, no. 1, pp. 79491-79509, December 2020. DOI: 10.1109/ACCESS.2020.2990434

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