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IoT and Sign Language System (SLS)

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Abstract

Deaf dumb students face problems when attending mainstream colleges unless they receive proper help and support. In this paper, an Internet of Things (IoT)-based framework for speech translating into UAE sign language is described. The purposed Sign Language System (SLS) is based on Raspberry Pi (RPi) energized with a power bank, it picks up the speech and translates it into UAE Sign Language in a real domain. This system is composed of Speech Recognizer, Natural Language Processor, and Videos Generator. Speech Recognizer decodes the speech into a written text. The Natural Language Processor splits the written text into a list of words using the syntactic analyzer and extracts the stem of each word using the morphological analyzer. Videos Generator contains a database of Sign Language System (SLS), which consists of 22 categories, retrieves the matching category in the database for each word, and plays the sign video based on the translation rules.

Keywords: Internet of Things, Raspberry pi, Natural Languag processing, Speech Recognizer, UAE Sign Language

I. INTRODUCTION

Nowadays, there is a growing interest in the smart systems using Internet of Things(IoT). IoT plays a critical role in the development of many applications. This paper presents the IoT and purposed Sign Language System (SLS). Natural Language Processing (NLP) is used to build this system. NLP is a subfield of Computer Science that allows computers to understand language in a "natural" way, as humans do. Typically, this would refer to tasks such as understanding the sentiment of text, speech recognition, and generating responses to questions [1]. Face recognition security system using Raspberry Pi which can be connected to the smart home system was proposed [16]. Matlab/ROS/Robot interaction was tested in a generic robot with Arduino Mega and Raspberry Pi 3, demonstrating the viability of the presented educational robotic platform [17]. Bangla Sign language converted to text through customized Region of Interest (ROI) segmentation and Convolutional Neural Network (CNN), five sign gestures are trained using custom image dataset and implemented in Raspberry Pi for portability [19]. A smart glove specifically designed to enable speech-impaired people to communicate with others by translating their performed gesture to speech with the help of machine learning and IoT, hardware-based glove loaded with homemade flex sensor to capture data points and machine learning algorithms to map these gestures to speech dynamically in real time [18]. Avatar Based Translation System for Arabic Sign Language translates the spoken Arabic language into Arabic sign language. The system refers to two sets of databases. The first database contains all the images of the alphabets and words of the Arabic Sign Language (ArSL) and the recorded Arabic words. While the second database called the Avatar database contains the equivalent avatar for each alphabet and word in the ArSL [2]. Mobile-based framework helps Arabic deaf people to communicate easily with virtually any one without the need of any specific device or support from other people. The framework utilizes the power of cloud computing for the complex processing of the Arabic text. The speech processing produces a cartoon avatar showing the corresponding Egyptian Arabic Sign Language on the mobile handset of the deaf [3]. A generator based on an expert-system was used in the translation from Italian to Italian Sign Language, the major steps of the applied algorithm are: segmentation, lexicalization for each message, and simplification of each message [4]. Spanish sign language translation system with new tools and characteristics for increasing its adaptability was developed. Avatar animation module in this system includes a new editor for rapidly design of the required signs [5]. Language translation technologies for generating Spanish Sign Language contains two main systems: the first is for translating text messages from information panels and the second is for translating spoken Spanish into natural conversations. Both systems are made up of a natural language translator (for converting a word sentence into a sequence of LSE signs), and a 3D avatar animation module (for playing back the signs) [6]. Different transformation techniques (Fourier, Hartley, and Log-Gabor transforms) for extraction and description of features from an accumulation of signs' frames into a single image are used, and different classification schemes are tested and compared [7]. SignAll technology depends on Computer vision, Machine Learning, and Natural-language processing algorithms. This technology enables spontaneous communication between a deaf and a hearing individual via automated American Sign Language (ASL) translation technology, and an education component that teaches sign language vocabulary to hearing users [8]. GnoSys application uses neural networks and computer vision to recognize the video of sign language speaker, and then intelligent algorithms translate it into speech. In this application, a deaf person wears a colorful glove and signs to the camera, and the colors on the gloves help the technology to differentiate the fingers [9]. Zayed Higher Organization is working to provide advanced services for people of determination and invest its resources and energies in a positive environment to enable them educationally, functionally, culturally and socially in line with their abilities and aspirations towards effectiveness of community roles and to achieve a social development [10]. A comprehensive review and comparative analysis of the existing IoT application development frameworks and toolkits was done, and it illustrated their strengths and weaknesses. Future research

directions are highlighted to improve the existing and future frameworks and toolkits for IoT applications [13]. IoT can help companies in creating new value streams for customers, speed time to market, and respond more rapidly to customer needs [14]. Face recognition using Genetic algorithm for the smart home security system on Raspberry Pi was implemented [15]. A prototype of Web based Smart Irrigation system was implemented using Raspberry Pi; a web page was developed to display the status of various field parameters such as temperature, humidity and soil moisture [11]. An IoT-based monitoring framework for non-invasive blood glucose monitoring was described, and the generated data was processed by an artificial neural network (ANN) implemented on a Flask microservice using the Tensorflow libraries [12]. An Arabic sign language features extractor with deep behavior was used to deal with the minor details of Arabic Sign Language, and a 3D Convolutional Neural Network (CNN) was used to recognize 25 gestures from Arabic sign language dictionary [20].

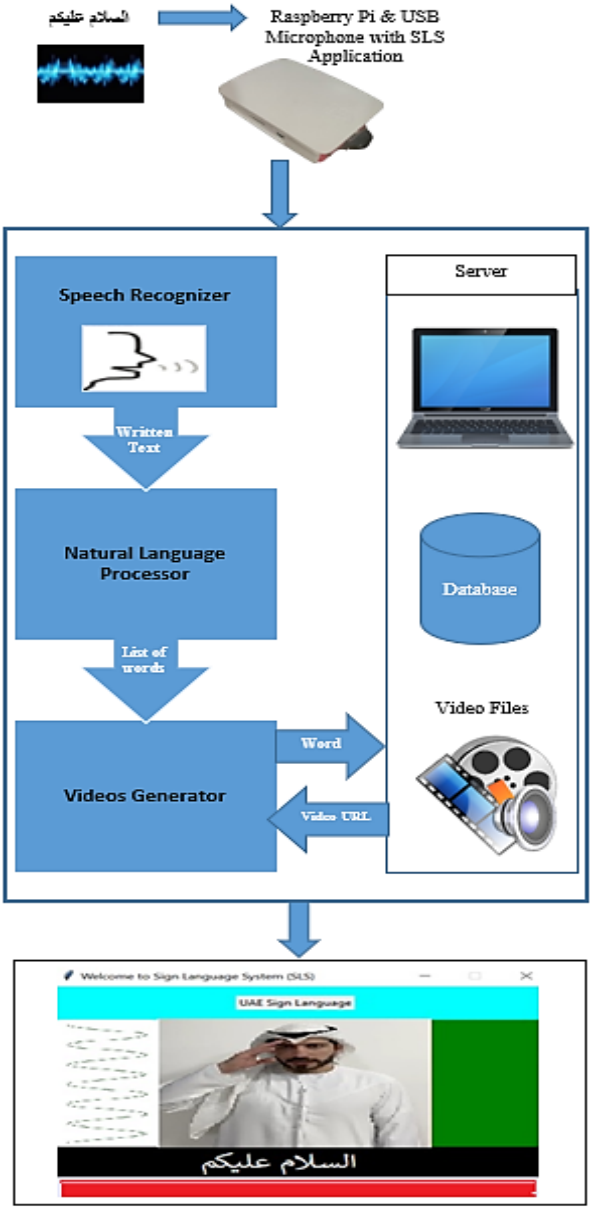

Fig. 1. Architecture of SLS

II. SLS ARCHITECTURE

SLS includes a Raspberry Pi connected to a USB microphone, a screen, and software contains three modules for translating speech into UAE sign language. The first module is the Speech Recognizer for converting the speech into a written text using Google Speech API. The second module is the Natural Language Processor contains syntactic analyzer to split the written text into list of words, and morphological analyzer to extract the stem of each word. The third module is the Videos Generator contains database of Sign Language System (SLS); this database has 22 categories; Alphabets, Numbers, Official Documents, Landmarks and Locations, Ministries, Departments, Clothing and Toiletries, Popular Cuisines, Family, Common Verbs, Attributes and Situations, Directions and Locations, Colors, Household Items, Professions and Jobs, Education, Measurement Units, Health, Environment, Animals, Plants, Sports, and Compound words. Also it has an inference engine to transform each word into a sequence of videos using translation rules to play the suitable matching in the SLS database. Fig. 1 shows the architecture of SLS.

We designed the modules of SLS: Speech Recognizer, Natural Language Processor, and Videos Generator using Python since it has the libraries that are used for speech recognition and natural language processing. We built the database using MySQL, which is a lightweight database management system, and it is used in an Apache server.

III. DATABASE OF SLS

The sign language consists of different elements: body movement / position, facial expressions, and hand / finger shapes. Therefore, the database of SLS contains 22 categories of the UAE sign language stored into videos [10]. Fig. 2. shows these categories. We used MySQL to build SLS database. The database consists of a table that has the following columns:

- SignID: A column which is used to identify each sign and it should be unique (Primary Key)
- SignName: A column, which represents the word after processing the speech by the natural language processor.
- SignVideo: A column, which represents the name of the video file that corresponds to the word in the column SignName. All the video files are stored within the server.
- Category: This column represents the category of the text, which is one of the categories in Fig 2.

SLS database holds the video representation of the UAE signs. Real video files were recorded by an expert person that performs the UAE sign language [21].

Currently, we have 246 signs in SLS database selected from different categories as shown in Fig. 2.

Fig. 2. Categories of the SLS

The data was inserted in the table as in the SQL command below:

- insert into tblsign1(signname,signvideo,category) values("ي", "yaa" ,"alphabets");
- insert into tblsign1(signname,signvideo,category) values("السلام عليكم", "salam" ,"compound words");

Fig. 3 represents a sample of the SLS database system.

IV. SLS DESCRIPTION

The modules of the SLS for translating human speech into UAE sign language are: Speech Recognizer to generate written text. Natural Language Processor tokenizes the sentences; it splits the written text into words and finds the stem of each word. And Videos Generator connects to the database and checks if the word is within any of the existing categories in the database. If the word doesn't exist within the database, the video generator will split it into letters and produce the video for each letter. Otherwise, it will produce the video for each word. Fig4. shows the flowchart of SLS.

signid	signname	signvideo	category
6	السلام عليكم	salam	compound words
7	حل	answer	verbs
8	امتحان	exam	education
9	تمرين	exercise	education
10	أول	first	numbers
11	علامة	grade	education
12	كيف الحال	howareyou	compound words
13	يجب	must	verbs
14	مشروع	project	education
16	عشره	ten	numbers
17	يوم	today	situations
18	بدء	start	verbs
19	محاضره	lecture	education
20	ع	aeen	alphabets
21	ل	lam	alphabets
22	ي	yaa	alphabets

Fig.3. Sample of SLS Database

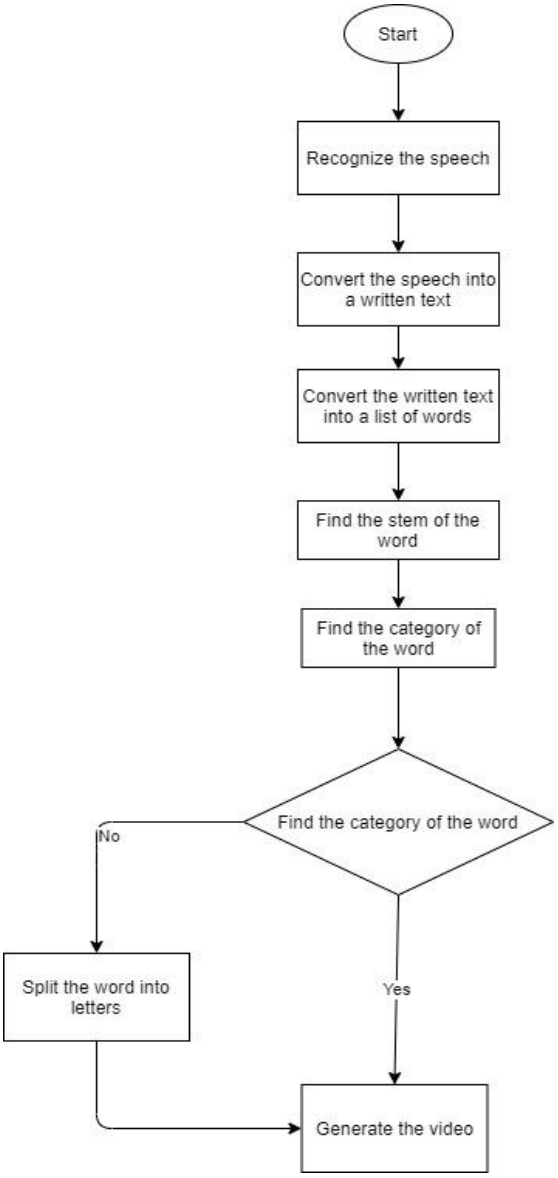

Fig. 4. Flowchart of SLS

V. SLS ALGORITHM

Algorithm of SLS is designed using suitable packages in Algorithm of SLS is designed using suitable packages in Python, Fig5. shows the Sequence diagram of SLS:

1- Build the SLS interface using tkinter package:

```
from tkinter import *
root = Tk()
root.title('Welcome to Sign Language System (SLS)')
```

2- Build Speech Recognizer module to convert natural speech into a written text using recognizeSpeech() function and PyAudio packages in Python to recognize the speech:

```
text = r.recognize_google(audio, language = 'ar-AR')
```

3- Build Natural Language Processor uses nltk package and ISRIStemmer() function to generate the tokens:

```
st = ISRIStemmer()
text = r.recognize_google(audio, language = 'ar-AR')
x=text.split(' ')
print (x)
for a in word_tokenize(text):
print(st.stem(a))
```

4- Build Videos Generator using getVideo(text) function and connect with the SLS database :

```
connection=
pymysql.connect(host='192.168.1.113',port=3306,user='sign_user',password='sign',db='signdb')
```

- Check if there is a category for this word in the database using connection.cursor() function.
- Play the video using playVideo(video) function, If there is not category then split it into letters:

```
if (result==0):
x=text.split(' ')
print (x)
i = 0
while i < len(x):
y=list(x[i])
print(y)
for z in y:
print(z)
cur.execute("Select SignVideo from tblSign1 Where signname='"+z+"'")
rows=cur.fetchall()
for row in rows:
video=row[0]
playVideo(video)
```

- SLS will send the command to the server to play the corresponding URL using playVideo(video):

```
def playVideo(video):
filename="http://192.168.1.113:90/sign_videos/"+video+".mp4"
print (filename)
chrome_path = '/usr/lib/chromium-browser/chromium-browser'.
```

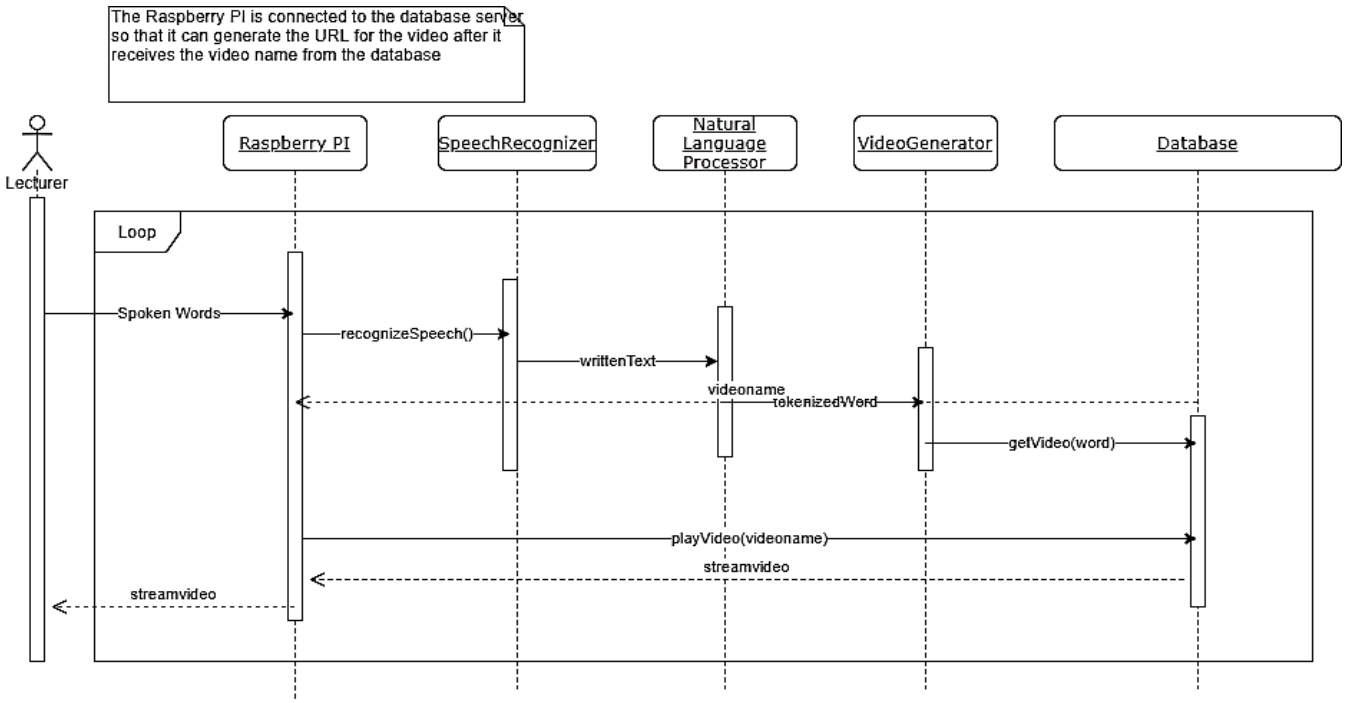

Fig.5. Sequence diagram of SLS

VI. EXPERIMENTAL RESULTS

The following Fig. 6 represents some samples of the SLS system where SLS system recognized the speech at the delay time retrieved results.

entence “First test mark” "علامة الاختبار الاول" :

- Sentence is splited to the list of words
  ['علامه', 'الاختبار', 'الأول']
- Stem of each word is founded ['أول', 'اختبار', 'علامه']
- Corresponding video files are generated.

Noun “ALY” “علي" :

- Word is splited to list of letters ['ي', 'ل', 'ع']
- Corresponding video files are generated for each letter.

Sentence “Today lecture will start” “سنبدأ محاضرة اليوم”:

- Sentence is splited to the list of words
  ['سنبدا', 'محاضره', 'اليوم'].
- Stem of each word is founded ['يوم', 'محاضره', 'بدء'].
- Corresponding video files are generated.

A performance test has been conducted to evaluate the SLS efficiency. Table. 1 shows some tested samples from deferent categories. Delay time was found to get the output of SLS, the accuracy of each sample was calculated as the following:

Accuracy= total of reorganized samples/total samples*100

The accuracy of the Google Speech engine that is responsible for converting from Arabic speech to Arabic text is 92% and the average delay time to display the video is 2.66

Table 1. Tested Samples

Word Said	Category	Accuracy	Delay time
أ	Alphabet	100%	2 sec
ت	Alphabet	90%	2 sec
ث	Alphabet	90%	2 sec
ح	Alphabet	95%	2 sec
س	Alphabet	100%	2 sec
ه	Alphabet	100%	2 sec
ي	Alphabet	100%	2 sec
أحمر	Colors	95%	2.5 sec
أخضر	Colors	90%	2.5 sec
أصفر	Colors	95%	2.5 sec
أزرق	Colors	95%	2.5 sec
أب	Family	80%	2.5 sec
أم	Family	85%	2.5 sec
أخ	Family	80%	2.5 sec
السلام عليكم	Compound words	100%	3 sec
علي	Noun	95%	2.5 sec
محمد	Noun	90%	3 sec
سنبدأ المحاضرة اليوم	Sentences	80%	6 sec
كتب الدرس	Sentences	85%	4 sec
كيف الحال	Compound words	80%	3 sec
عشرة	Numbers	90%	2.5 sec
امتحان	Education	9%	2.5 sec
سامر	Noun	95%	3 sec
حسام	Noun	90%	3 sec

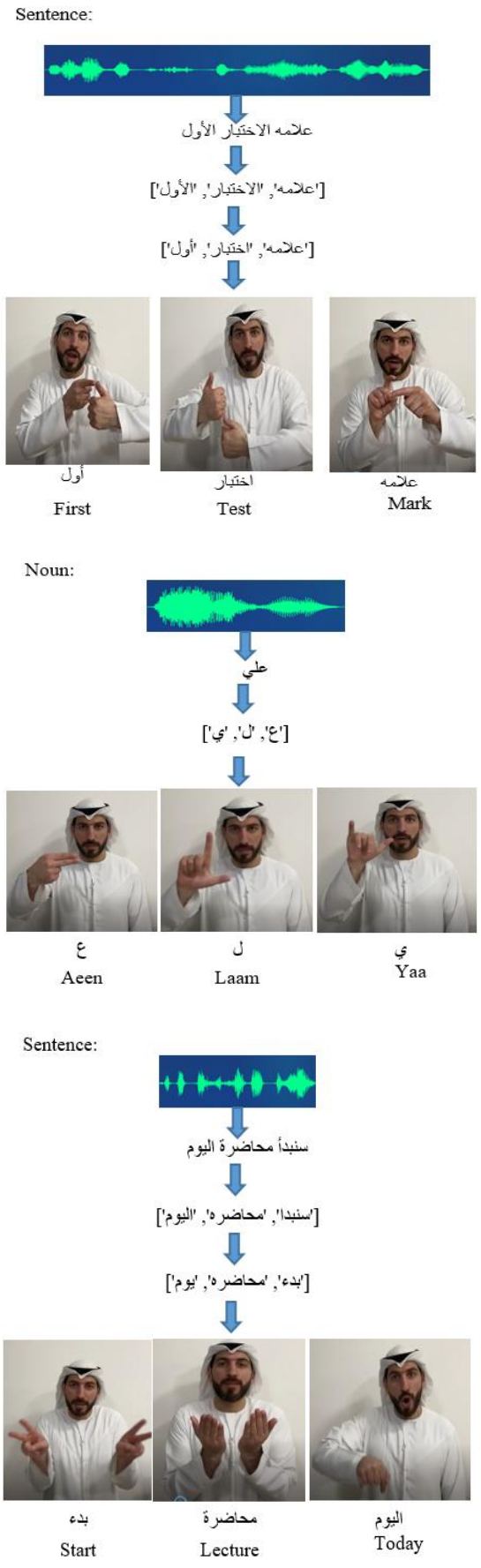

Fig. 6. Some samples of the SLS

VII. CONCLUSION

This paper introduces Sign Language System (SLS) using Raspberry Pi to translate the spoken language into UAE sign language. This system helps the deaf in learning and understanding all the speech around them.

In this paper, we explained SLS architecture; Speech Recognizer to detect the speech, Natural Language Processor to process the text using google speech API to do syntactic and morphological analyses, and Video Generator to connect SLS with the database to generate the corresponding video streams of the UAE sign language.

SLS focuses mainly on the UAE deaf community. Our paper creates a paradigm for future studies of building an automatic Sign language translator for all languages not only for the UAE language because Sign language is widely used by hearing impaired people all over the world.

We recommend that the deaf people must be able to interact with other people by converting their sign language into spoken words.

REFERENCES

[1] T. Beysolow II, (2018) "What Is Natural Language Processing?," in Applied Natural Language Processing with Python, Berkeley, CA: Apress, pp. 1–12.

[2] S. Halawani, (2012) "An Avatar Based Translation System from Arabic Speech to Arabic Sign Language for Deaf People,".

[3] M. M. El-Gayyar, A. S. Ibrahim, and M. E. Wahed, (2016) "Translation from Arabic speech to Arabic Sign Language based on cloud computing," Egypt. Informatics J., vol. 17, no. 3, pp. 295–303, Nov.

[4] A. Mazzei, (2012) "Sign Language Generation with Expert Systems and CCG,". Dipartimento di Informatica Universita degli Studi di Torino ` Corso Svizzera 185, 10185 Torino Italy.

[5] V. López-Ludeña, R. San-Segundo, C. González Morcillo, J. C. López, and J. M. Pardo Muñoz, (2013) "Increasing adaptability of a speech into sign language translation system," Expert Syst. Appl., vol. 40, no. 4, pp. 1312–1322.

[6] V. López-Ludeña, C. González-Morcillo, J. C. López, R. Barra-Chicote, R. Cordoba, and R. San-Segundo, (2014) "Translating bus information into sign language for deaf people," Eng. Appl. Artif. Intell., vol. 32, pp. 258–269.

[7] A. A. I. Sidig, H. Luqman, and S. A. Mahmoud, (2017) "Transform-based Arabic sign language recognition," in Procedia Computer Science, vol. 117, pp. 2–9.

[8] First product in the world that enables spontaneous communication between the d\Deaf and hearing individuals via automated ASL translation

technology, https://www.signall.us/about-us/, signal.us for sign language,2016.

[9] 'New AI app for deaf translates sign language into speech in real time, (2018) 'Press Trust of India | New Delhi Last Updated at October 25.

[10] A Sign Language Dictionary, Zaid Higher Origination for people of determination, UAE, (2019) https://zho.gov.ae/ar/UAESignLanguageDictionary/Pages/default.aspx,2019

[11] Sunehra, Dhiraj, (2019) "Web Based Smart Irrigation System Using Raspberry Pi." International Journal of Advanced Research in Engineering and Technology 10 (2). IAEME Publication: 55–64. doi:10.34218/IJARET.10.2.2019.006.

[12]. Alarcón-Paredes, Antonio, Victor Francisco-García, Iris P. Guzmán-Guzmán, Jessica Cantillo-Negrete, René E. Cuevas-Valencia, and Gustavo A. Alonso-Silverio, (2019) "An IoT-Based Non-Invasive Glucose Level Monitoring System Using Raspberry Pi." Applied Sciences (Switzerland) 9 (15). MDPI AG. doi:10.3390/app9153046.

[13]. Udoh, Itorobong S., and Gerald Kotonya, (2018) "Developing IoT Applications: Challenges and Frameworks." IET Cyber-Physical Systems: Theory & Applications 3 (2). Institution of Engineering and Technology (IET): 65–72. doi:10.1049/iet-cps.2017.0068.

[14] Wahi, Ashok Kumar, and Vandana Ahuja, (2017). "The Internet of Things - New Value Streams for Customers." International Journal of Information Technology and Management 16 (4). Inderscience Publishers: 360–75. doi:10.1504/IJITM.2017.086863.

[15] Subiyanto, Subiyanto, Dina Priliyana, Moh. Eki Riyadani, Nur Iksan, and Hari Wibawanto, (2020) "Face Recognition System with PCA-GA Algorithm for Smart Home Door Security Using Rasberry Pi." Jurnal Teknologi Dan Sistem Komputer 8 (3). Institute of Research and Community Services Diponegoro University (LPPM UNDIP): 210–16. doi:10.14710/jtsiskom.2020.13590.

[16] Gunawan, Teddy Surya, Muhammad Hamdan Hasan Gani, Farah Diyana Abdul Rahman, and Mira Kartiwi, (2017) "Development of Face Recognition on Raspberry Pi for Security Enhancement of Smart Home System." Indonesian Journal of Electrical Engineering and Informatics 5 (4). Institute of Advanced Engineering and Science: 317–25. doi:10.11591/ijeei.v5i4.361.

[17] Rosillo N., Montés N., Alves J.P., Ferreira N.M.F. (2020) "A Generalized Matlab/ROS/Robotic Platform Framework for Teaching Robotics". In: Merdan M., Lepuschitz W., Koppensteiner G., Balogh R., Obdržálek D. (eds) Robotics in Education. RiE 2019. Advances in Intelligent Systems and Computing, vol 1023. Springer, Cham.

[18] Shanbhag, V., Prabhune, A., Choudhury, S. R., & Jain, H, (2020) "GestTalk—Real-Time Gesture to Speech Conversion Glove". In Advances in Intelligent Systems and Computing (Vol. 1016, pp. 391–400). Springer. https://doi.org/10.1007/978-981-13-9364-8_28

[19] Khan, Saleh Ahmad, Amit Debnath Joy, S. M. Asaduzzaman, and Morsalin Hossain, (2019) "An Efficient Sign Language Translator Device Using Convolutional Neural Network and Customized ROI Segmentation." In 2019 2nd International Conference on Communication Engineering and Technology, ICCET 2019, 143–47. Institute of Electrical and Electronics Engineers Inc. doi:10.1109/ICCET.2019.8726895.

[20] Elbadawy, Menna, A. S. Elons, Howida A. Shedeed, and M. F. Tolba. (2018) "Arabic Sign Language Recognition with 3D Convolutional Neural Networks." In 2017 IEEE 8th International Conference on Intelligent Computing and Information Systems, ICICIS 2017, 2018-January:66–71. Institute of Electrical and Electronics Engineers Inc. doi:10.1109/INTELCIS.2017.8260028.

[21] Hussam Eid, (2020), Sign Language Translator, Khawarizmi International College KIC, AD, UAE.