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Realization of Turkish Sign Language Expressions with the Developed Humanoid Robot

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Abstract

Given the potential of the developed technology, it has been increased the impact on human life in many areas. This is an indication that one of the newest technological outputs in education, health, and many other fields is now widely used as a vital component of humanoid robots. The humanoid robot is one of the main innovations used as auxiliary equipment especially in the field of education and even in the language learning process. The most obvious example to be given to this situation is that the humanoid robot is used for the education of speech and hearing-impaired individuals, with successful results in sign language learning. There are a series of studies on Turkish sing language (TSL) that only professional ready-made has been used so far and no sign language studies have been carried out with any humanoid robot developed accordingly. Within the scope of the study, some expressions in TSL were carried out with the developed humanoid robot, whose design and software were originally developed. In all statements made, a high success rate was achieved. The study aims to develop a humanoid robot that can be developed, including original design and software elements, as well as to use where necessary, the developed humanoid robot as an educational instrument, or as a useful tool to enable individuals affected by hearing and speech to participate more closely in daily life.

Keywords: *Sign Language, Humanoid Robot, Human-Robot Interaction*

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1 Giriş

Hearing and speech impairments individuals use sign language (SL) for communication with each other or other people. SL contains hands gestures, body movements, and facial mimics to represent expressions. It is like spoken languages, and it differs countries and cultures. The bulletin was published by the Republic of Turkey Ministry of Family, Labor, and Social Services that there are approximately 1.5 million hearing and speech impaired individuals in Turkey [1]. Besides, it is stated that approximately 466 million people are hearing impaired [2]. The technology is used for this purpose. The developed humanoid robots have been used in a second language [3]. The learning of SL is more important especially for the hearing and speech impaired individuals, because of that the development of cognitive functions and academic success [4, 5].

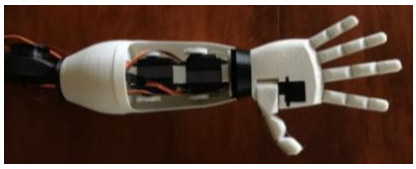
According to some studies conducted, it was mentioned that the use of humanoid robots gives more sufficient results than computer-based education systems [6, 7]. There have been some studies conducted that humanoid robot is performed to teach SL. In one, these studies were conducted in 2017 that humanoid robots used for teaching Indian Sign Language (ISL) [8]. The other one was performed to teach Spanish Sign Language (SSL) in 2019 [9]. In 2018 there was another study conducted to perform Malaysian Sign Language (MSL) [10]. The last one was conducted in 2019 to perform Persian Sing Language (PSL) [11].

In Turkey, to date, Kose and her colleagues have been conducted a series of studies to perform Turkish Sign Language (TSL) with the humanoid robot. In the first study, it was particularly used professional humanoid robot. This humanoid robot is the Nao H25. It was examined to the effect of the humanoid robot on TSL learning [12]. In the ongoing studies, human-robot interaction was examined with the game components. In these studies, the Robovie R3 and the Nao H25 professional humanoid robots were compared in 2014 and 2015 [13, 14]. The last study was conducted in 2019 and in this study, the Hidden Markov Model (HMV) was used to simulate participants' gestures [15].

The usage of the humanoid robot is proved with these studies. In addition to this, there were only in some of these studies that humanoid robots developed. In the most of other studies, the professional humanoid robot was used such as the Robovie R3 or the Nao H25. In this study, the humanoid robot was developed and used for the TSL expressions. In the study, there are respectively the developed humanoid robot, the developed integrated software, results and discussion, and conclusion and future aspects parts.

1 The developed humanoid robot

The developed two-armed humanoid robot was named EC-Tema in honor of the great Muslim inventor Ismail Al-Cezeri who lived in the 12th century. The EC-Tema humanoid robot was printed 3D printer and it has 23 degree of freedom (DoF). At first stage the referenced humanoid robot arm was used than after examination, it was noted some deficiencies. According to these deficiencies, the humanoid robot was developed and the study continued with the other body parts.

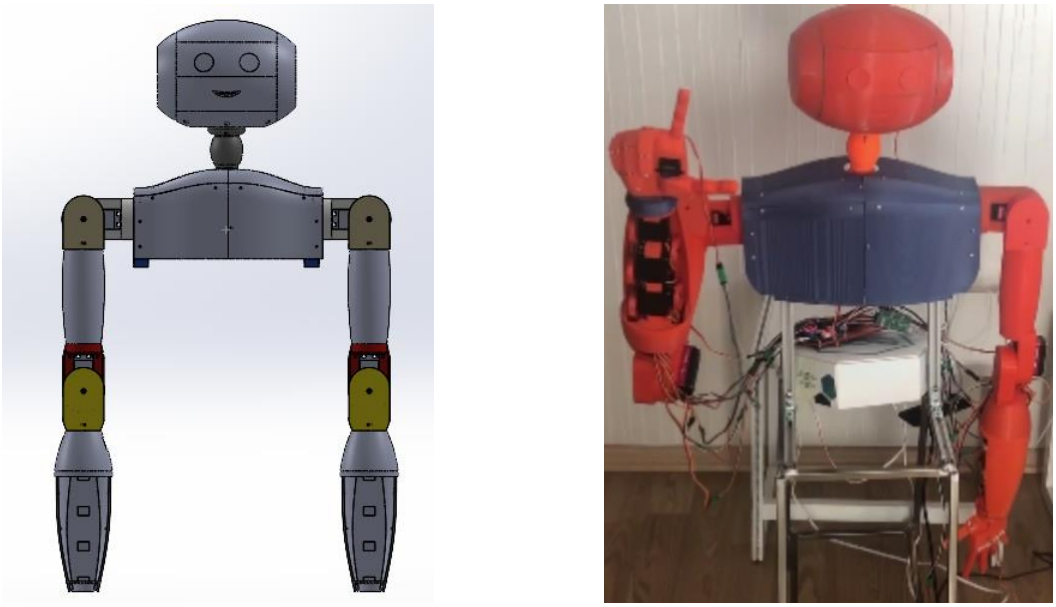


a) referenced humanoid robotic arm

b) developed humanoid arm

Figure 1. The first part of humanoid robot

The longer humanoid robotic arm gave more effective results than the other humanoid robots [9]. According to this, upper arm of the humanoid robot was developed and the other body parts was developed with real like dimension (figure 2).



a) The developed humanoid robot b) The printed humanoid robot

Figure 2. The printed EC-Tema humanoid robot

The wrist and shoulder parts need more torque force to run for this purpose the stronger servo motor was used in these joints. The each of EC-Tema arm has 10 DoF properties and the remaining 3 DoF is in the head part. For this EC-Tema humanoid robot, the special servo horn was developed to control especially finger joints.

1.1 The developed integrated software

For the controlling humanoid robot, the Python and the Arduino software were used together. The speech of normal people was recognized and converted to text than send to the Arduino to control servo motors. The Google Speech Recognition (GSR) library was used for this study. If there is not any online option, in the prepared software user can use input text option to give command. The system was performed in both conditions, online and offline. The success of speech recognition library (SRL) is related to low Word Error Rate (WER) option [16].

$$WER = \frac{S+D+I}{N} \quad (1)$$

Where "S" is the substitutions number, "D" is the deletion number, "I" is the insertion number, and "N" is the word number in the reference. In the one of the studies conducted, some SRL were compared and the GSR library error rate was 9% [16]. In the another one conducted in 2020, the remarkable results were obtained too. In that study, the GSR results were more successful than any others [17].

2 Results and discussion

In this study, the design stages of the humanoid robot developed for the representation of TSL expressions were discussed. Within the scope of the study, the robotic arm, which was taken as a reference first, was examined, and existing deficiencies were corrected. The upper arm compatible with the developed robotic arm was developed by taking the real dimensions of a human as a model. Care was taken to ensure that the whole developed arm was the closest to normal human size. With the development of the right and left arms, the humanoid robot should be developed in addition to the skeletal structure and chest structure, as well as the head structure too. The caricatured facial expression with its unique design was developed on a humanoid robot. It has been proven that expressions made with a humanoid caricature face and life-size human arms are more successful than expressions made with other humanoid robots [9, 18].

With the EC-Tema humanoid robot developed within the scope of the study, some of the basic numbers found in TSL were demonstrated. 11 numbers between 0 and 10 were displayed. All of the number expressions realized were executed very successfully. When the numbers performed with the humanoid robot arm were examined, it was found that some number expressions were not sufficiently realized. Especially when the numbers 2 and 7 are displayed, while the index and middle

fingers are used, the two fingers specified in the number 2 are spaced, and when the number 7 is specified, the fingers must be adjacent.

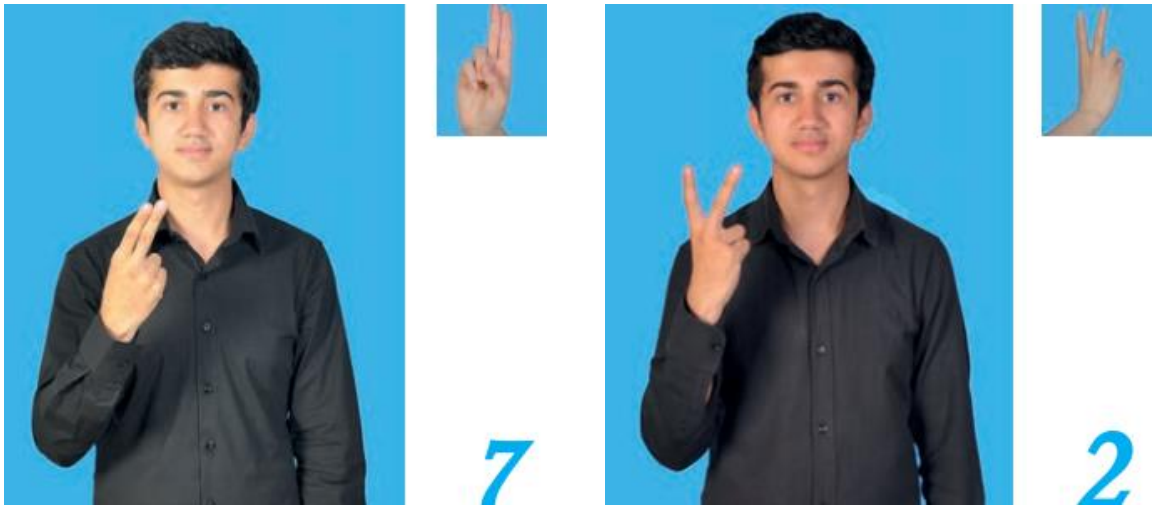


Figure 3. The number of "2" and "7"

On the other hand, it was stated that there was not enough finger flexion in the developed humanoid robot, and this distinction was not accepted by some participants. However, a similar issue was noted in the 6 issues, which was represented. Some participants stated that the movement was not performed correctly due to the lack of wrist flexion while performing the number 6. Each of the 11 issues carried out was accepted by at least half of the participants. Except for the insufficient flexion movements, which were detected especially in the 7 and 6 numbers, almost all the participants stated that all the other numbers were done correctly. For the numbers 6 and 7 stated only, close to half of the participants agreed that the movements were done correctly.

The developed humanoid robot is in the prototype stage and is in the development process. In case the development stages are completed, the EC-Tema humanoid robot can be used as an educational tool for the learning of sign language for the hearing and speech impaired individuals by recognizing the voice of normal individuals, especially by recognizing the voice of normal individuals, and to increase the participation of hearing and speech impaired individuals in social life. It is aimed to be used as an interpreter or as a tool in the application center in institutions that provide public services.

Figure 4. EC-Tema represents the "3" number.

This EC-Tema design is unique and this project aims to contribute to speech and hearing impairment people's communication problems. The EC-Tema humanoid robot is controlled by GSR sound processing. One of the representing of the EC-Tema humanoid robot is shown in figure 4.

3 Conclusion

As it is mentioned in this study, speech and hearing impairment people still have difficult communication problems, especially with normal people. In this study, we examined current studies

and we have found fewer studies related with especially in Turkey and with the technological solutions. According to this, we prepared a humanoid robot to represent signs that communicate with speech and hearing-impaired people. This EC-Tema humanoid robot is controlled by GSR sound processing. In this study, we have gotten successful results.

In Turkey, just a few studies have been done with ready-made professional robots such as Robovie R3 and the Nao H25. On the other hand, we aim to design the new unique humanoid robot. This study is hoped to contribute robotic technology for solving problems for the benefit of society.

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