Real-time Remote Control of Robotic Hand System - TeleTouch

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Abstract - **Robots offer an efficient way as assistive devices to perform many errands. In this study, it is aimed to present a proof-of-concept robotic system that is called TeleTouch. TeleTouch allows mimicking user's fingers motions/gestures to be transferred in a desired remote location within an acceptable delay. In the implementation, Leap motion sensor, RaspberryPi, and Arduino kits are used. Hand model that is manufactured by 3D printers is actuated by Arduino system which drives the servo motors connected to the hand model. RaspberryPi is used not only for transferring camera view of the hand model to the controlling remote system but also for transferring fingers attributes to the Arduino system. A special software is developed in .Net platform to gather the user's attributes of the fingers from leap motion sensor. Delay times of the local and remote system are investigated and it is understood that proposed system successfully transfer motion in almost real time.**

Keywords – **robotic hand, real-time control, leap motion**

I. INTRODUCTION

THE efforts of mankind to facilitate lifesytle are based on their first years of existence. These struggles, which are anticipated as the design of new hunting tools in the Stone Age; continued as mechanization and nowadays it has reached such a dimension to produce with robots and computer-aided automation. So, machines are being designed that can either replace humans for some works or help alleviate their burden ensuring a quality and fast production. The next step in robotics in production industry is the design and usage of humanoid robots widely. Recent studies [2-8] in literature clearly show a rapid developments in the field today. Of course, these developments will also be reflected in the exploration of humanoid robot development in the near future, as well as in all areas [1].

In this study, it is aimed to develop a system that could be used in different application fields in order to contribute to the technological developments. In the proposed study, an integrated structure has been developed that uses image processing to interpret human movement. In this system, image processing technique is used without the need for any gloves or sensors unlike the reviewed studies in literature. The developed system stands out with its potential to be widely used in remote control systems as well as providing innovation in different areas of technology.

The rest of the paper is organized as follows. In Section II, details and scope of the project is given. Section III introduces the proposed methodology. Section IV investigates the results of the study. Finally, conclusions are summarized in Section V.

II. SCOPE OF THE STUDY

In the proposed study, it is aimed to develop software and the mechanical system which enables real hand movements to be imitated simultaneously by the robotic hand. In the system, hand movements are read from Leap Motion, and the collected data is transmitted to robotic hand via TCP / IP protocol. The robotic hand is connected to the processor and assessed for live hand images. The movements of hand is captured and imitated to perform the same movements. Thus, a robotic hand control system has been developed to apply remote controlled hand movements on an individual basis. The user panel has the ability to send the environment images, temperature and humidity data, and the degree of cushion stiffness it touches. Use of this kind of systems open up new possibilities such as bomb disposal, unmanned exploration, surgical operations and so on.

III. METHODOLOGY

The design of the system consists of three basic stages. The first stage includes the user interface software, which is developed in C#. The second stage is the one where the finger and hand gestures are sensed and converted to values. The image data are transferred via the TCP / IP protocol Internet. Finally, the Arduino platform is used to read sensor values and control of the servo motors. First of all, the user plugs Leap Motion to the computer. Then it starts the application. Whenever the user moves his/her hands and fingers, hand information is read and interpreted by the application. Later, the user specifies the IP address of the device he/she wants to connect to and then connects to the remote device (to a server). The remote device is actually a small computer, an embedded-system card, called RaspberryPi. Alternatively, other cards such as BeagleBone may be used. The most important feature of these cards is to have an operating system (Linux) embedded in them. With this operating system, it is possible to run complex programs that microcontrollers can not run. In this context, the Python code in RaspberryPi responds to requests to connect over IP (clients). After the

connection, the Arduino card virtually connected to Raspberry Pi reads the sensor values via the serial port and the environmental information is sent to the interface. These values are plotted in real time on the interface. Hand and fingers data from the interface are also sent to Arduino in the same way. These are converted to PWM waves for robot hand control and are provided for hand movement. In addition, the user interface from the camera on the robot hand goes to the camera image and the media data read from the sensor. Flowchart of the program looks as shown in Figure 1

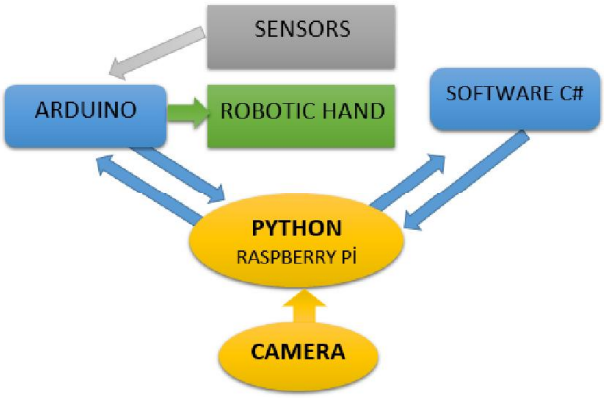


Figure 1: Flowchart of the program.

A. Leap Motion

Leap Motion is used to transfer live hand movements to the computer. Leap Motion is an electronic device marketed by Leap Motion company in 2012 to detect movements of the hand and fingers, seen in Figure 2. The working principle of Leap Motion is based on infrared lights, cameras and optical lenses. The light scattered at an angle of 150 degrees on the Y axis is returned to the camera and processed. It can measure between about 25 cm and 60 cm.



Figure 2: Leap Motion

Leap Motion uses a 3-dimensonal axes. The X and Z axes operate in the horizontal plane while the Y axis is in the vertical axis. Y axis tells the height of the hand from Leap Motion. X axis is the right and left information, and Z axis is the distance from the hand to Leap Motion. There are four main factors in the operation of Leap Motion device. These factors are listed below.

- Distance: millimeters
- Duration: microseconds
- Speed: millimeters / second
- Angle: radian

The coordinate information must be transferred to the computer by a mapping method. It is necessary to know and adjust the angles of field in Leap Motion. The image to be captured in this area will take on the shape of an inverted pyramid [9].

Developed software can detect hand movements instantly by courtesy of the introduced hand patterns. The generic functions available for hand movements are found in the Hand library. Leap Motion gives us the information of the fingers and hand. The system can also detect partially available information.

B. Developed Software in Python

In this study, the Python language is preferred for the program that will run on a Linux computer, RaspberryPi. Python is a popular programming language in the world because it is easy to use with RaspberryPi.

C. Developed Software in C#

The C # programming language is preferred to develop a user-friendly interface to run Leap Motion. Main reason for the preference of this programming Language is due to its useful SDK. Figure 3 show the user interface of the software.

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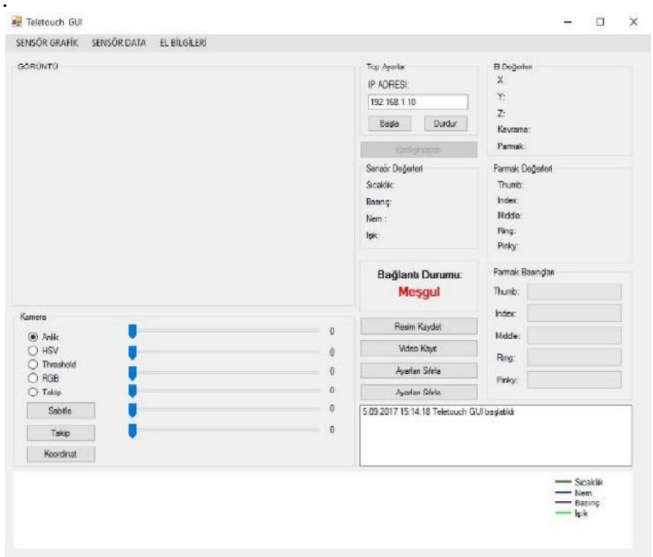


Figure 3: User interface of the software.

In order to move the finger of the robot hand, it is first necessary to detect and take movement data of the user's fingers. Leap Motion enables to use the vectors of bones on the fingers. According to anatomical research related to bones, when the hand is twisted, the twist angle can be measured between the proximal and intermediate bones. The vectors of these two bells and the angle between them are given in Figure 4.



Figure 4: Angles between bones of the user's finger.

The angle is calculated using formula given below.

$$\alpha = arccos\left((\vec{u} \cdot \vec{v})/(\|\vec{u}\|\|\vec{v}\|)\right) \quad (1)$$

D. Arduino Hardware

Arduino Hardware Platform is preferred for electronic circuit installation in the study. Because Arduino Hardware Platform is very useful for rapid prototyping and it is an open source platform. Also printed circuit (PCB) design of the electronic circuit is realized for comfortable using. This design is shown in Figure 5.



Figure 5: PCB schematic design of the hardware.

IV. Results and Discussion

One of the most important factors in system operation is how long it takes to send the hand movement commands. In the experimentation, the Arduino kit receives the data and echoes it after turning the servo motor. Then, the program in .Net platform sends command, and start a timer and measure the time elapsed. Later, the measurement is divided by 2, and certainly there exists a delay on virtual transmission line. Results of time delay at different experimentations are shown in Figure 6.

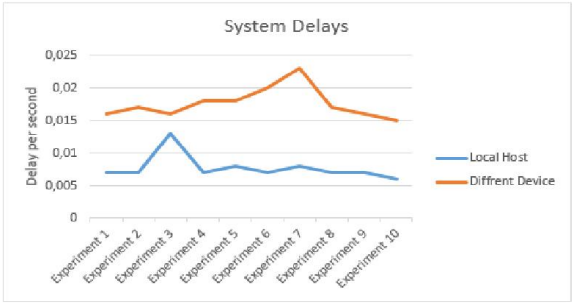


Figure 6: Time delay at different experimentations.

As a result of several experimentations, it has been observed that the average latency in the local host was 7.7 miliseconds. The delay in the RaspberryPi has been measured as 17.6 miliseconds. It has been determined that the delay in the system is mostly caused by the servo motors.

The implemented system has the possibility to take the data in three dimensions. With Leap Motion, hand depth and movement information of hand can be taken.

V. Conclusion

On the running system, the user can control the robotic hand system via TCP / IP without any glove or sensor from the C # interface. Sensor values such as humidity, temperature, pressure from the robotic system, and camera images are also displayed at the interface. The targeted live imitation has also been successful. This will enable the system to be used in many areas such as bomb disposal, unmanned exploration, surgical operations and so on and also it will open up new future developments.

Acknowledgment

This project got prize in six different competition as follows:

- TÜBİTAK - 48th Secondary Students Research Projects Competition Coding Category - Istanbul Asia Region- First Prize
- Marmara University Mechatronics and Innovation Days Freelance Category- Second Prize
- Okan University Engineering Competition Mechatronics Field- First Prize
- TÜBITAK - 48th Secondary Education Students Research Project Competition Coding Category – Turkey- Second Prize
- Çekmeköy Municipality ALIYA IZETBEGOVIC International Science Olympics Technology Category- First Prize
- International Informatics Science and Applications Project Competition- First Prize

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