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Design and Interfacing of Tactile Feedback with Virtual Environment

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Abstract: We, humans, use the sense of touch in our everyday physical interaction and manipulation tasks. The tactile feedback is important because if the user press anything or touches anything and if it does not give any response then the user will not be able to know whether his command is being processed or not and such behavior often causes multiple unnecessary operations. We have developed a customized haptic glove for virtual interaction with a force feedback mechanism. Our proposed methodology comprises Velcro/fiber with soft pneumatic and vibrotactile actuators, leap motion sensor, and Arduino Uno. The haptic glove is integrated with a Graphical User Interface (GUI) based virtual hand model in a unity graphics engine. Through the proposed software and hardware setup, we successfully interacted with virtual pushbuttons and cube manipulation and obtained satisfactory force response. We are confident that our proposed software/hardware framework will serve as guidelines to new students aiming to design fully functional haptic glove

Keywords: Haptics, Virtual interaction, GUI, Actuator, Arduino, Unity, Tactile Feedback

I. INTRODUCTION

Haptics is defined as the science and technology of understanding information through the sense of touch. Haptics is a technology which provide sense of touch by applying force, vibration, and motion feedback. Over the last few years, Haptics popularity has increased, as a feedback that helps improve the human experience. Nowadays, Haptics is used in vast variety of applications. Some of the fields where haptics is used include Virtual Reality Systems, education, medicines, rehabilitation, etc. A lot of devices have been built that provide feedback according to the type of application. With the assistance of Haptic device individuals get a feeling of touch with computer generated environments, so that when virtual objects are contacted, they seem to be real and substantial. [1]

The use of touch to communicate is known as Haptic Feedback. It is basically a mode of communication and is nothing less than a new way for humans and machines to communicate.[2]

There are two types of haptic feedback i.e., Tactile, and kinesthetic. Tactile sensations are the things that a person feels on the fingers. The tissues in fingers have several numbers of sensors fixed in the skin, they permit the brain to feel things for example: pressure, touch, texture, vibration and so on. Tactile feedback mechanisms respond to contact, recreating a sensation of tapping.[3]

Kinesthetic feedback refers to the perception of limb movements and position and is often broadly defined to include the perception of force as well. It is responsible for recording peoples body position and movements in relation to itself.

Enormous work has been done in simulating haptic tactile feedback designs – both hardware based and software. In [4], the author proposed a haptic button based on inductive sensing. For delivering customize pushbutton feedback. Similarly, [5] has developed a haptic knob of varying rotational stiffness. Theses haptic buttons and knobs are used in designing haptic simulators e.g., flight simulator [6]. However, these methods require physical hardware to simulate force feedback which may always not be possible. Therefore, we proposed an alternative strategy for simulating haptic feedback using virtual environment with minimal hardware components. In this regard, the significance of this work is. (1) We developed a GUI which contains Hand, Button and Cubes. (2) We interfaced the GUI with the Arduino and Motion Sensor. (3) We developed a customized Pneumatic actuator.

The structure of paper is as follows: (1) Section II describes technical details (2) Section III describes the proposed methodology (3) Section IV describes the conclusion of the project.

II. TECHNICAL BACKGROUND

Arduino:

Micro-controller is often referred as the brain of the machine. It executes specific program to communicate with the hardware and make decisions. It uses several pins to communicate with the hardware and makes them ON and OFF through programming. A microcontroller can be used to operate small motors, actuators, and other devices.

The Arduino uno is good for basic learning. It has 14 digital IO pins, 6 analog inputs pins, a 16 MHz resonator, a USB connection, a power jack, an ICSP header and a reset button. They are used in smaller projects as they have small memory and cannot store large arrays.

Fig. 1: Arduino Microcontroller[7]

Leap Motion:

Leap Motion. It tracks hand and finger joints and save them in position and rotation matrix, kind of like a mouse, however not requiring any physical contact. It is Universal Serial Bus power-driven. Leap Motion is a high accuracy device.

Leap motion uses AI and Computer vision technique. Leap motion contains three infrared sensors and two cameras, these are used to make a depth image of whatever is present in its ROI (Region of Interest). Then using this image, it finds the hand using Convex Hull Algorithm to find the Contour which make a contour of hand, and this contour is further used to track the joints.

Fig. 2: Leap Motion [8]

Unity:

It is a platform for virtual reality systems and used for game development. We have used this to control all the models by interfacing with hardware. Unity provide support to build and deploy games on various platforms such as android, windows, iOS, or can be directly run using html file on web browsers.

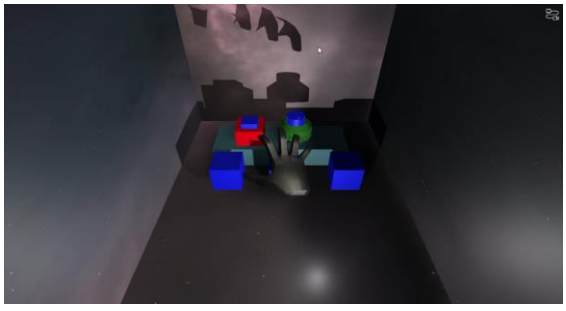

Fig. 3: Graphical User Interface.

Pneumatic Actuator:

We have made a balloon like structure which is called as soft pneumatic actuator. We made it from a plastic material and attached an air flow pump which pumps air in it and fills it as soon as the hand fingertips of our model in unity collide with any object.

Fig. 4: Pneumatic Actuator

Air PumpMotor:

Air pumps are the devices that take away air from a blocked space or use closed space to add air.

Fig. 5: Air Pump Motor [9]

Solenoid Valve:

A valve is used to guide the air flow in the system, from the pump to the actuator. It is a three-way valve that is operate on 12 volts DC. On one end of valve, the pump is connected and on the other end the actuator is connected, the third way is kept open to release the air.

Fig. 6: Solenoid Valve [10]

DC Switching Relay:

The relay is the device that opens or closes the contacts to cause the operation of the other electric control.

It works on the principle of an electromagnetic

attraction. The closing and opening of the connections through relay armature are achieved through the magnetic field. Control coil is wounded on the relay's iron core. Current flowing through this coil will generate magnetic field

Fig. 7: DC switching Relay [11]

III. Proposed Methodology

First, a Graphical User Interface was developed in Unity Editor (2019 version), then blender was used to make models for dashboard (cockpit) and hand and import the models in unity. After that, we had the task of hand and finger movement detection.

Leap Motion device was used to detect the movement of hand and fingers. It detects the movement of hand and fingers through the three infrared sensor LEDs and two cameras. We integrated the Leap motion with Unity through the unity core assets package and the Leap motion interaction engine. We used the SDK documentations to develop the understanding of how human hands are tracked and how the co-ordinates are obtained.

After the hand is detected and its coordinates are obtained, actuators were used to provide feedback of desired nature. The actuator is controlled using the Arduino microcontroller. The interaction is detected by the unity collision detection component and a signal is send to the Arduino to activate the actuator.

The functional video can be seen here: https://youtu.be/b8r5gvw9O7U

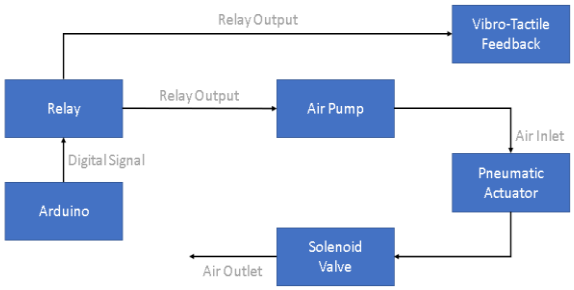

Fig. 8: Block diagram of proposed approach.

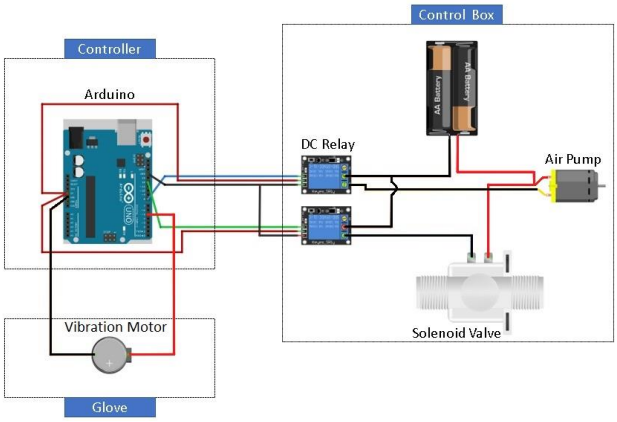

Fig. 9: Schematics of proposed approach.

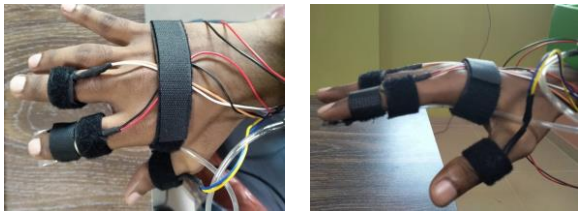

Fig. 10: Actuator's setup on Hand.

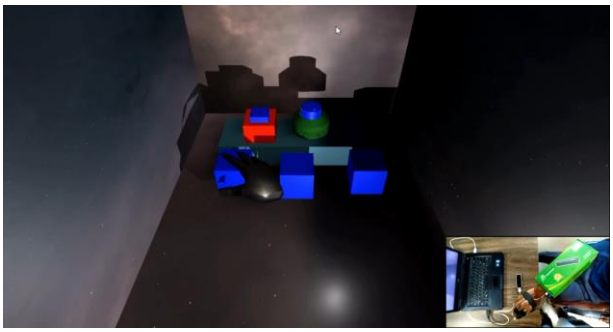

Fig. 11: Final game User interaction.

IV. CONCLUSION

The virtual interface (GUI) has been developed and the interfacing between the hardware with the GUI has been done. We have used Blender for modelling. Then import it in the unity and interface it with the script of rigged Hand in the unity which tell the position and orientation of the hand which is detected by the camera and infrared of leap motion. We have interfaced the values from the Arduino with the Unity software through Uduino package.

This project can be used for medical Rehabilitation, pilot training and can be used in disaster condition.

REFERENCES

[1] A. L. Association, "Haptic Technology," ed, 2015.

[2] R. Blenkinsopp, "What is Haptic Feedback?," ed.

[3] W. Howard, "What Is Tactile Feedback?," vol. 2020, ed.

[4] B. K. a. L. Lapointe, "How to design inductive touch-on-metal button panels," 2016. [Online]. Available: https://www.edn.com/how-to-design-inductive-touch-on-metal-button-panels/.

[5] R. Y. T. P. H. H.A.Rahman, C.F.Yeong and E.L.M.Su, "One Degree Of Freedem Haptic Device," 2012. [Online]. Available: https://www.researchgate.net/publication/257725301_One_Degree-of-Freedom_Haptic_Device.

[6] D. M. a. N. W. J. T. Coles, "The Role of Haptics in Medical Training Simulators: A Survey of the State of the Art," 2011. [Online]. Available: https://www.researchgate.net/publication/220413415_The_Role_of_Haptics_in_Medical_Training_Simulators_A_Survey_of_the_State_of_the_Art.

[7] Arduino. "Arduino UNO." https://www.arduino.cc/en/Guide/ArduinoUno

[8] UltraLeap. "Leap Motion Controller." https://www.ultraleap.com/product/leap-motion-controller/

[9] D. E. Parts. " Air Pump Motor." https://www.deltakit.net/product/12v-mini-air-pump-motor-air-vacuum-pump-for-aquarium-tank-oxygen-circulate/

[10] H. Tools. "3/2 way Solenoid Valve." https://www.hqc-tools.com/shop/solenoid-valves/32-way-solenoid-valve/3v310-10npt/

[11] Amazon. "Relay Module." https://www.amazon.com/SunFounder-Channel-Optocoupler-Expansion-Raspberry/dp/B00E0NTPP4

[12] a. D. T. Pauchot Julien, Ahmed Lounis and Mourad Benassarou, "Leap Motion Gesture Control With Carestream Software in the Operating Room to Control Imaging," 2015. [Online].Available: https://www.researchgate.net/publication/277079330_Leap_Motion_Gesture_Control_With_Carestream_Software_in_the_Operating_Room_to_Control_Imaging.