ROBOTIC GRIPPING ANALYSIS OF FORCE-SENSITIVE RESISTOR ON DIFFERENT RIGIDITY OF OBJECT

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***ABSTRACT*: *Human has the capability of sensing various types of inputs from their surroundings (environment). Sense of vision, audition, taste, olfaction, and touch is a multitude of sensor in the human body. Vision is sometimes assumed to be the most important human sensory modality which may underestimate the sensitivity of the sense of touch. Human is an expert and able to determine the object type or the specification of the object whereby they can also classify it into categories. In this paper, we focus on classifying the object with different rigidity. This paper presents the results of an experiment that investigates the detection of certain irregularities in the signal generated by a force-sensitive resistor (FSR) to classify objects of different rigidity, from soft to rigid. The sensor is attached to the two-finger Kuka Youbot gripper and with a single grasp the object. Thus the sensor will generate the signal and the data that contains is enough for classifying the object.*

Index Terms: Force Sensor, Rigid, Gripper

I. INTRODUCTION

Robotics plays an ever-increasing and vital role in the manufacturing industry in the automated processes of today and tomorrow. Some of them are exposed to the radioactive or chemical environment where this field will be harmful or even lead to death for a human being. Therefore to avoid such events, a human is replaced with a robot in a harmful environment to perform tasks. Thus, the sense of touch, visual, audition, taste, and smell are elements possessed by a human. Out of the senses in the human body, the sense of touch is important to perform the task in any environment. Based on the human sense of touch physiology indicate that when the skin was embedded with force sensory elements and encoded by frequency modulation comes to inform the human brain while in motion. Touch is one of the most important core human skills like grasping, temperature detection, classifying object, and material identification, among others [1]. The article [2] states that grasping is eye-hand coordination, which means that the perception (eye) drives the motion of the manipulation end and the design and construction of robotic hands is a critical issue in robots because different hands lead to quite different grasping strategies and computational needs.

In the robotic sense of touch, there are four segments based on working principle, task, location, and mechanical nature. Depending on the aim or the function being performed, the main identity of the robot can be classified into two categories. First, grasp control and dexterous manipulation are known as 'Perception for Action', and second, are object exploration, modeling, and recognition referring as 'Action for Perception'. Depending on where the sensor is fitted, the robotic touch sensing can be classified into two; extrinsic and intrinsic sensing. However, sensors of intrinsic type are positioned within the structure of the system (mechanical) and acquire the contact data such as the magnitude of force using force sensors; the extrinsic or some call tactile sensors/sensing arrays are placed close to or at the contact interface and deal with the data from regions which are localized. Article [3] noted the stereotype with which objects are explored when people seek information about the properties of a particular object.

In article [4], an experiment is conducted to evaluate exploratory procedures to understand and showing more than 95% of analyses trials are classified correctly. Moreover, discrimination based on material properties such as hardness, roughness, and temperature, shows more consistent classification results compared to discrimination based on the shape information acquired. Stiffness classification can be determined by pressure or pressing of exploratory procedures. Every object has different stiffness, and a force sensor has been used to perform this classification. In recent times, a new invention of force sensors has been designed and utilized in applications with regard to robotics. Some of them include piezoresistive thin film, piezoelectric force, strain gauge, and optical forces [5]. Generally, the force-sensitive resistor sensor is been used for classification in the medical article. The article [6-9] shows the ability to use the FSR sensor to study walking gait, sleeping posture, and wireless gait where extract the data from the sensor to develop pattern recognition and classify.

In this study, Force Sensitive Resistor (FSR) sensors are used because this sensor allows for detecting physical pressure, squeezing, and weight. They are simple to use and low cost. Various purposes of Force Sensitive Resistors (FSR) sensors were summarized by researchers in [5]. Gesture recognition was the intention of a study in 2007, whereby the Interlink FSR sensor was placed on the arm for a muscle monitoring system. It was found that by merging FSR sensors with gyro and accelerometer which forms a closed-loop system, there was an increase in parameter detection accuracy from 1% to 29%. In addition, article [11] state that the FSR sensor is appropriate for human touch control of electronic implementation moreover, the author state it can give accurate result in continuous touch or detection contact between two objects.

The various investigations performed classification using a force sensor along with another sensor. For the purpose of this study, we focus on using force sensors for classification.

II. METHODOLOGY

The idea of the research is to extract data for six different rigid objects using a force sensor. To ensure obtaining the reading of the sensor, the object is explored by grasping or pressing, which is to determine compliance with applying force to the object, while squeezing the object.

A. Experiment setup

For experiment setup, KUKA Youbot gripper is been used as a manipulator and the FSR sensor is attached to the gripper as shown in figure 2.1. This figure also indicates the placement of the force sensor which "s" is referring to the sensor. Figure 2.2 shows the overall experiment platform where the gripper grasps the object.

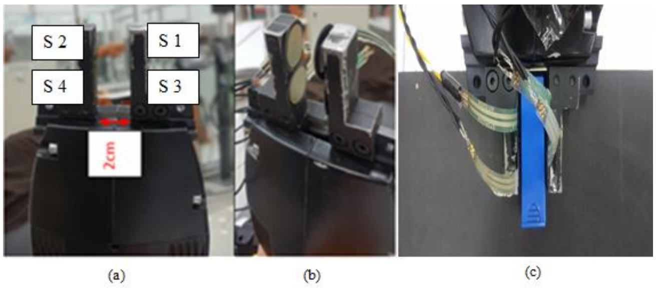

Figure 2.1: Kuka youbot gripper. (a) front view with attached sensor label, (b) side view of the gripper, and (c) top view

Figure 2.2: Platform of the experiment. (a) right view, and (b) left view

B. Data Extraction

During the experiment, the object is been automatically placed in a place so the gripper can grip the object. The object is explored by closing the gripper's finger until it contacts the object. The object is squeezed with each step of the gripper at 0.0175cm. In grasping the object, the soft object will deform/compress while the hard object stays. The gripper will reach its maximum grip with respect to the object size. While the object is being squeezed, the sensor will obtain the reading in amplitude. The start of the grasping procedure (time t = 0) is considered when the kuka youbot is in a state of initial. The procedure ends at time t = N, where N represents the number of samples recorded from the force sensor. In this study, the data acquisition system provides data for each 10ms.

C. Hardware Setup

The hardware setup in this research includes Raspberry Pi, an IMU sensor, and a camera used for the vision sensor. Raspberry Pi operating system is used for setting up the OpenCV software for image processing and machine vision learning. The vision sensor and IMU sensor used in this research are presented in this section.

1. NI My RIO

The main hardware used to run the software in this research is the National Instruments myRIO-1900. It is a portable reconfigurable Input Output I/O device used to design robotics, control, and mechatronics system. It is a 16-bit Xilinx Z-7010 processor running at 667 MHz, dual core ARM cortex A9, has 2.4GHz wireless Local Area Network, USB 2.0 Hi-Speed, and Ethernet. MyRIO is a real time embedded system. It was introduced by National Instruments and helps in learning controls, mechatronics, and designing interesting capstone projects.

Figure 2.3: NI myRio

2. Sensor

The concept of an FSR is the changing of resistance with different applied pressure, which must be applied on the sensor's active area. Two flexible layers combined using adhesive spacer as in Figure 2.4(a) shows its internal structure. A layer has printed circuits, while another hosts a printed semi-conductor layer whose conductivity increases with pressure. The moment a force/pressure is applied, the two layers contact each other and close the circuit. The circuit's resistance is inversely proportional to the pressure applied with a nonlinear relation (Figure 2.4b). Figure 2.5 show the circuit diagram of FSR sensor and 10kiloOhm resistor.

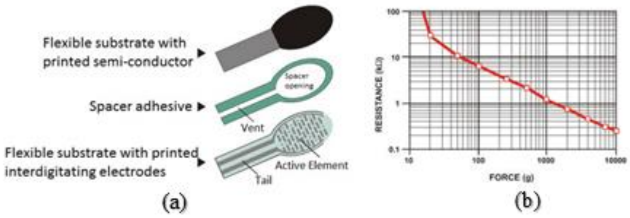

Figure 2.4: a) Exploded view of the sensor, and b) Resistance-force relation.

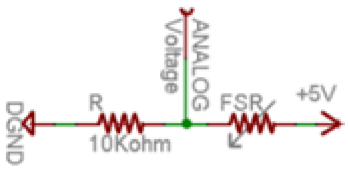

Figure 2.5: FSR sensor circuit diagram.

3. Object

To illustrate the use of the sensor, we apply it to an object to extract data. The goal of application is for differentiate six different rigid object that shown in Figure 2.6. The object is design with same thickness (1.4cm).

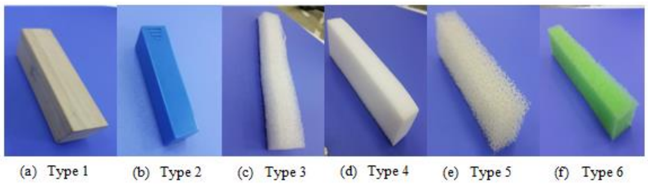

Figure 2.6: Objects used in the experiment.

D. Software Setup

For the KUKA Youbot's motion is programmed using Robot Operating System (ROS) via Ethercat connection. To extract data using an FSR sensor was used in the MI myRio hardware. The module used for this research is myRio, signal processing and programming module via Labview. LabVIEW is systems engineering software for applications that require test, measurement, and control with rapid access to hardware and data insights.

III. RESULTS

The rigid object data experiment result is presented in this section. To analyze this sample, the chart is categorized into 6 parts which are the 1st section to the 6th section as shown in table 3.1. This sample is divided to determine the starts and maximum amplitude in the section. Figure 3.1 shows the amplitude reading while the gripper is close without any object while the x-axis shows the sample which is taken per 10s. This figure shows the reading remains the same for all sensors at 0 voltage but changes at the 6th section with a drastic increase of not more than 3.5 voltages for sensor 1 while other sensors remain the same. Section 6 has a drastic increase due to kuka fingers meeting each other.

Table 3.1: Categories of sample

Section	Sample
1st	1 – 1557
2nd	1558 – 3113
3rd	3114 – 5058
4th	5059 – 7003
5th	7004 – 8170
6th	8170 – 10115

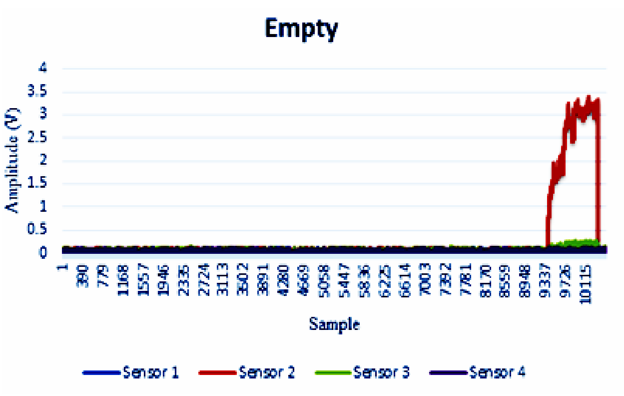

Figure 3.1: Amplitude reading of gripping no object.

Figure 3.2 shows the different amplitude readings of six different rigid objects as shown in Figure 2.6. Chart object type 1 (wood) and object type 2 (plastic) show the reading is fluctuating between 0 – 0.16 V. Both of these objects grip without squeezing, therefore the reading does not rise. Object types 3 to 6 are foam with different stiffness. In conjunction with this type 1 and 2 objects, object types 3 and 4 hype increase once the object is start to touch. In chart object type 3 shows reading as a spike at 2nd section while in chart type 4 shows the reading rose at 1st section. This type of object has been increasing and reaches a steady state until the gripper is loosening. Chart objects 5 and 6 shows a gradual increase to reach maximum voltage. From here it shows that these two object data reading increase while the gripper press and squeezed the object.

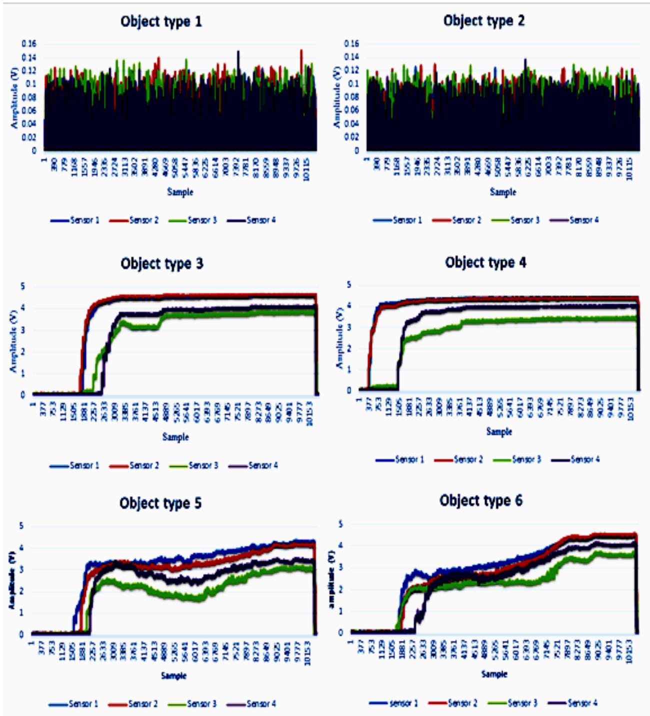

Figure 3.2: Different amplitude readings of six different rigid objects shown in Figure 2.6

IV. CONCLUSION

In this paper, analysis using force sensitivity resistor sensor is shown by using an interactive manner, using two fingers KUKA Youbot gripper and FSR sensor. By obtaining the data, it shows six different data correspond to the rigidity of the object. Moreover, the reading shows that solid object does not have high voltage while the foam with different stiffness shows hard foam has drastic increment and reaches a steady-state earlier compare to soft foam. The experiments were performed with an under-actuated compliant robot hand which was controlled in an open-loop fashion.

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