PRG711225SA-1

Reg No.: _____ Name : _____

Jyothi Engineering College(Autonomous)

M.Tech Degree S1 (R) Examination, December 2025 (2025 Scheme)

25PRGT100- RESEARCH METHODOLOGY AND IPR

Total Mark: 60 Total Time: 2hrs 30min

CO MARK

PART A

Answer All Questions

1. Explain the levels and styles of thinking? CO1 (5)
2. Describe the TRIZ method for creative problem solving. CO2 (5)
3. How do random and systematic errors occur? Analyze and explain the methods to reduce them. CO3 (5)
4. What are the five major forms of communication, and how does each form differ in terms of participants and purpose? CO4 (5)
5. Assume that you are filling an invention for patent in India Explain the various process involved in granting in your patent. CO5 (5)
6. Explicate the common rules of IPR practices. CO5 (5)

PART B

7. Read the given article and write a report that addresses the following issues:

Proximity Skin Sensor Using Time-of-Flight Sensor for Human Collaborative Robot

Human cooperative robots (HCRs) that work in the same spaces as humans have attracted a significant amount of research attention. For safety, it is important to equip such robots with proximity sensors. This thesis aims to propose a proximity skin sensor for collaborative robots using time-of-flight (ToF) sensors that are able to detect the distance between the sensors and the objects. These proximity skin sensors can detect an object's position and its approximate shape before contact. The prototype sensors are attached to the surface of the robot and can detect an object at a given proximity range. Therefore, this proximity skin sensor can ensure safety and workability of a robot by preventing unnecessary contact between the robot and the objects, including humans. Therefore, the sensor may be applicable to tactile sensors for HCRs.

HCRs can save working space and improve workability because safety fences are not required and HCRs can work with humans. HCRs require various sensors for safety to be able to perform certain tasks in collaboration with humans to avoid injury. Recently, various types of tactile skin sensors have been proposed for robots, that is , a tactile skin sensor that uses optical elements to detect the contact pressure, a stretchable skin sensor that uses conductive rubber by impedance tomography, a triangular module capacitance skin sensor that can detect pressure, etc. However, the operating speed of the robot may be limited for safety reasons because it is difficult to detect an object until touch. A sensor used in a robot should detect an object before contact to ensure greater safety. Among these

sensors, proximity sensors are important for safety. Some proximity sensors have been developed, as reported in the literature - a proximity sensor array using a polymer light-emitting diode and a polymer photodetector, a proximity sensor that uses optical elements to achieve low wiring and high response speed etc. It is difficult to accurately detect the distance between the sensors and object because the measurement value changes depending on the characteristic of the object. The sensor detects the distance to the object, and the robot is operated according to this distance. Thus, the distance sensor can improve the safety and workability of HCRs. A method for detecting objects around a robot, including their distance using a 3D camera external to the robot has been proposed. The system may improve safety because it can detect objects around the robot. However, the robot may constitute a blind spot to the camera when the robot moves. In addition, an advanced processing system is required to analyze the camera images. In the previous work, a tactile and proximity sensing method using self-capacitance measurement. The sensor can detect an object before and after contact. However, it is difficult to accurately detect the distance between the sensor and the object because the measurement value changes according to the characteristic of the object.

The objective of this study is to establish a proximity sensor system on an entire HCR surface for safety. The application goal in which the sensor on the robot surface to detect the object before contact. When the object (human) approaches the surface of the robot, the sensor detects the object before contact. Therefore, the sensor ensures the safety and functionality of the robot because the robot will avoid unnecessary contact with objects, including humans. A proximity skin sensor using a ToF sensor that can be attached to the entire HCR surface for safety. The sensor comprises 54 pieces of ToF sensors that can detect the distance between the sensor and an object. The prototype sensor is set at the tip arm of the robot arm and detects the position of an object without making contact with the object. CO5 (30)

Basic Characteristics of Prototype Sensor - As a basic experiment, the prototype sensor is placed on a plane, whereas the sensor measures the distance to the object. The object is attached to the arm of the robot, and the distance between the object and the sensor is set from 0 to 300 mm. Contact (0 mm) is detected using a force gauge. The objects include white and black paper applied to a glass epoxy flat plate with a diameter of 100 mm. The ambient light condition that is measured using the digital illuminance meter (HIOKI, 3423) is about 800 lx from the daylight white light emitting diode (LED) ceiling lighting of the room. The measurement result shows the measured distance (D) of the ToF sensor at the center of the object, the average error of the white paper. In the case of the black paper, the detected distance is approximately 250 mm in the 300 mm detection mode. It could not be detected at 300 mm. Also, the sensor often has difficulties detecting the object when the black paper was in contact. The sensor can detect the distance because D is changed according to the distance. The accuracy of the sensor is low when the object is 10 mm or less; however, the sensor can detect that the object is close or in contact. The detection area for the X–Y axis is spread when the object is far away, depending on the irradiation angle of the ToF sensor. The sensor can detect the approximate shape of the object using some results obtained from the ToF sensor.

Sensors on the Robot Arm Surface - a sensor system attached to the surface of the robot arm. The sensor detects the distance to an object. The ambient light is from the LED ceiling lighting. The sensor on the surface of the robot can detect the distance and shape of objects

in the same way as when the objects are placed on the plane. However, the light irradiation direction of the ToF sensor on the curved surface is dispersed, and the X–Y axis resolution decreases. This problem can be solved by increasing the number of ToF sensors on the curved surface.

Herein, proposed a proximity skin sensor using a ToF sensor that can be attached to the entire surface of a HCR for safety. The sensor comprises 54 pieces of ToF sensors that can detect the distance between the sensor and an object. The ToF sensor can detect the distance from approximately 300 mm under visible light, such as a fluorescent lamp or LED. The prototype sensor is set at the tip arm of the robot arm and can detect the distance to an object and its position without making contact with the object. Additionally, proposed a control method for HCRs using the output of this sensor. The robot moves at a normal speed when the object is far, reduces its speed when an object approaches, and stops when the object is close. Thus, the robot can avoid making contact with the object using this operating method.

a) What is the main research problem addressed? (4)
b) Identify the type of research. (4)
c) Discuss the shortcomings in the literature review, if any. (4)
d) Discuss the significance of the study. (6)
e) Discuss the appropriateness of the methodology used for the study. (6)
f) Summarize the important results and contributions by the authors. (6)

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