Sensor-Controlled Robotic Hand

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Introduction

Robotics is a rapidly growing field in the past few decades. The potential uses and functionality of robots are substantially researched in a variety of fields. In recent years, robots are used to perform tasks in dangerous environments in place of human. For example, many robots have been designed and built to clean up contaminated places like nuclear facilities, defuse bombs, search for survivors in ruins, etc. However, these robots have a lot of limitations that their functionality, flexibility and efficiency cannot be compared with human. This restricted the application of robots. Human workers are forced to be sent in hazardous situation if robots are not capable of performing the job. This paper proposes robotics hands with haptic feedback and are sensor controlled. The robotic hands will mimic the movement of hands of the user who is wearing the sensor glove. These robotic hands can perform complicated tasks and are as capable as human hands. They can take the place of human in dangerous situation to the greatest extent possible.

The remainder of this paper proceeds as follows. First, we offer some background information on the current robotics and their limitations. Then we present how can this project solve the challenges and improve the current practice. Next, we discuss the methodology and approaches to implement this project. We then mention the challenges and deliverables. We end with the project schedule.

Background

The current robots usually consist of moving components and one or more robotic arms. [1] These robotic arms are designed for specific purposes. For defusing bombs, a cutter is likely to be attached on the robotic arms. For fixing machine in radioactive environment, screwdriver is likely to be attached. The functionality of these robotic arms are limited. These robots are controlled by controller. The design of controller will affect the flexibility of robots. The operator obtains information about the surrounding environment through the camera attached on the robot in most cases. The channel of receiving information is restricted.

Several difficulties arise from the current practice. First, unknown challenges are often faced when performing tasks in hazardous places. Having robotic arms that are designed for too specific purpose limits the functionality and flexibility of robots. The robots cannot perform complicated operation and tackle all the problems that may be faced. In Fukushima Daiichi nuclear disaster, human workers were sent to stabilizing the reactors instead of sending robots because current robots are not qualified for these jobs in terms of functionality and efficiency. Second, the reception of surrounding environment is restricted to sight. The operator cannot feel what the robots touch. Some tasks should be effortless with tactile cues like cutting a wire. However, without the pressure feedback, the operator need to apply constant visual confirmation. This increase the cognitive load of the operator and limits the efficiency and functionality of the robots. Finally, using traditional controller to control robotic hands is counter-intuitive. The operator needs to have sufficient training. The effectiveness of robots is also largely dependent on the skill of using controller and the design of it.

To tackle these problems and to provide a practical solution to avoid human from working in dangerous environments, this paper proposes robotic hands with haptic feedback and are sensor controlled. The robotic hands will have the same movement as the gloves which are worn by the operator. The robotic hands imitate the structure of human hands so that they can utilize different tools to ensure the capability of handling different kinds of task. The controller will be a pair of wearable gloves that are sewed with sensors. This provide the most intuitive control to the operator and let the operator focuses on the task instead of handling the controller. The haptic feedback design allows the operator to feel what the robotic hands touch and would assist in judging surrounding environment when performing the tasks.

Objective

In this project, the robotic hands will mimic the gesture of operator's hands through a pair of sensor glove. The robotic hands will have certain amount of strength to hold light instruments and objects but strength will not be the focus of this project. This project will focus on the flexibility and functionality of the robotic hands. The robotics hands will be able to perform delicate tasks such as operating scissors and screwdriver. The ability to handling different instrument will ensure the multi-functionality of the robots.

The robotic hands will have measure on pressure bearing and provide haptic feedback to the sensor glove so operator can feel the same. Operator can control the robotic hand to perform tasks even with no visual information. The glove will measure the force that operator apply and the robotic hand will apply similar force. This is important in performing precise task such as holding fragile object like egg.

Wearable sensor glove instead of traditional controller will be used in this project. This will provide an intuitive way to control the robots. The robotic hands will move in the way that the operator move. This will smoothen the learning curve of using the robotic hands.

Methodology

The robotic hand will be 3D printed as it will save the time of shaping the materials. There are 3 common materials that used in 3D printing, namely Acrylonitrile Butadiene Styrene(ABS), Polylactic Acid(PLA), Polyvinyl Alcohol(PVA) [2]. ABS will be picked to print the robotic hands as it is very durable, strong, resistant to heat, slightly flexible. It is also the cheapest plastic between the three materials. PLA is a little brittle and cannot withstand high temperature. PVA is water-soluble. These make the latter two materials not suitable in making the robotic hands as the robotic hands should be able to work in variety of environment including hot temperature and humid environment.

There are various internet resources of the 3D models of robotic hands. Design of robotic hands that the knuckles are not movable will not be considered as they cannot satisfy the flexibility that we asked for. There are 3D models that satisfy the flexibility requirement but haptic feedback is not included in these designs. Integrating haptic feedback design can be difficult without studying the actual robotic hand. Therefore, haptic feedback will not be included at the first stage of this project. There will be only robotic hands that can be controlled by a pair of sensor glove at the first stage. Since only the skeleton of the robotic hands can be printed, the servomotors that controlled the movement need to be purchased. The size of servomotors may not fit the requirement of the 3D models. In this case, the 3D model need to be edited using 3D modeling software like AutoCAD. After 3D printed the components of the skeleton, we can assembly them and link the moving part to the servomotors by strings to build the robotic hands. [3]

In this project, we use sensor glove with flex sensor as controller because the gesture of operators can be detected most accurately with it and the delay is the shortest compare to other sensor such as leap sensor or brainwave sensor. Furthermore, to provide haptic feedback, operator has to wear a device on the hand. This make the leap sensor and brainwave sensor loss their advantage which the operator can operating with bare hands or without hands. The flex sensors require a circuit for them to compatible with the microcontroller, Arduino. The circuits and the flex sensors are sewed on the gloves.

The robotic hands and the pair of sensor glove are linked to the same microcontroller board, Arduino Uno. Then the microcontroller board will be programmed to perform required functionality and being calibrated to make the robotic hands perform accurate movement.

Haptic feedback will be added in stage two after the completion of robotic hands and sensor gloves. Pressure sensor will be attached on the robotic hands and motors will be attached on the sensor glove to generate necessary torque to create a sense of feeling at operator's end. Calibration of the pressure sensor using know mass is required to provide accurate feedback. [4]

Deliverables

Two Robotic hands

Different component of the robotic hands will be 3D printed with ABS as the material and assembly together. Several servomotors will be mount to the movable part of the hand by strings. Pressure sensor will be installed on different part of the hands to detect the pressure applied on the robotic hands.

Two Flex sensor glove

Multiple flex sensors will be sewn onto the gloves. The flex sensors will be mount together to a circuit. Motors will be attached to the sensor gloves to create a sense of feeling at the user's end. The user will be wearing these gloves in order to control the robotics hands.

Microcontroller

Arduino Uno will to used to link the robotics hands and flex sensor glove. It will be programmed to response to the signal sent from the flex sensor glove by moving same parts of the robotic hands. If the robotic hands touch an obstacle, Arduino will response to the signal sent by pressure sensor on the robotic hands by limiting the movement of sensor glove through the motors on it.

Challenges

It is difficult to perform action as precise as human does. For example, picking up an egg require accurate control of strength so that the egg will not be broken or dropped. Tying shoelace require flexible robotic hand and great coordination. Both flex sensor glove and robotic hand need to satisfy certain technical aspect. The flex sensor glove need to be equipped with enough flex sensors so that not only finger movement is detected but the shape of the palm can also be detected and mimicked. The robotic hands need to be equipped with many movable parts like knuckles to enable flexible movement.

The robotic hands are made according to the 3D model that is provided in the internet. However, the robotic hands may be not compatible with other accessories that mounted to it. In this case, the

3D model may need to be fine tuned or the accessories may need to be fixed to suit the robotic hand.

Project Schedule

Oct 2	Deliverables of Phase 1 - Project Plan - Project Website
Oct	- Find a 3D model of robotic hand - Buy servomotors and Arduino Uno - Amend the 3D model - Build the robotic hand
Nov	- Make flex sensor glove - Link the flex sensor glove and robotic hands to Arduino
Dec	- Program the Arduino
Jan 22	Deliverables of Phase 2 - Interim report - Robotic Hand - Sensor glove - Arduino Uno
Feb	- Attach motor to sensor gloves - Attach pressure sensor to robotic hands - Program the Arduino
Mar	- Final Calibration
Apr 16	Deliverables of Phase 3 - Finalized implementation - Final report

Conclusion

There were a lot of investments on the research of robots to take the place human in some dangerous situation. However, most of these robots cannot perform very precise act and therefore cannot compete with human. With the robotic hand in this project, which mimic the user's action by the sensor glove, there is an economic way to ensure some emergency case can be handled quickly while human life is protected.

References

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