Progress Report

Human Interface for Robotic Control

SYSC 4907 – 4th Year Project

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Summary

The project aims to develop a robotic arm system that mimics human movement. Integration of feedback control will allow the robotic hand to pick up an egg without cracking it. Furthermore, the system can be remotely controlled over the internet. Focus will be put on system performance with minimal latency and high accuracy.

Overall with the progress made so far, the system is currently able to:

1. Obtain coordinates from Leap Motion sensor and convert to rotational angle
2. Send the information over IP (internet protocol) to the micro-controller
3. Receive the packet at the micro-controller
4. Move the fingers according to the rotational angle specified in packet

Individual Progress

A detailed description of individual tasks sorted by the team member responsible is included below.

Hardware and Sensors [Yuzhou Liu]

Task 1: Hardware Assembly

Past Work:

The 3D printed hand, wrist and forearm have been assembled. Although this portion of the work does not count towards the design or contribution of the system, it was time consuming and tedious.

Future Work:

In the coming weeks, the fingertip sensors must be installed which may warrant some tweaking to the existing hardware assembly. Also the current servo motors are very weak. A decision must be made whether to keep or swap them out for more expensive and powerful servos. The decision will be made by testing the system against the requirements.

Task 2: Servo Motor Control

Past Work:

Code has been implemented so that any of the 5 fingers plus wrist can be instructed to rotate to a position from 0 to 180 degrees inclusive. This was accomplished by translating the positional angle into the appropriate duty cycle on the PWM waveform.

Future Work:

No future work planned.

Task 3: Force Sensor on Fingertips

Past Work:

Experimentation using low-cost static foam yielded unfavorable results. The idea is when the foam is compressed (squeezed), more current will flow through which can be converted into a voltage and interpreted by the ADC (analog to digital converter) on the micro-controller. However the accuracy of the foam is poor and the results are unstable.

Future Work:

Must obtain a small piezoelectric sensor and compare the accuracy of this product to the static foam.
Additionally the force sensors must provide feedback to the servos which serves as a safety mechanism preventing the fingers from placing too much pressure on the object being held. The algorithm for the feedback control loop must be developed.

Wireless Implementation on the Micro-controller [Minh Mai]

Task 1: Connect the Micro–controller to the WiFi network

Past Work:

The micro controller was already able to connect to the WIFI network. However, the network SSID and password is manually coded into the source code. Furthermore, the micro controller currently cannot connect to WPA- enterprise (i.e.: CU-WIRELESS).

Future Work:

Must create an ability for user to enter network SSID and password via UART terminal. For stretch goal, the micro-controller will have an ability to connect to WPA-enterprise.

Task 2: Establish the server socket

Past Work:

The server socket was established in the micro-controller to receive data to the computer client. However, the socket is only available within the local network. In order to make the socket available in the internet, a NAT traversal mechanism need to be created. A simpler way is to implement port – mapping on the router.

Future Work:

Must make the socket available in the internet using port-mapping. For stretch goal, the NAT traversal mechanism will be created.

Task 3: Listen and Respond to commands from the computer

Past Work:

The micro-controller was able to listen to the computer client via the socket it created. However, the listening task is blocked waiting meaning that the micro-controller cannot do any else while it is waiting for the data. The data is received using TCP protocol which has low latency.

Future Work:

Must remove blocked waiting by using socket interrupt. Furthermore, need to change from TCP to custom protocol to reduce latency.

Leap Motion Sensor and Computer Interface [Brandon To]

Task 1: Interface with the Leap Motion Controller

Past Work:

Leap Motion provides an SDK to talk to their controller over USB. Currently, we have figured out how to use the SDK to query vector information from the sensor and map those to the corresponding PWM signals using our conversion algorithm.

Future Work:

In the future, we may need to query more data from the sensor if the requirements for the system changes. What that data will be is to be decided. We predict that this will be the case once we incorporate the closed-loop feedback system into our implementation.

Task 2: Communication to the microcontroller

Past Work:

A socket interface communication link has been established to allow communication to the microcontroller over TCP. The PWM signals are sent over the said communication link to the microcontroller.

Future Work:

A custom designed real-time protocol may have to be implemented over UDP if TCP fails to meet our delay requirements. The data format of the message must be laid out once we figure out what additional information must be sent after the closed-loop feedback system is implemented and integrated.

Task 3: Feedback System GUI

Past Work:

Design of the feedback system has been sketched out. Feedback will be received from the microcontroller through the socket interface and displayed onto a GUI for the user. The GUI will display a hand and coloured fingertips based on the feedback from the pressure sensors.

Future Work:

Implementation of the design must be done once the feedback system integrated into the project.

Tasks in the Queue

Playback of recorded motion

The system allows the users to record a set of their hand movements. The recording can be played back onto the hardware afterwards at any time.

Socket over Internet

The local network socket will be replaced by the internet socket to allow the computer to communicate with the arm over the internet [refer to task 2 under Minh Mai].

Custom Protocol

The custom protocol built on top of UDP to reduce the network latency [refer to task 2 under Brandon To].

Movement of entire arm along a single axis

The arm will be able to move freely in a single axis.

Conclusion

Quantitatively our team has achieved about half of the listed tasks set out in the proposal. Currently we are ahead of schedule by 1 week accounting for the Christmas break. We have a line-of-sight with regards to completion of existing tasks and have a clear idea of what needs to be worked on in the coming weeks. In that respect the project is going well.

However as the project progressed the issue of design vs. implementation appeared. As brought up by Prof. Dansereau, the amount of implementation work done far exceeded the amount of design work. As a fourth year project the design portion is critical. So going forward, new requirements or features may be incorporated into the system to expand the design component. This will require critical thinking into what can be incorporated and accomplished given the time and resource constraints.

We have full confidence the remaining tasks and incorporation of design components can be completed. In the upcoming weeks the foundations (or framework) of our project will be solidified, allowing further improvements or features to be readily integrated into the system.