**Project Proposal** – Robot Hand, Human Gesture Imitation

Robotic hands have always been the spotlight of popular technology. In particular, the biomimetic anthropomorphic robot hand that uses EMG sensors that analyze muscle electrical activity to control the arm has always been the focus of IEEE Spectrum. These even have pressure sensors to relay touch sensations . Most robot hands use flex sensors which link a human hand and a robot hand and correspond to the position of the server via reading codes of analog value and maps. There is another part of the study using image-based visual servoing to control the motion of the robot system. In this context, the visual system can be integrated by a single or multiple cameras, mounted in ﬁxed (eye-to-hand) or moving (eye-in-hand) conﬁgurations. The visual servoing techniques can be broadly classiﬁed into the following categories: position-based, image-based, or hybrid, which combines the common characteristics of the ﬁrst two[1]. For my project, I want to combine what we will learn in the class about vision and robotics and [pose](https://en.wikipedia.org/wiki/Pose_(computer_vision))-based (PBVS) visual servoing to let the robot hand copy simple gestures and motions of a human hand, such as bending a single finger or making a fist.

My initial plan is to assemble a robot hand with six degrees of freedom, five mimic fingers and three joints per finger. An "eye in hand" single video camera is embedded in the lower part of the robot's palm to control kinematics. The initial robot hand is kept open and vertical, and each time the movement state is changed, it returns to the initial state, which is used to more accurately coordinate the individual fingers or joints. The palm of the tester is directly in front of the palm of the robot at a certain distance. The tester performs basic hand gestures in front of the camera, and the image is captured by the camera. This approach consists of four modules: (a) A real time hand gesture formation monitor and gesture capture, (b) feature extraction, (c) pattern matching for gesture recognition, (d) command determination corresponding to the shown gesture and the action performed by the robotic system[2]. I plan to use the length of the finger and the proportion of missing fingers to recognize basic gestures. Extracted hand gesture is matched with the stored database of hand gestures using pattern matching. Corresponding to the matched gesture, action is performed by the robot[2].

For the next plan, I will further improve the camera type, number and location, 3-D image analysis, error estimate of finger coordinates, kinematic calibration, etc. I may add another “eye to hand” camera below or on the side of the robot hand. For example, I can use an infrared vision system, which also converts images into hand shape features, the Leap Motion Controller (LMC). In this way, a 3-D image can be constructed for analysis, kinematic calibration can be better performed, and the range and degree of finger movement can be accurate. I may also use a 3D printer to print Anthropomorphic fingers and joints to mimic a human skeleton hand.

Learning to imitate and copy human gestures can help society in many aspects. For example, this may help interpret the meanings of the sign language used by hearing-impaired people, from imitating their gestures to outputting the meaning of their gesture language, and even combining voice language libraries to allow gestures to "speak". Moreover, the simulation of subconscious behavior of humans can help design future robots. It also understands the limitations of human hands. For example, when the little finger is bent, the ring finger is also bent subconsciously, which also strengthens the simulation of the robot hand. It can even build an intuitive human-robot interaction (HRI) framework for gesture and human behavior recognition. It relies on a vision-based system as interaction technology to classify gestures and a 3-axis accelerometer for behavior classification (standing, walking, etc.). An intelligent system integrates static gesture recognition with artificial neural networks (ANNs) and dynamic gesture recognition using hidden Markov models (HMM)[3].

References

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[3] Mendes, N., Ferrer, Vitorino, Safeea, & Neto. (2017). Human Behavior and Hand Gesture Classification for Smart Human-robot Interaction. Procedia Manufacturing, 11, 91-98.