Human-Computer Interaction using Facial Expressions and Hand Gestures

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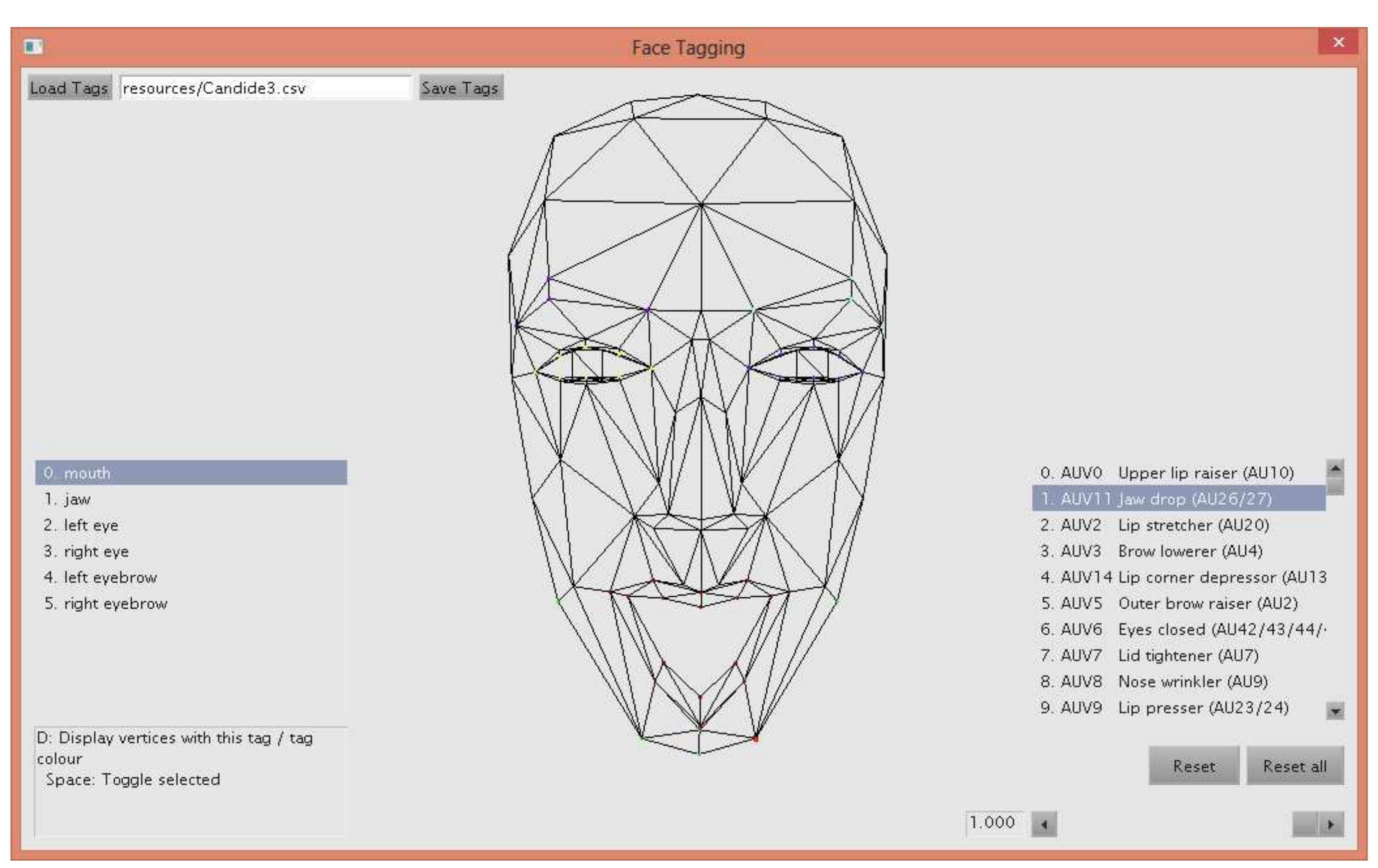
Introduction

When humans talk face-to-face, 65% of the information conveyed in such a conversation is conveyed through nonverbal communication [1]. We are developing technologies to integrate nonverbal communication into smart homes and healthcare user interfaces and robots. These technologies include facial expression cloning for face animation, and hand tracking and motion transfer to humanlike robot hands to for emulation of hand gestures.

Facial Expressions

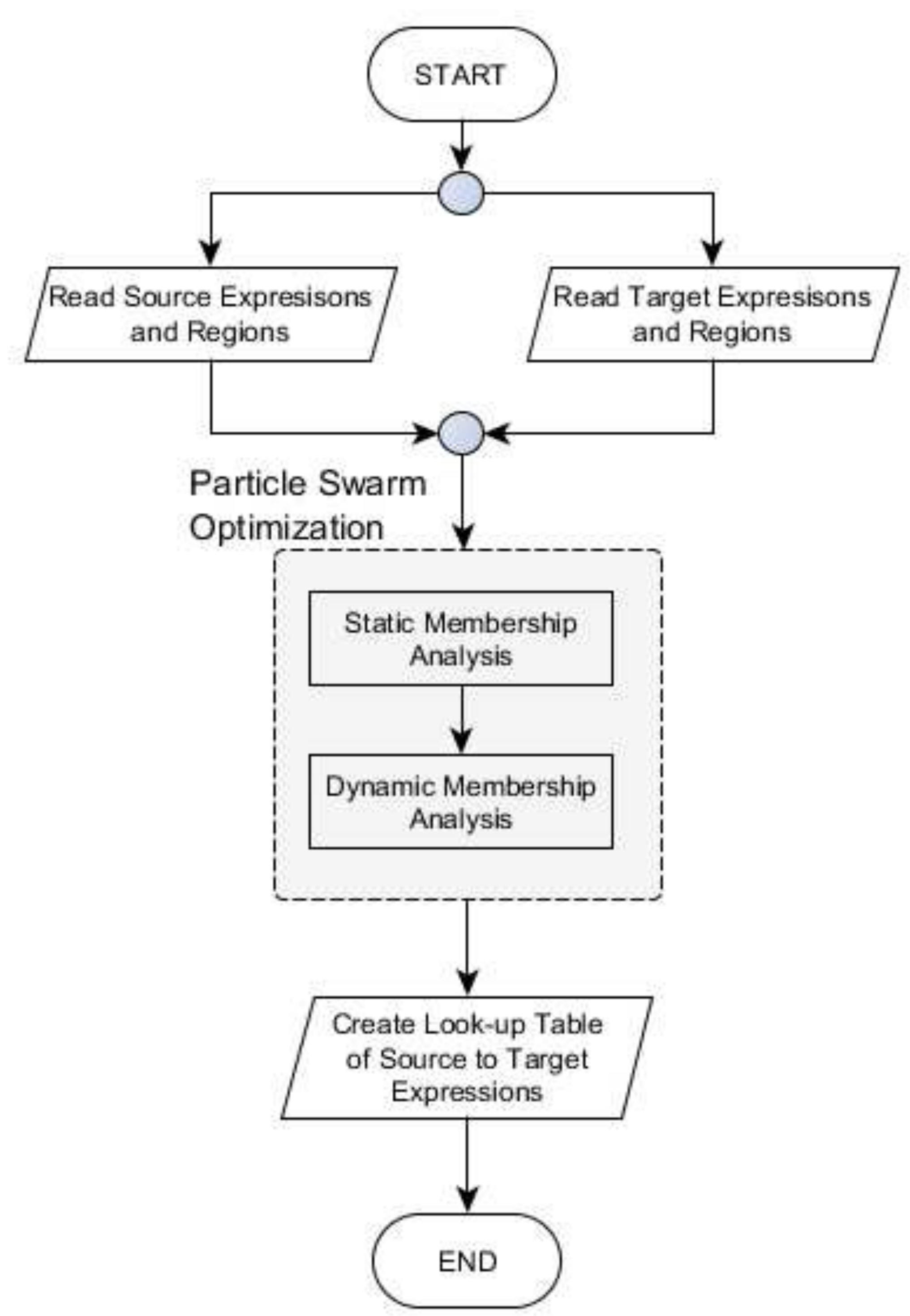
Facial expresisons are temporary deformations in a human's face. They convey emotional and physiological states, and they can be used to respond to parts of a conversation [2].
The proposed system uses parameterized faces, meaning that each face represents expressions using a set of numerical values. (example below)



List of parameters and face regions in proposed system

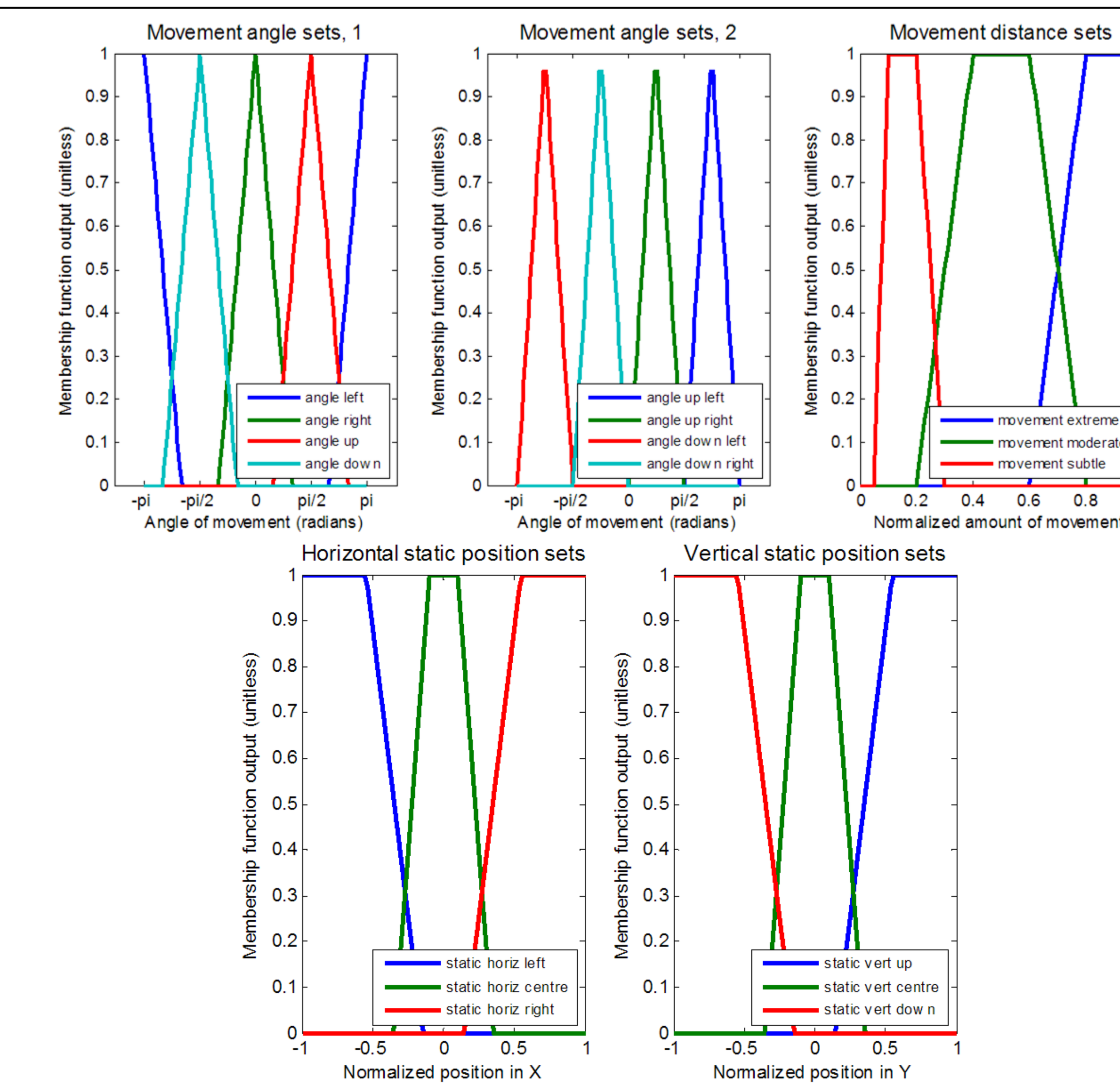
Facial Expression Cloning System

The proposed facial expression cloning system (workflow below) transfers facial expressions between two parameterized faces. It can operate between faces with different implementations of their animations and different resolutions.



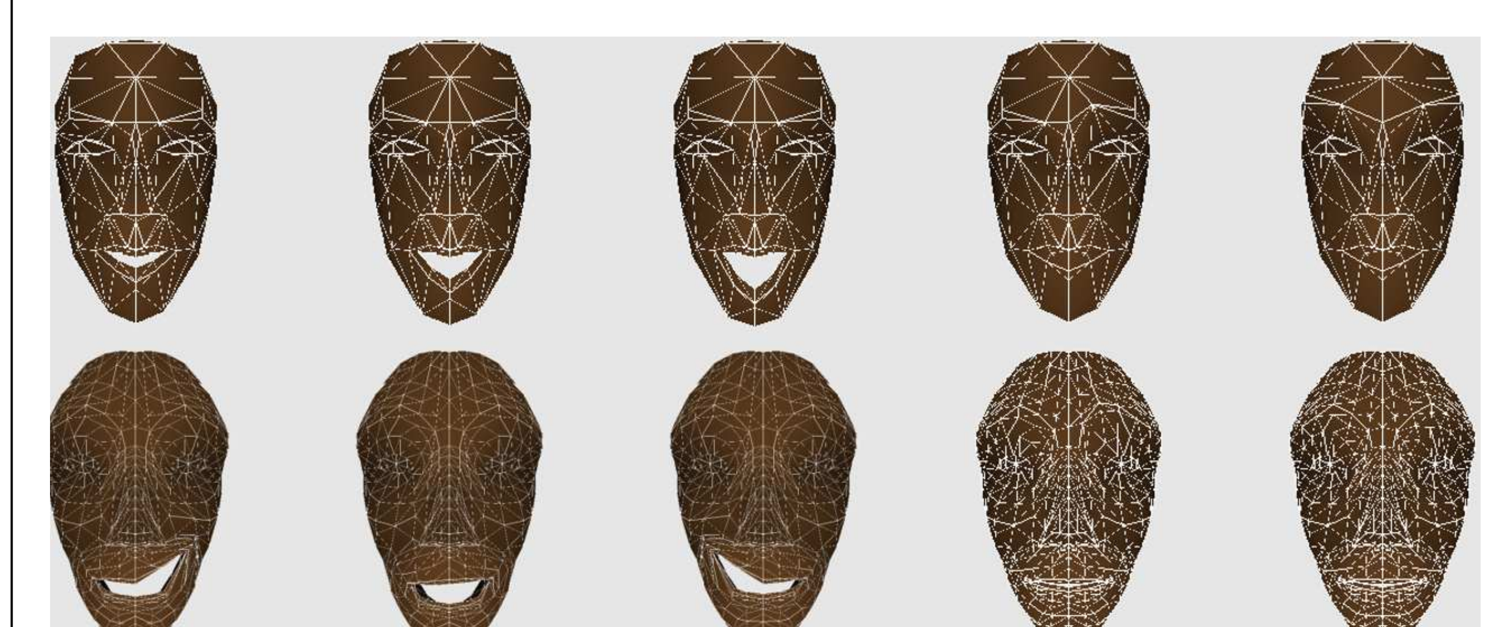
Flow Chart of System

To offer this flexibility, the system uses fuzzy membership functions and subtractive clustering to represent faces and expressions in an intermediate space. Particle swarm optimization automatically selects weights used to create this intermediate space, tailored for the source and target face being used.



Fuzzy Membership Functions used by System

Results



Region	Mean Error Per Vertex	Standard Deviation of Error	Perfectly Restored Mappings	Unique Mappings
Mouth	0.095	0.029	4	12 of 20
Jaw	0.625	0 (all same error)	3	3 of 4
Left Eyebrow	0.358	0.102	4	5 of 8
Right Eyebrow	0.423	0.088	4	5 of 8

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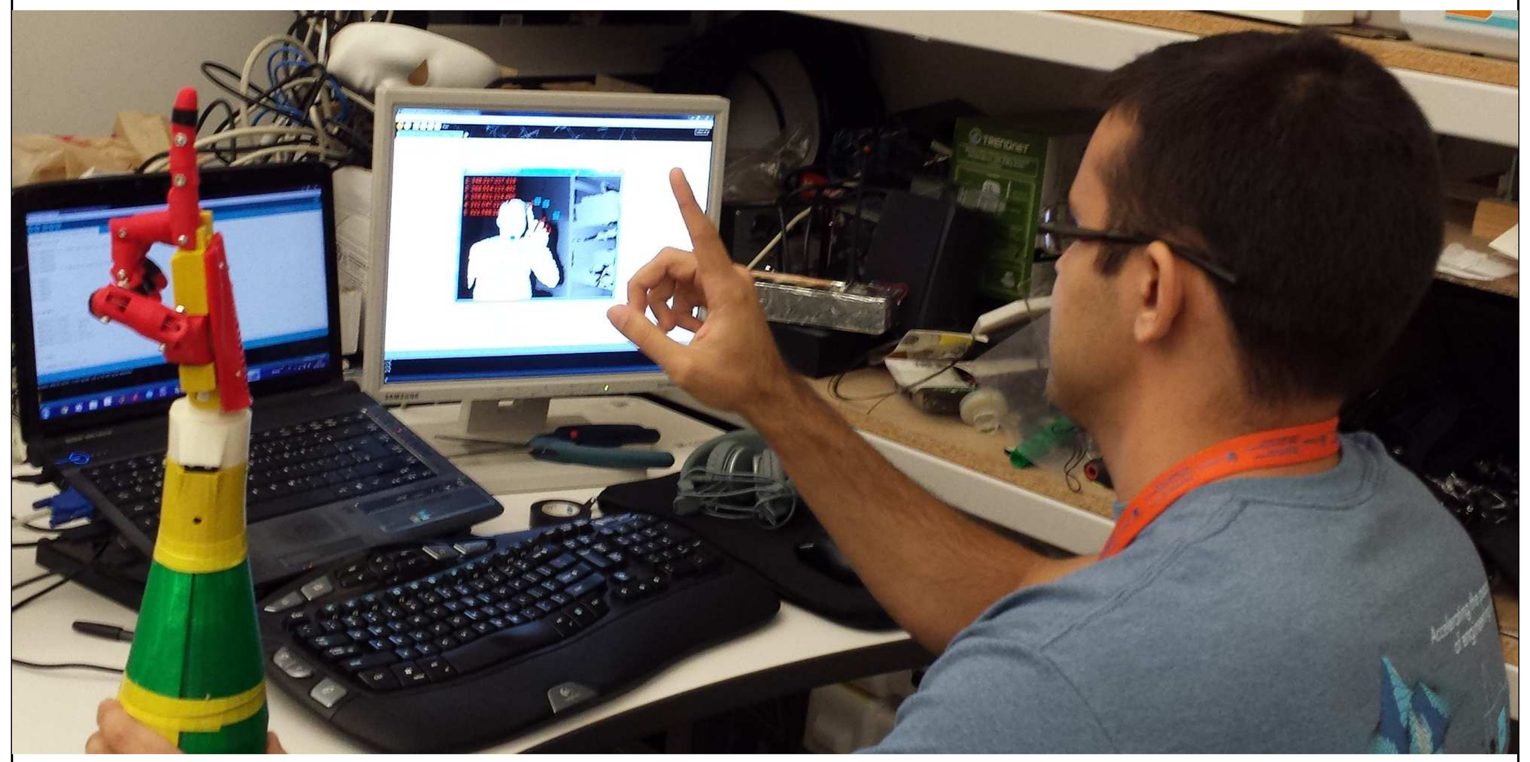
Hand Gestures

Hand gestures are a nonverbal communication method that involves static hand poses or movements of the hand. They are used to complement verbal conversation, or they can be used as a language on their own [1].

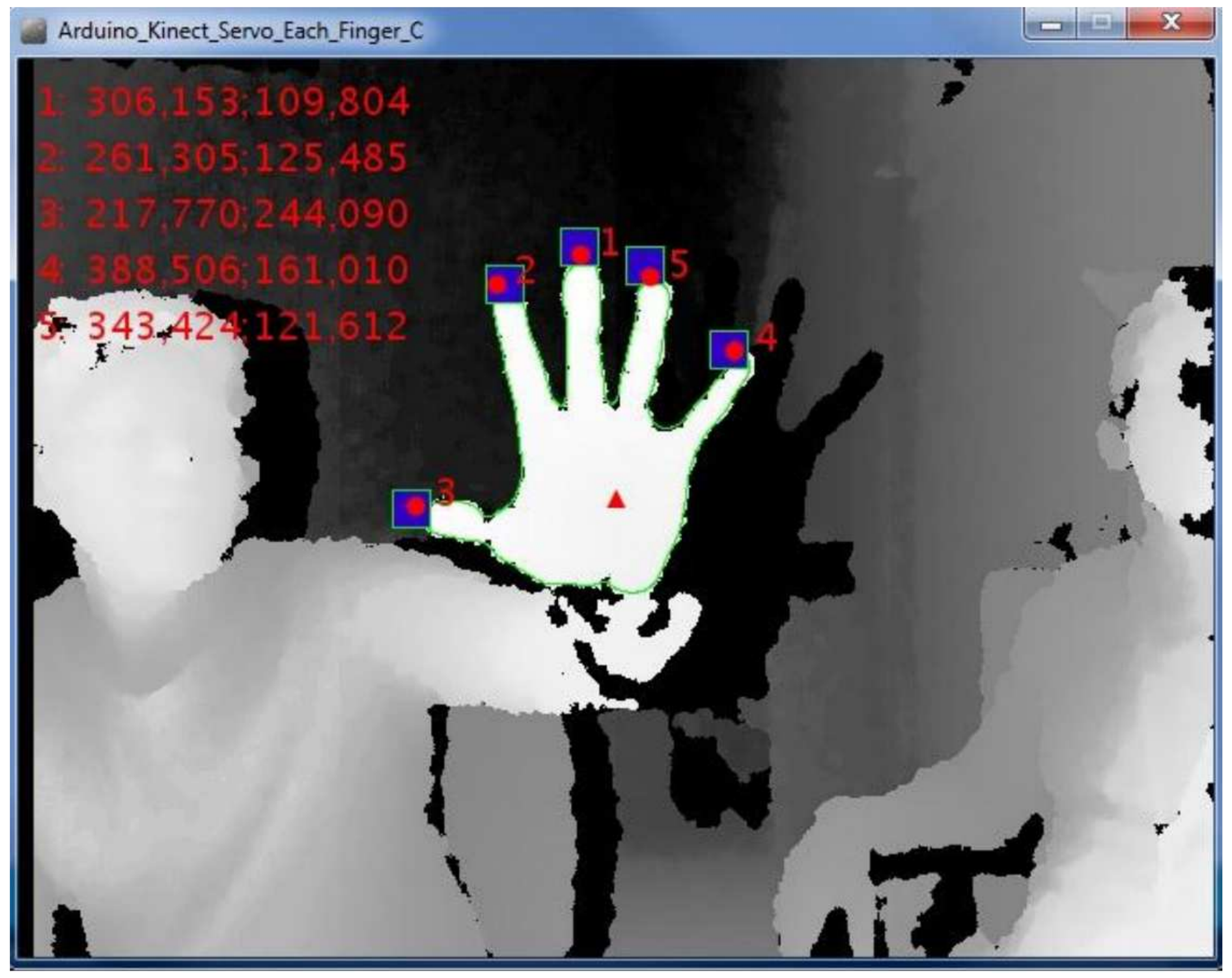
We are developing a system that reads the fingers using a Microsoft Kinect for Windows sensor [3] and animates a robot hand to mimic hand gestures. An example of the system tracking is shown below.



System duplicating a raised finger

Tracking of Hand Gestures and Control

The system reads hand gestures using the OpenNI SDK 2.2 and fingertracker library [4,5]. The user interface and communication with the robot is programmed in the Processing programming language. A picture of the tracking user interface is shown below.



Screenshot of Tracking Interface

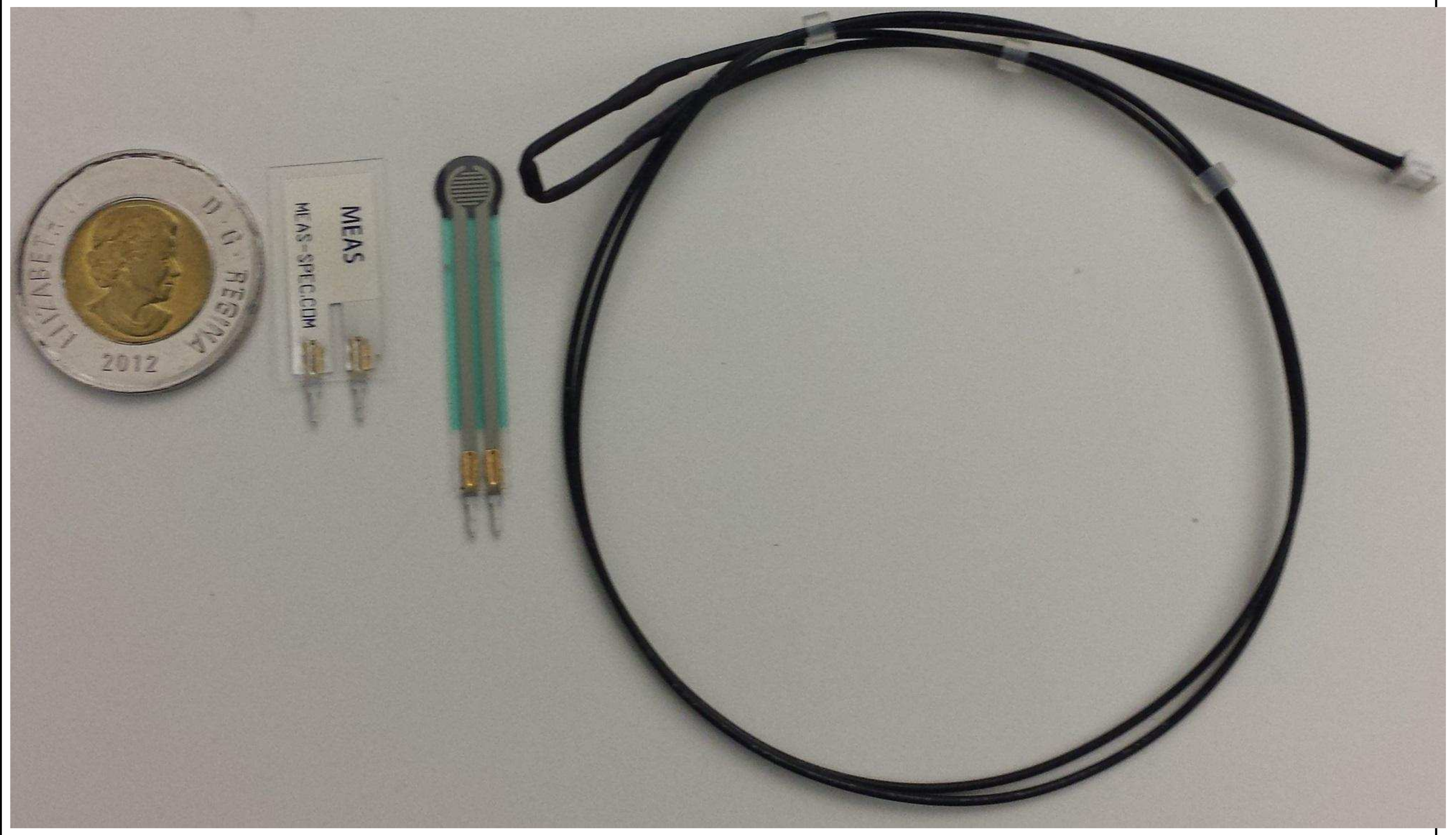
Robot Arm

The robot is a 3D printed Inmoov right hand with the rotational wrist and version 3 servo bed [6]. Six standard servos are housed in the forearm and the wrist. The electronics consist of an Arduino Uno board which sends the control signal to the motors and a separate power supply for the motors. The tracking interface, which runs on a Windows PC, connects to the Arduino board with USB.

The plastic components of the robot were printed with a fused deposition modeling (FDM) 3D printer. The arm components were printed with polylactic acid (PLA) plastic for added rigidity, while the fingers and wrist mechanism were printed with acrylonitrile butadiene styrene (ABS) plastic.

Tactile Sensing Interface

In a healthcare or smart home environment, robots will come into contact with humans and various objects [7]. To allow effective interaction with the environment, we are exploring options for temperature and force sensors to be equipped on the robot arm. A selection of the sensors are shown below.

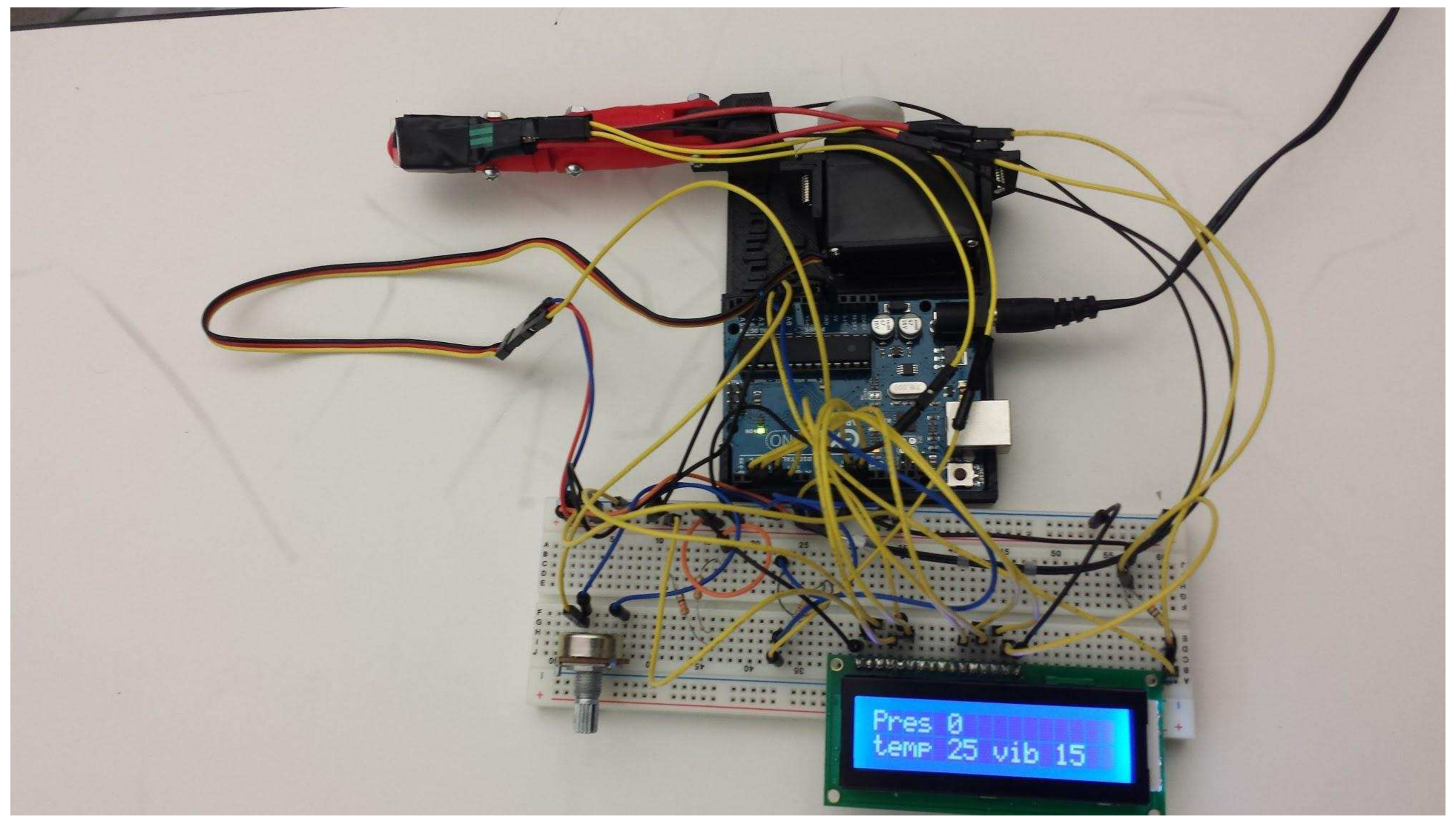


From left to right: (Coin for size comparison), HTS-TEMP temperature sensor, FSR 400 force sensor, LDT0-028K vibration sensor

These sensors are wired to an Arduino Uno board which performs sensing and controlling of a small robot [8, 9].

Sensor Testing Platform

A platform was built to explore the utility of various sensors and to see how to integrate sensors into a robot hand. The platform consists of the “Finger Starter” design from the robot in [6] printed from ABS plastic. The Arduino board is mounted inside the plastic platform.



Future Work

These subsystems will be combined into a robot designed to interact with humans in healthcare and smart home enivronments. Another arm will be built, and the robot will be equipped with tactile and temperature sensors. A robot face will also be constructed for facial expression animation. All of the robot components will be covered in a rubber skin.

References

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