Acceleration-Based Gesture Recognition Using a Fuzzy Neural Network Variant

David Mace, John-Nicholas Furst, Ayse Coskun
Boston University Electrical and Computer Engineering Department, Boston, MA
davidmace13@mittymonarch.com, jnfurst@bu.edu, acoskun@bu.edu

Introduction

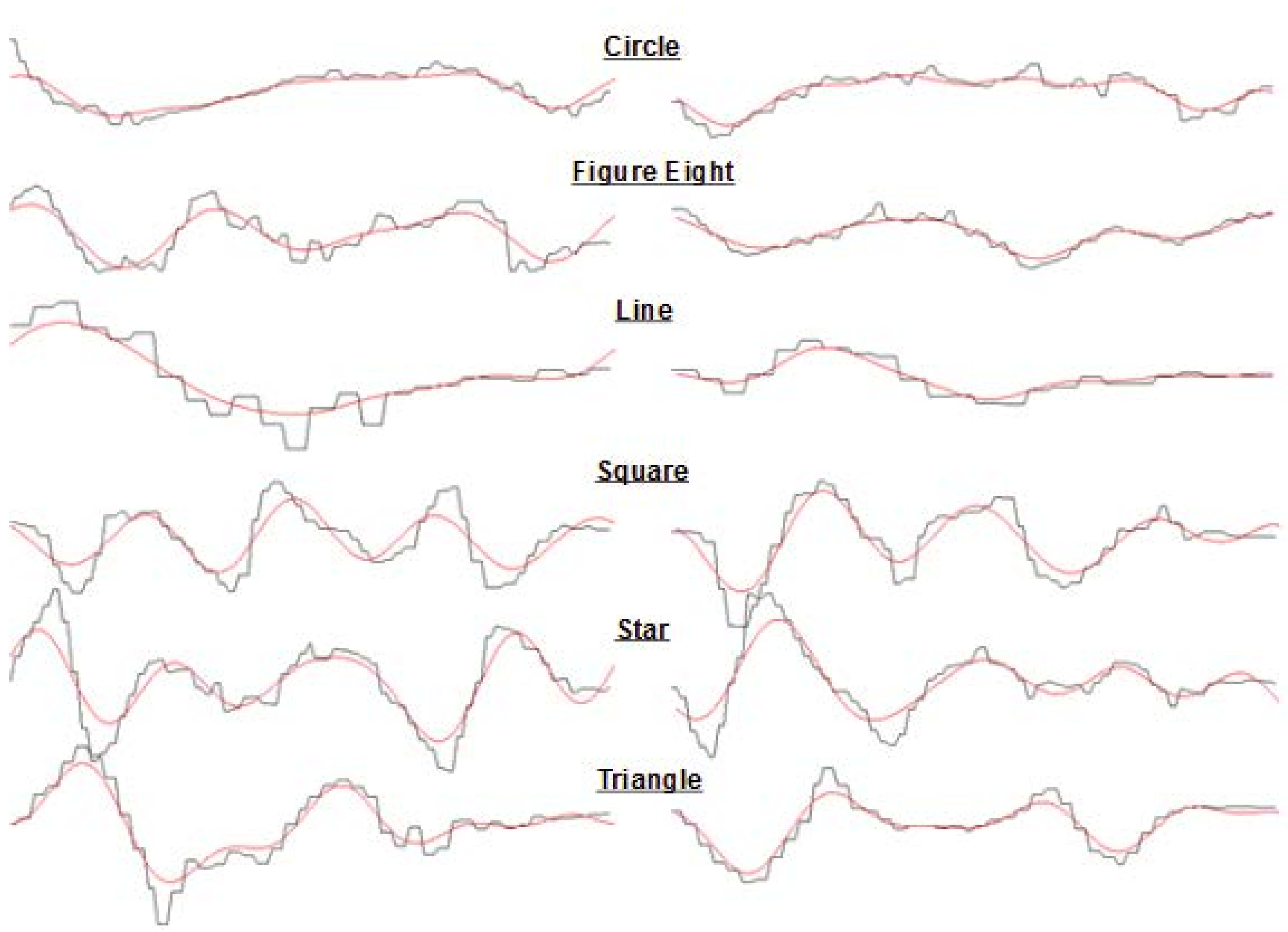
Currently there is a large demand for convenient computer interface systems that allow for more seamless interaction with the technology that we use everyday. One such type of system is acceleration-based hand gesture recognition. The recent creation of the Wii[1] and Xbox Kinect have drawn attention to hand motions as a way of manipulating devices. Beyond video games, this technology has also been used in sign language recognition, remote control technology, and socially assistive robotics. In this project I test the validity of using a TI EZ430 Chronos Watch to communicate with an Android tablet through gestures. Acceleration-based gesture recognition systems have been implemented with accuracy over 90%; however, there remain topics in acceleration-based gesture recognition that have not been extensively explored. The purpose of this project is to introduce an original feature-based gesture recognition algorithm and improve the recognition of motions performed in varying planes.

Setup

TI Chronos EZ430 Watch & ASUS Transformer Pad TF300T

Low Pass Filter

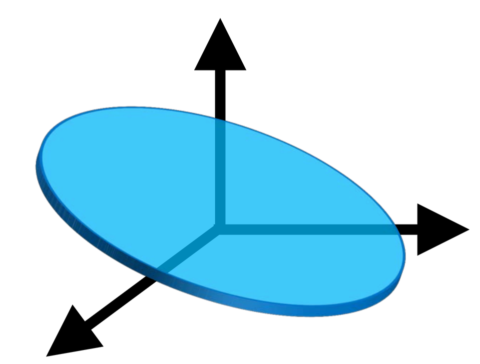
Objective: Filter out high frequency noise in acceleration data to reveal the underlying major components of motion by using Fast Fourier Transforms



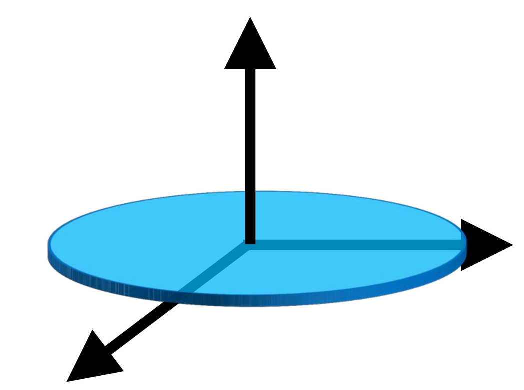
Red=after low pass filter Black=before low pass filter

Plane Normalization

Objective: Rotate acceleration vectors so that motion is relative to x-y plane instead of original plane.



Motion of Circle Before Plane Normalization



Motion of Circle After Plane Normalization

- Find average acceleration vectors of similar, contiguous segments of acceleration data
- Use least squares error plane fitting on segment sum vectors to find average plane of motion
- Rotate all acceleration vectors to be relative to average plane

Gesture Recognition Algorithm

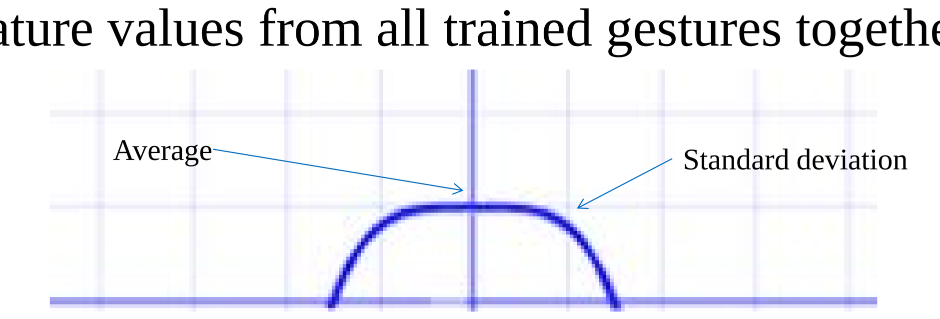
Objective: Correctly classify gesture queries based on measurements obtained from other trained gesture data.

Feature Extraction

Extract 21 features from acceleration data on both X and Y axis. Features include RMS, standard deviation, average distance between maximums, area under curve, average energy, and others.

Fuzzy Set Membership

When training for each feature type, take average value and standard deviation of feature values from all trained gestures together.

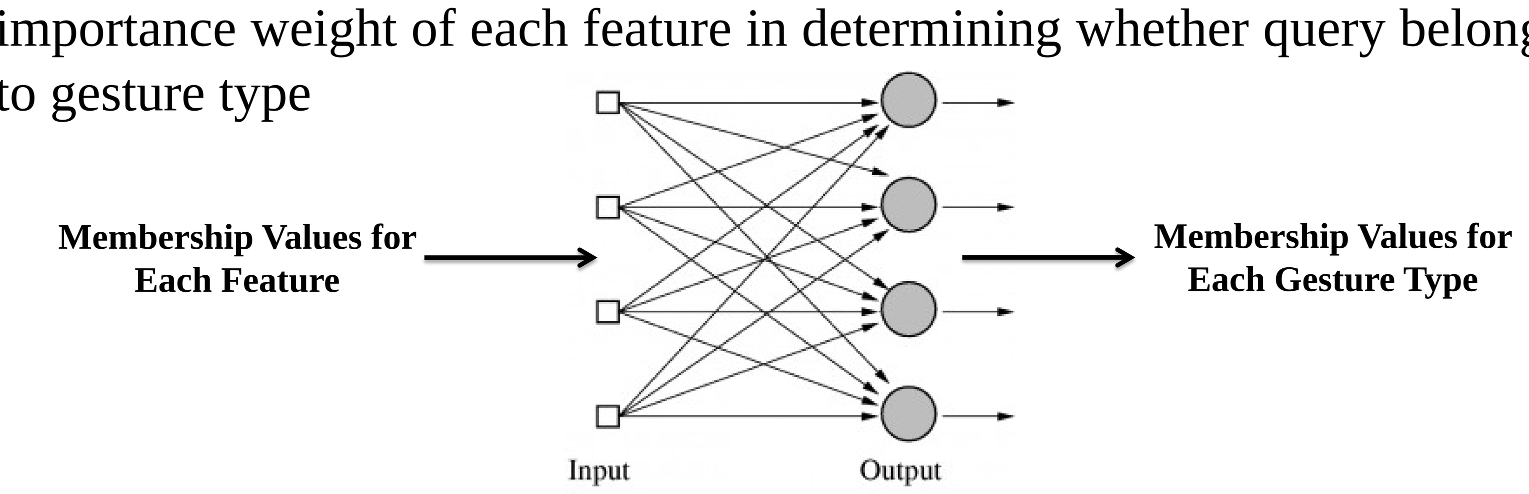


$$membership = -(\frac{2}{3} * stddev * (x - avg))^4 + 1$$

When querying, use function above to find closeness of each of query's features to the average of the features of a gesture type; this value between 0 and 1 is the membership of a query to each of the gesture types

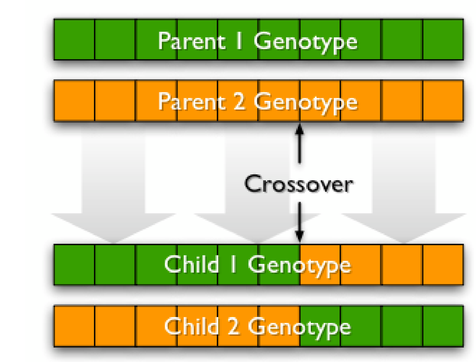
Neural Network Feature Importance Adjustment

Use perceptron neural network for each gesture type to determine importance weight of each feature in determining whether query belongs to gesture type



Genetic Algorithm Feature Subset Selection

Objective: Find optimal subset of features to use because having too many unnecessary extra features degrades performance



- Use genetic algorithm because cannot test every possible subset, so try to construct best one
- Feature subset is found for only two of the four participants to ensure that the subset doesn't only work for a certain group of data

Results

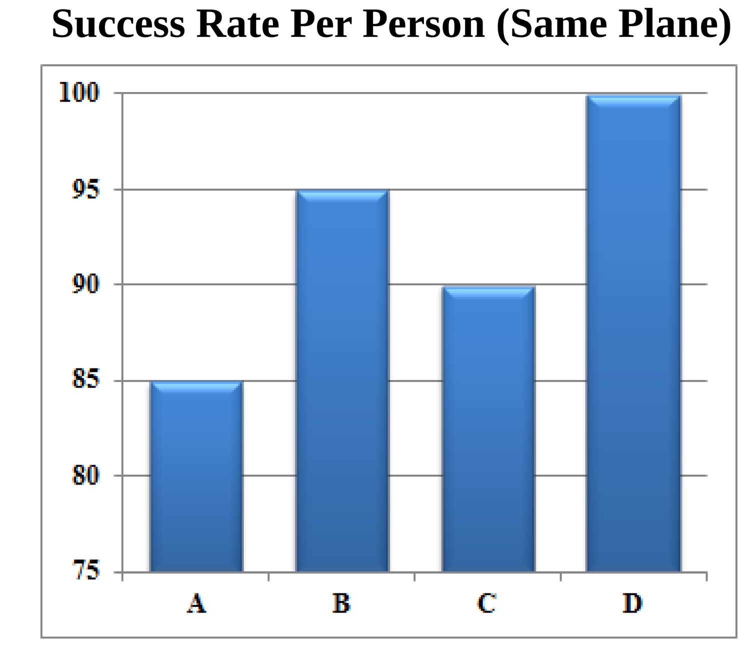
Confusion Matrix Same Plane

Classified As	Circle	Figure Eight	Square	Star
Circle	19	0	0	1
Figure Eight	1	18	0	1
Square	0	0	19	1
Star	0	0	2	18

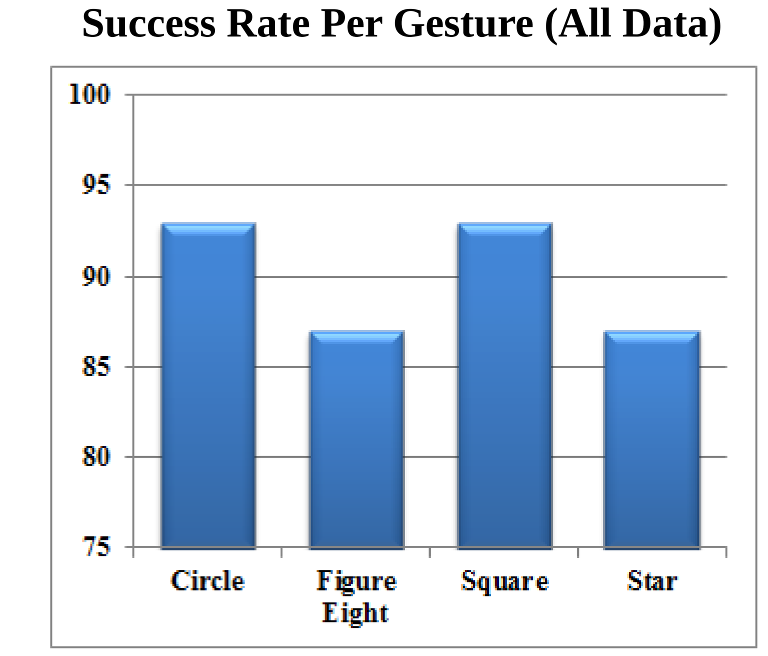
Confusion Matrix Different Planes

Classified As	Circle	Figure Eight	Square	Star
Circle	9	0	0	1
Figure Eight	1	8	0	1
Square	0	0	9	1
Star	0	0	2	8

Success Rate Per Person (Same Plane)



Success Rate Per Gesture (All Data)



Results are obtained by training all of the data sets except one from the same person. The class of the left out gesture is then determined by the algorithm with a success of 93% for same plane motion and 83% for different plane motion. These results are comparable to those of other similar studies.[1,2,3]

References

[1] Schlommer, Thomas. "Gesture Recognition With a Wii Controller." Wiigee.com. N.p., n.d. Web.

[2]Yang, Jhun-Ying. "Using Acceleration Measurements for Activity Recognition: An Effective Learning Algorithm for Constructing Neural Classifiers." Pattern Recognition Letters, n.d. Web.

[3] Kim, Joonki. "On-line Gesture Recognition By Feature Analysis." Computer Vision and Shape Recognition. N.p.: n.p., n.d. N. pag.