

A Framework for Sensor Based Sign Language Detection using Machine Learning

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Background

Human Computer Interaction (HCI)

To be able to interact with computers the same way
we interact with other Humans



Vision Based

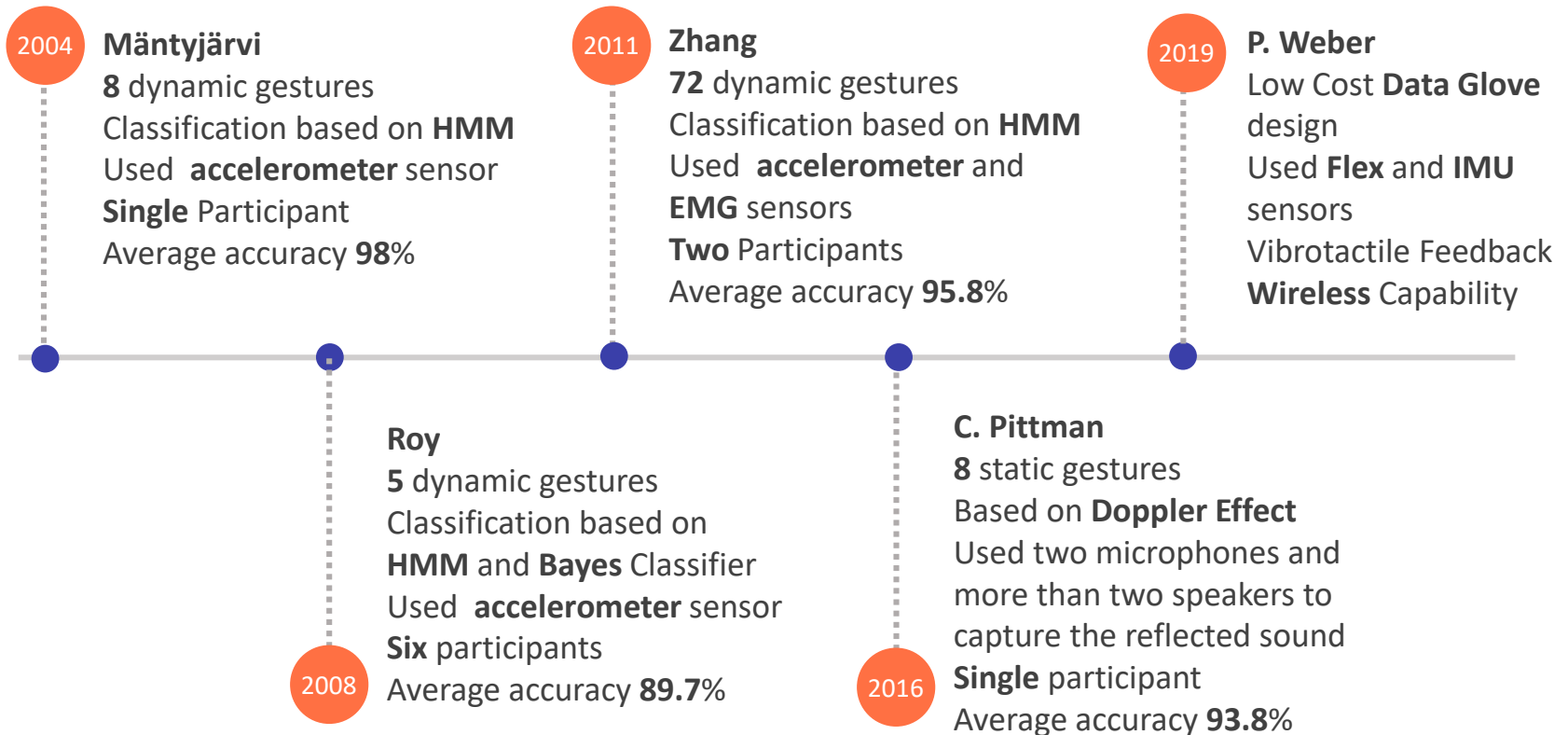
- No extra hardware needed other than the **Camera**
- **Sensitive** to the background and hand orientation
- **Can not** be designed as a standalone device



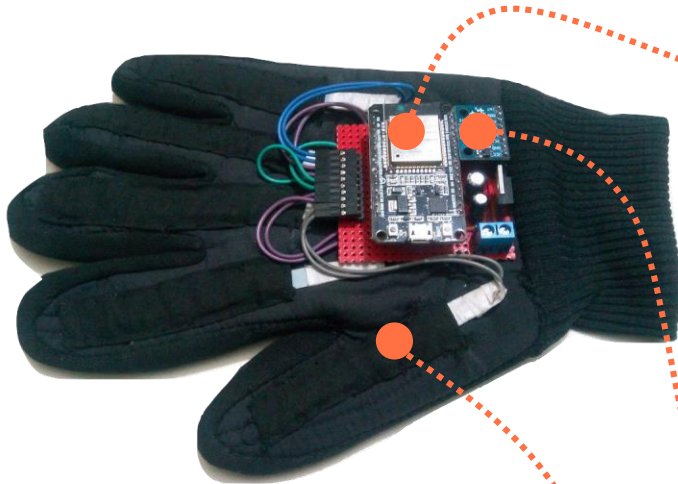
Sensor Based

- Extra hardware is required e.g. **Data Glove**
- **Not sensitive** to the Background and orientation
- **Can** be designed as a standalone device

Related Works



Hardware Setup



ESP-32 Microcontroller

Xtensa dual core **32-bit** CPU

240MHz clock frequency

4MB Flash and **520KB** RAM memory

Wi-Fi and **Bluetooth** Connectivity

MPU6050 IMU Sensor

3-Axis **Accelerometer** sensor

3-Axis **Gyroscope** sensor

Digital Motion Processing (**DMP**)

Flex Sensor

2.2" Flex sensors

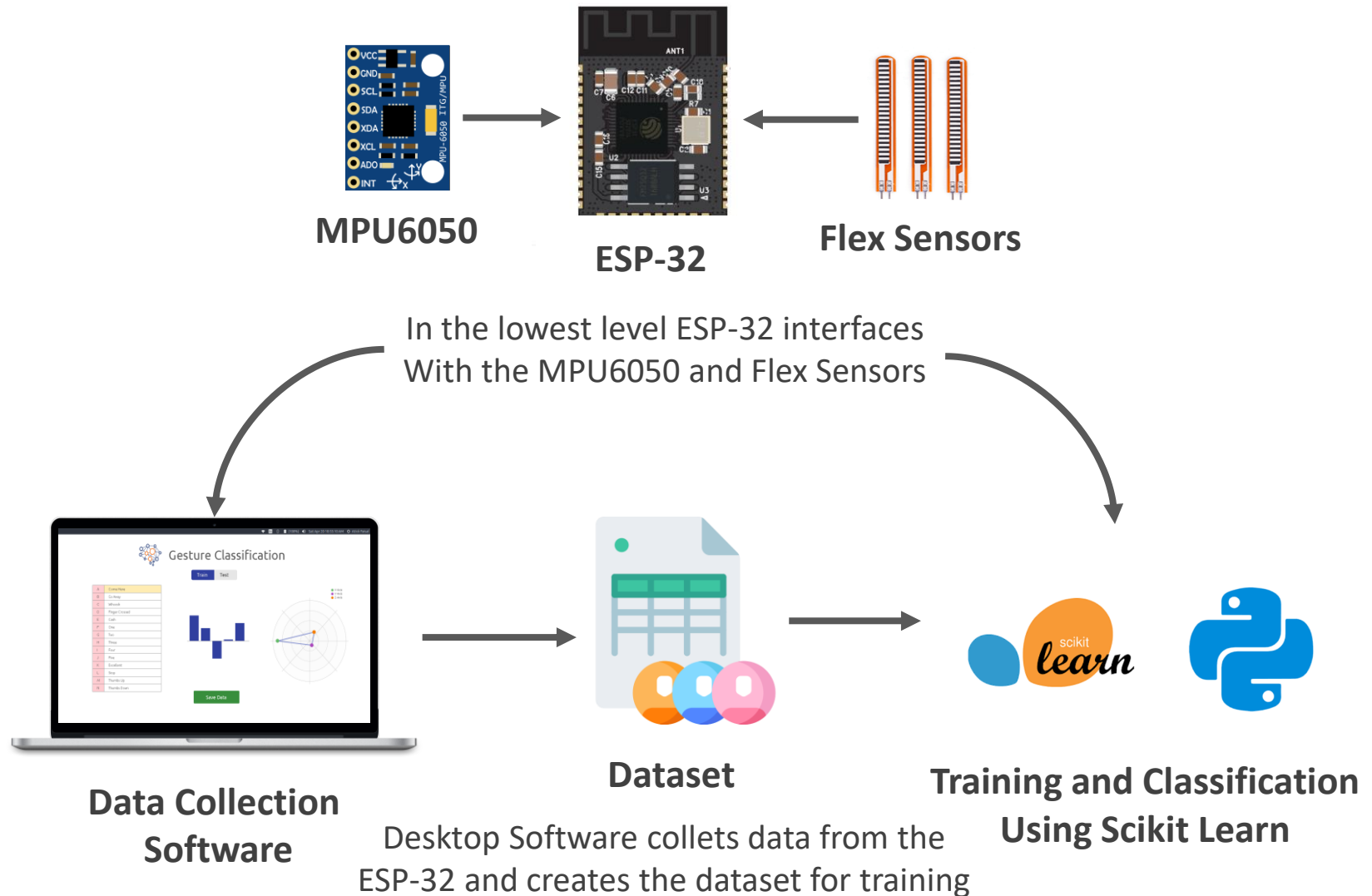
2x Resistance at 180° bend

Cost Breakdown

Esp-32 MCU	600/-
MPU6050	160/-
Flex sensors (x5)	3500/-
Others	200/-

Total **4460/-**

Software Framework



Data Collection

Static Gestures

14

Number of Gestures

30

Number of Participants

21 : 9

Gender

21 – 32 years

Age Range

N/A

Sampling Frequency

N/A

Window

Dynamic Gestures

3

5

4 : 1

21 – 23 years

7Hz

Size: 10 samples

Length: 1.67s

Overlapping: 50%

Data Filtering

Statistical Median

Removes **outliers**
Used for Flex Sensor

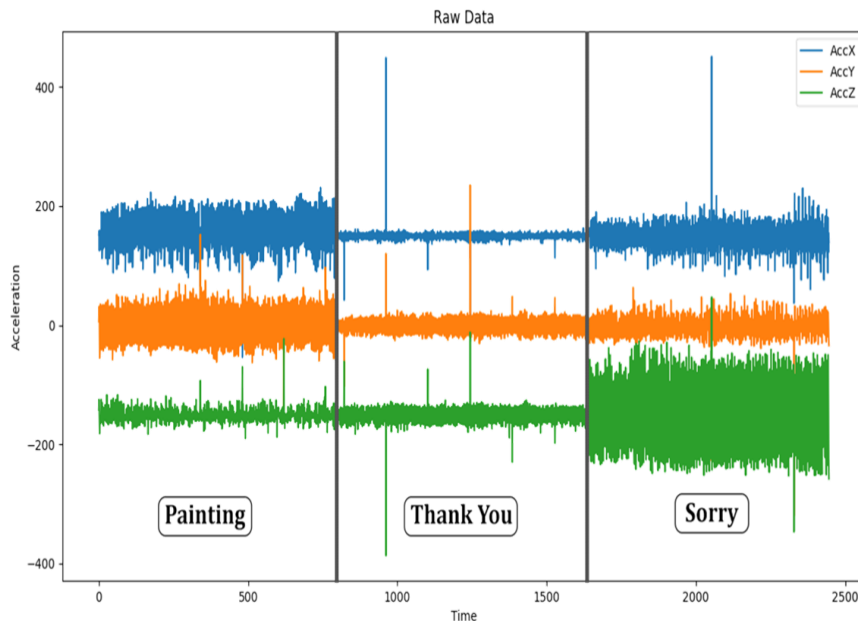
Complementary Filter

Stops the **yaw angle drift**
Used for IMU Sensor

Digital Motion Processor

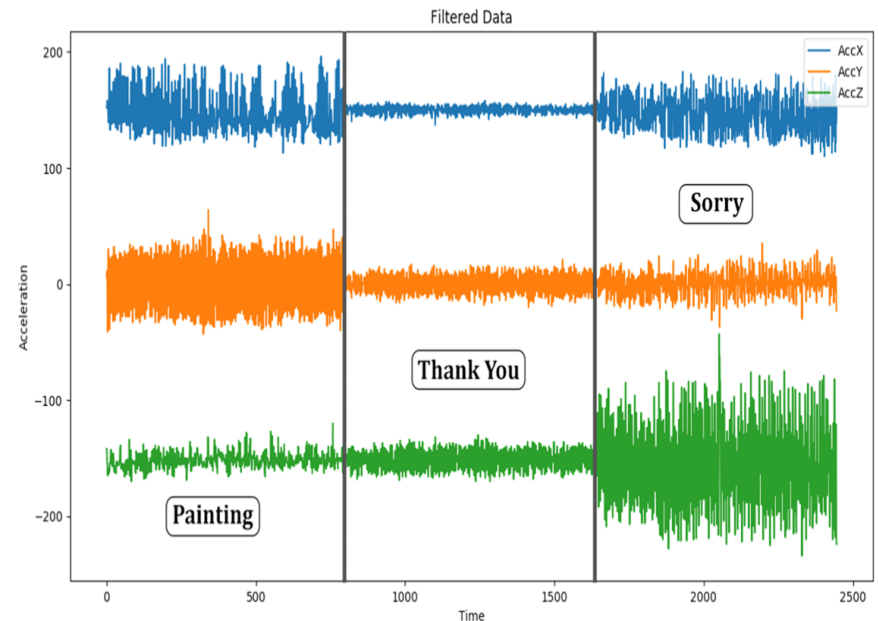
On-chip filtering
Used for IMU Sensor

Unfiltered Data



vs

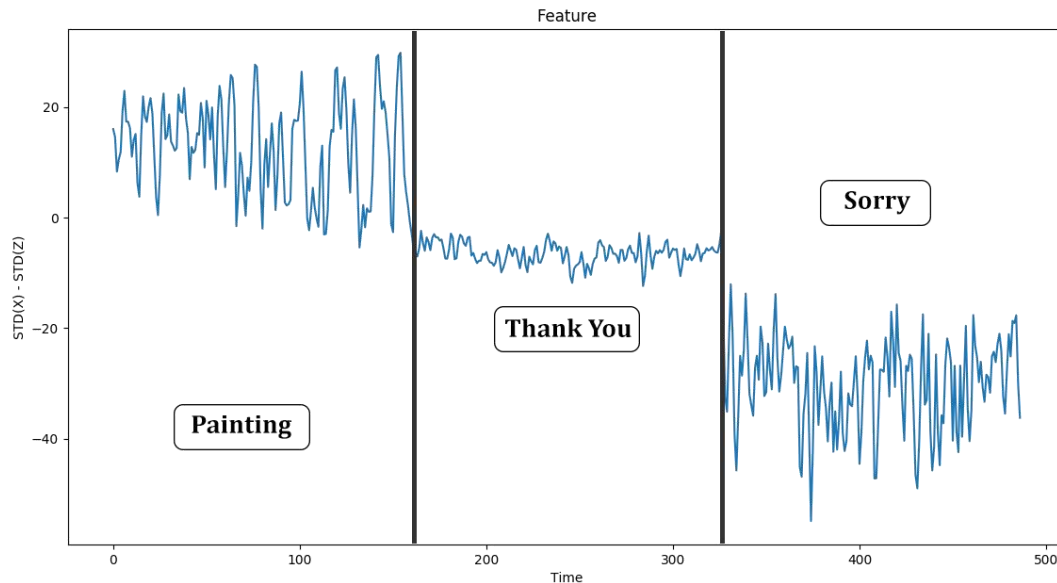
Filtered Data



Feature Extraction & Training

Static Gestures

Mean
Median
Standard Deviation (σ)



Dynamic Gestures

Mean
Median
Variance
Standard Deviation (σ)
Root Mean Square

Chosen Feature

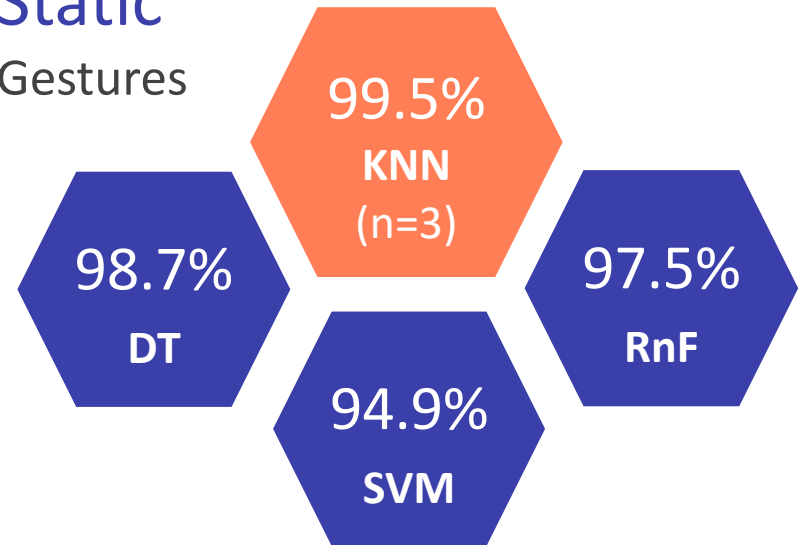
$$\sigma_x - \sigma_z$$

Result Analysis

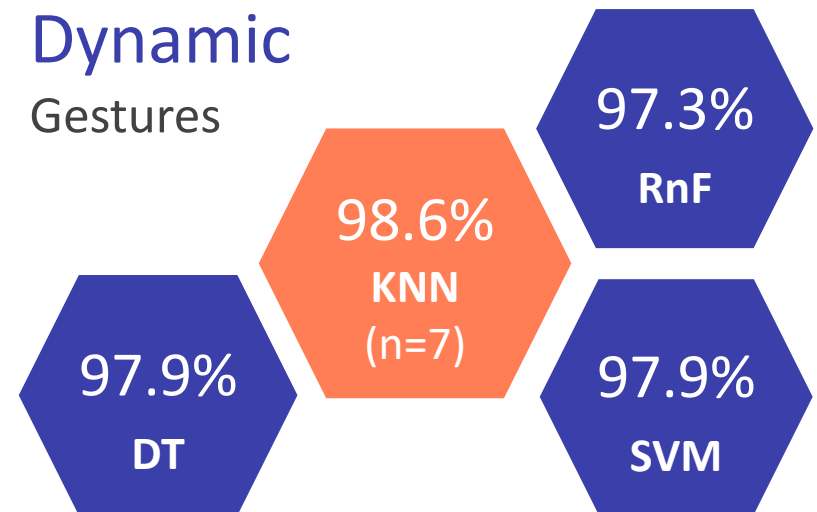
Evaluation Process

- Accuracy using **Cross Validation**
- Precision and Sensitivity
$$Precision = \frac{TP}{TP + FP}$$
$$Sensitivity = \frac{TP}{TP + FN}$$
- Confusion Matrix

Static Gestures



Dynamic Gestures



Future Works

Using **Kalman Filter**
with IMU Data
Better optimization



Bangla Sign Language
Classification

First ever complete sensor-based
Bangla sign language framework



Extending the Dataset

Increase the number of gestures
Data from actual impaired



On-device Classification

Portability
Cost reduction

Thank You



Appendix A

Euler Angle Equations:

$$\phi = \tan^{-1} \frac{2(wx+yz)}{1-2(x^2+y^2)}$$

$$\theta = \sin^{-1} 2(wy - xz)$$

$$\psi = \tan^{-1} \frac{2(wz + xy)}{1 - 2(y^2 + z^2)}$$

Here, w , x , y , and z are real numbers, and i , j , and k are the fundamental *quaternion units*.

Appendix B

Orientation Angle Equations:

$$yaw = \tan^{-1} \frac{2(xy - wz)}{2(w^2 + x^2) - 1}$$

$$pitch = \tan^{-1} \frac{gravity_x}{\sqrt{gravity_y^2 + gravity_z^2}}$$

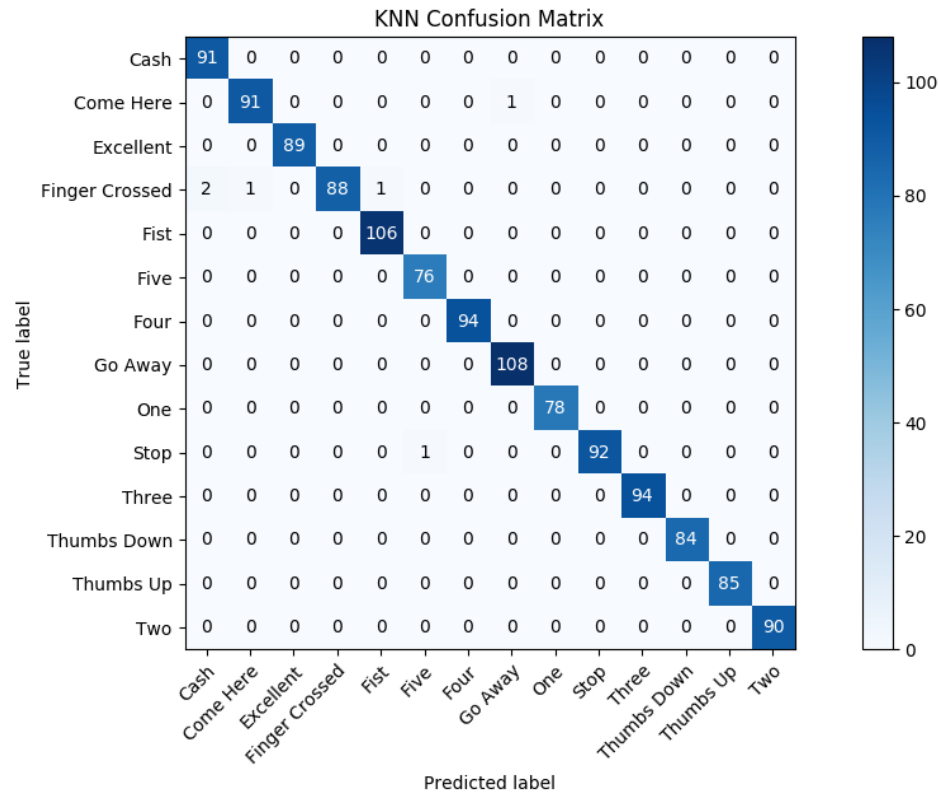
$$roll = \tan^{-1} \frac{gravity_y}{\sqrt{gravity_x^2 + gravity_z^2}}$$

Here, w , x , y , and z are real numbers, and i , j , and k are the fundamental *quaternion units*.

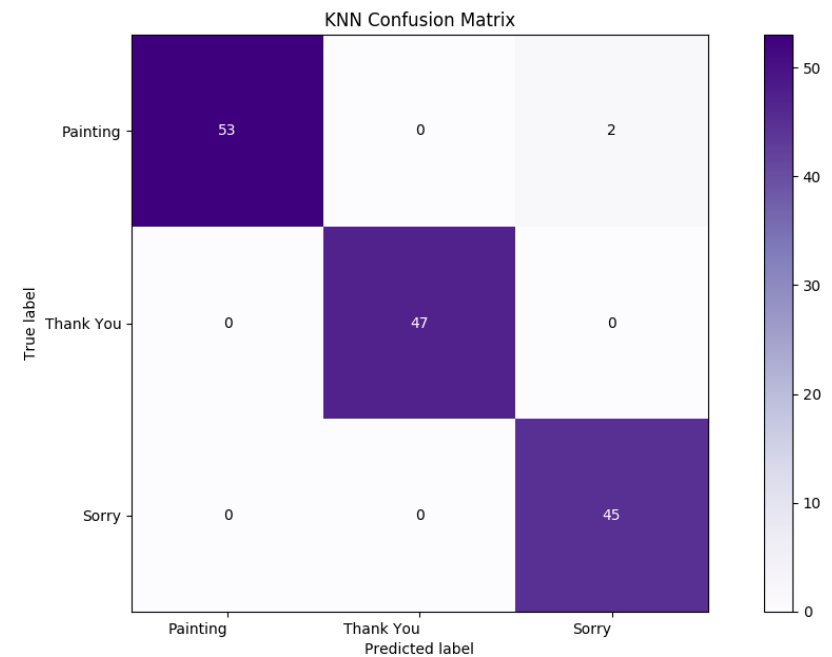
Appendix C

Confusion Matrix of KNN Classifier

Static Gestures



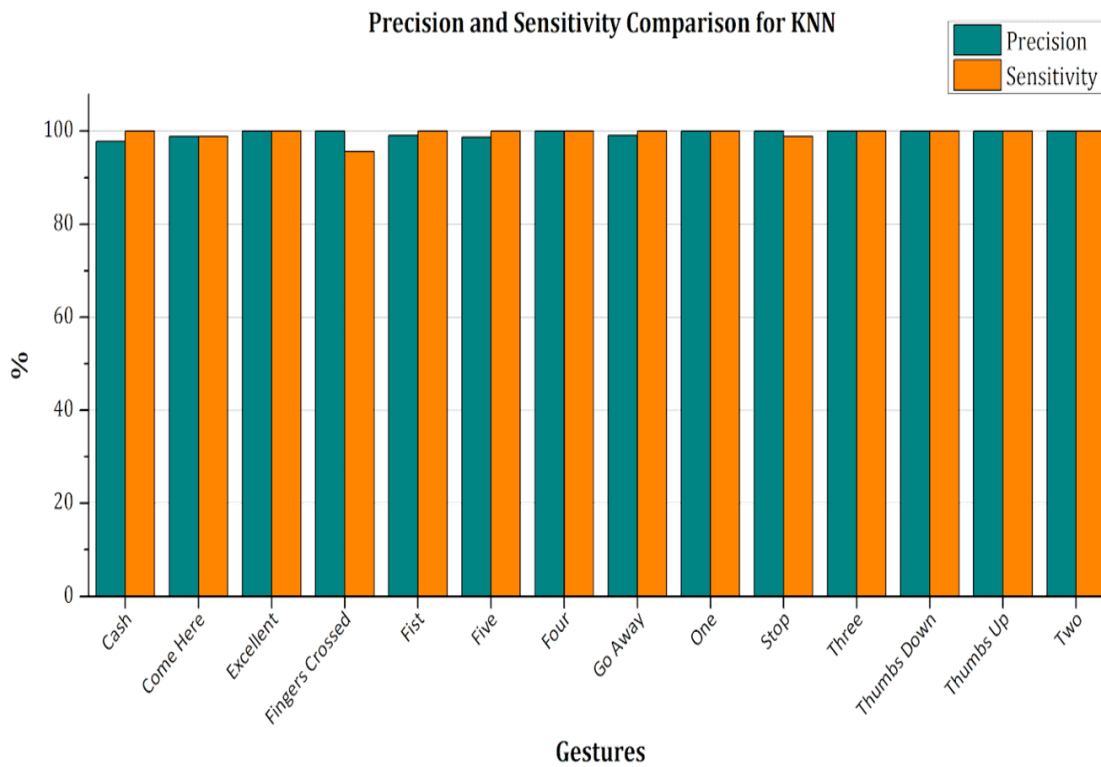
Dynamic Gestures



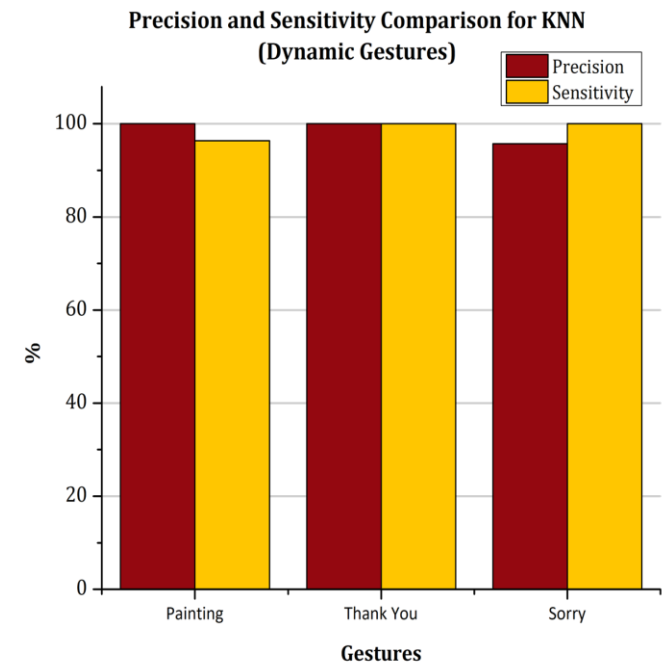
Appendix D

Precision vs Sensitivity of KNN Classifier

Static Gestures



Dynamic Gestures



Appendix E

Static Hand Gestures



Come Here



Go Away



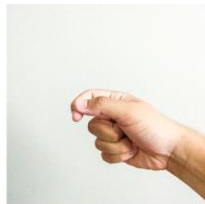
Fist



Fingers Crossed



Thumbs Down



Cash



One



Two



Three



Thumbs Up



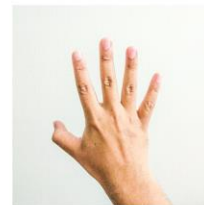
Four



Five



Excellent



Stop

Appendix F

Dynamic Hand Gestures



Painting



Thank You



Sorry