Wrist-based Gesture Recognition on Garmin Smartwatch

Maxwell Botham, Michele Esercitato, Cheyenne Goh & Faisal Hossain
Schulich School of Engineering, University of Calgary

GARMIN.

SCHULICH School of Engineering
UNIVERSITY OF CALGARY

Abstract

- Smartwatches are a useful tool for maintaining a healthy lifestyle by allowing users to track workouts and monitor important health metrics
- Garmin is an industry leader in the field of smartwatch technology
- Due to small screen sizes and miniature buttons on smartwatches, there is room for improvement in user interaction
- Project aims to improve the usability of Garmin smartwatches by using existing sensors on the Venu 2 Plus to allow for hand gesture recognition
- Developed a system capable of recognizing multiple gestures using the Venu 2 Plus and interacting with a connected Android device
- Strong proof of concept for the feasibility of gesture recognition features on Garmin smartwatches

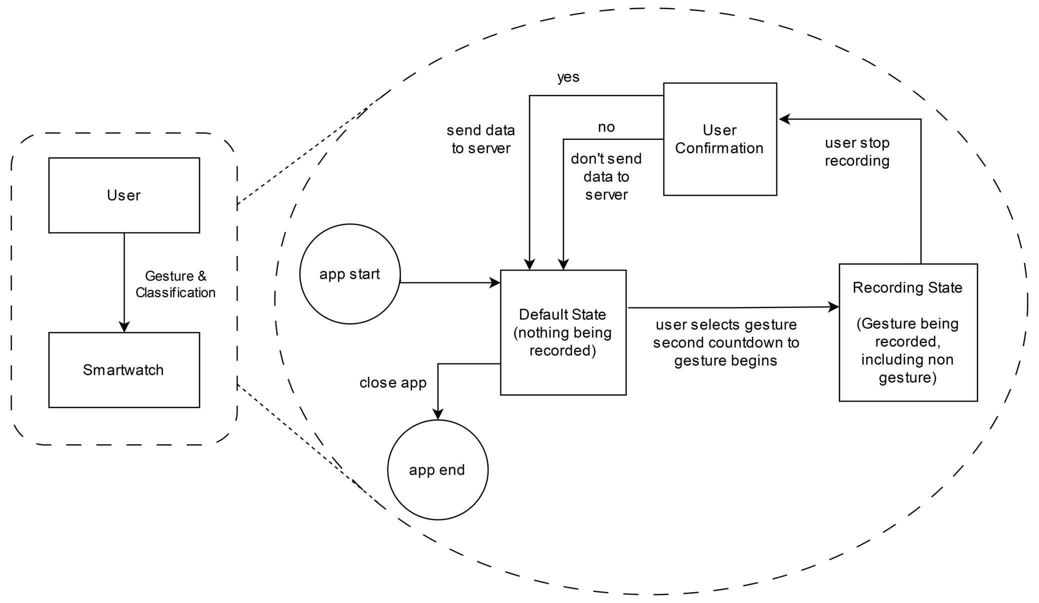
Introduction

- Project involved the training and creation of a machine learning model that is able to recognize common hand gestures on a Garmin's Venu 2 Plus smartwatch
- End goal was to produce a system that could identify a gesture on the watch and perform an associated action on a smartphone device (e.g., play or pause music)

Methods and Materials

Machine Learning Model Training

- Selected gestures that were unique from each other and simple for the user to perform
- Decided on three motions – hand wave, hand raise, and clap
- Trained model using six input vectors from two onboard sensors on the Venu 2 Plus: accelerometer (x-, y-, and z-axis) and gyroscope (x-, y- and z-axis)
- While hardware allowed up to 100 samples per second, 50 samples per second was chosen to ensure high model performance as well as overall lower system latency
- To train the model, every team member performed each of the selected gestures numerous times
- Created a training data collection application using ConnectIQ, Garmin's smartwatch app development package
- Developed system that records gyroscope and accelerometer data until the user indicates gesture recording is complete
- Data is then forwarded to a server hosted with Heroku to be classified and stored



Machine Learning Model Development

- Model developed in PyTorch
- Convolutional Neural Network (CNN) model architecture
- Cross-entropy loss function

Application

- Created an application that would utilize the sensors to perform live classification of gestures
- Due to the lack of computational power on the watch, we opted to use an Android application to run the ML model
- PyTorch model is converted to TensorFlow Lite using Open Neural Network Exchange (ONNX) for compatibility with the mobile device
- Utilizing Bluetooth Low Energy (BLE) capabilities on the Venu 2 Plus, sensor data is forwarded once per second to the Android application
- Android application uses a sliding window method to input the data into the model, and receives gesture classification as output
- When a gesture is classified as something other than non-gesture, the application responds to the watch using the same BLE link to alert of the classification
- Watch displays the gesture performed, and performs an action as appropriate
- By default, the three gestures, hand clap, hand raise, and hand wave will play and pause a music track, while the "no gesture" classification will not execute anything on the phone

Results

- High validation and testing accuracy (>95%) for ML model
- ML model inference on the mobile phone takes around 50 ms
- Latency lower than 7 seconds on average
- Reduced BLE lost packets by optimizing BLE connection

Discussion

- Most of the latency comes from the Bluetooth connection, which could be improved by studying the underlying hardware and protocol, as we are using the Garmin Connect Mobile SDK to facilitate the connection
- Due to privacy concerns, data was only collected from team members, which is a source of bias
- Given more data and variance in data, the machine learning model could recognize more false positives

Conclusions

- Was able to meet the Minimum Viable Product of creating a gesture recognition system with a Garmin Smartwatch and Android Device
- High potential for developing and executing ML models on low powered devices, such as mobile phones and microcontrollers
- Learned a lot about developing a system made up of various interconnected components

CONTACT
Faisal Hossain
Email: faisal.hossain1@ucalgary.ca
Phone: 403-993-7760