Detecting Health-Related Behaviors and Habits using Mobile Phones and Wearable Sensors

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Turning Discovery Into Health

Abstract

When recording data using wireless sensors data may be lost, which is often discovered after the recording process has concluded. By using a program that provides real-time feedback of the processed data, it's possible to determine errors within the data instantly and prevent them from occurring. Computing and plotting the sampling rate of data recorded by the wireless sensors provides a more accurate representation of the time/instance at which an error(s) occurs along with additional information to where the source of error is from, in this case the sensor Bluetooth proximity from the computer. This can be done by using Python to format CSV files containing thousands of datasets to graphically visualize abnormal occurrences in sampling rates. The goal of this project is to create a tool to help researchers studying real-time systems for activity detection through multiple-wireless sensors worn on a human body.

Introduction

Background: Accelerometer sensors record change in velocity within a three-dimensional plane. They can be used to record motion of the limbs of a person, and the resulting data can be used with machine learning algorithms to infer daily-activities performed by individuals. Even the slightest of vibrations acting upon the accelerometers can be detected which can make the difference in the signals being transmitted and the data being processed by the program. Participants who volunteer for research studies and who wear the sensors for anywhere between hours and months can then supply enormous amounts of data to researchers, which might ultimately be used to study relationships an individual's behavior and habits and health.

Problem: Based on the data used to train an algorithm to predict certain behaviors, errors may occur such as the program predicting the wrong activity being performed due to bad data or not receiving any data from the sensors. Data-loss may occur during the recording process of the experiment, which can effect the overall quality of the data. The root of these errors can be difficult to determine since there are many factors lying within the process, such as bugs in the code written for the software or firmware malfunctions in the sensors being used. By using real-time feedback from the program and maintaining the confidence at which a program predicts any activity correctly, the experimenters may be able to determine data errors during the experiment process and prevent errors from occurring.

Materials and Methods

Figure 2: MetaMotionR Accelerometer Sensors
Used for lab-experimental exercises and recordings

In-Lab Experiment

Participants were asked to wear multiple accelerometer sensors such as on their wrist, ankle and/or on their thigh, as part of the experiment process in order to record data of physical activities. MetaMotionR sensors were worn throughout the experiment, which consisted of a "typical activity phase" and "breaking the algorithm phase," where the participant performed daily activity exercises, depending on the given task. During the typical activity phase, the participant would perform the activity in a more controlled and direct fashion, one that would be recognizable and predictable to the program. However, during the "breaking algorithm phase," the participant would perform the same activity, but in different variations and attempt to "beak the algorithm" by tricking it into predicting the wrong activity. The participant would perform various daily activities like walking, folding laundry, using a computer, sitting and writing, etc. Within the voice feedback that were transmitted to the participant, whom were wearing headphones, consisted of at most 3 exercises that the program *thinks* is happening. The feedback with the highest volume response is the most "confident" prediction the program has, followed by quieter responses which are considered doubtful predictions by the program. Depending on the quality of the data recorded, the data would be used to help train the algorithm so that the accuracy of prediction would be improved

Figure 3
Experimental Wrist Motion-Sensor

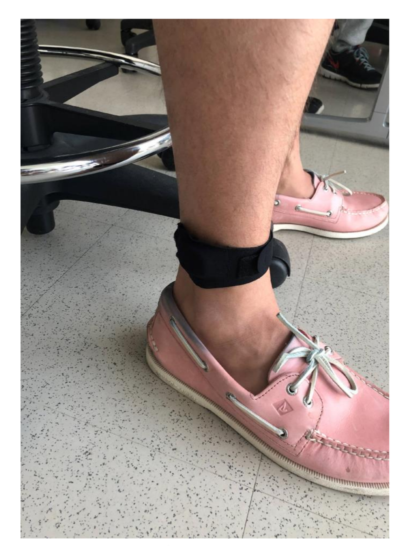

Figure 4
Experimental Ankle Motion-Sensor

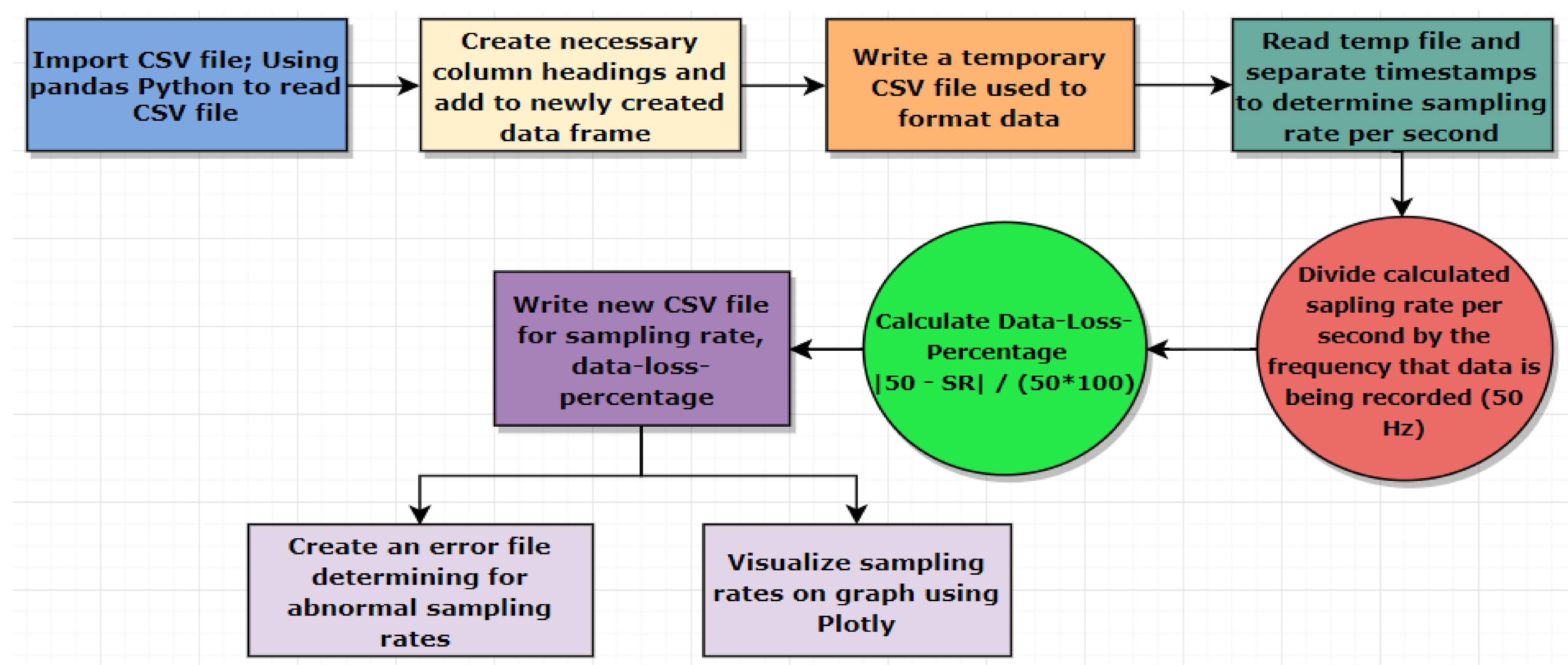

Figure 5
Flowchart diagram of steps taken to construct graphs and new CSV files

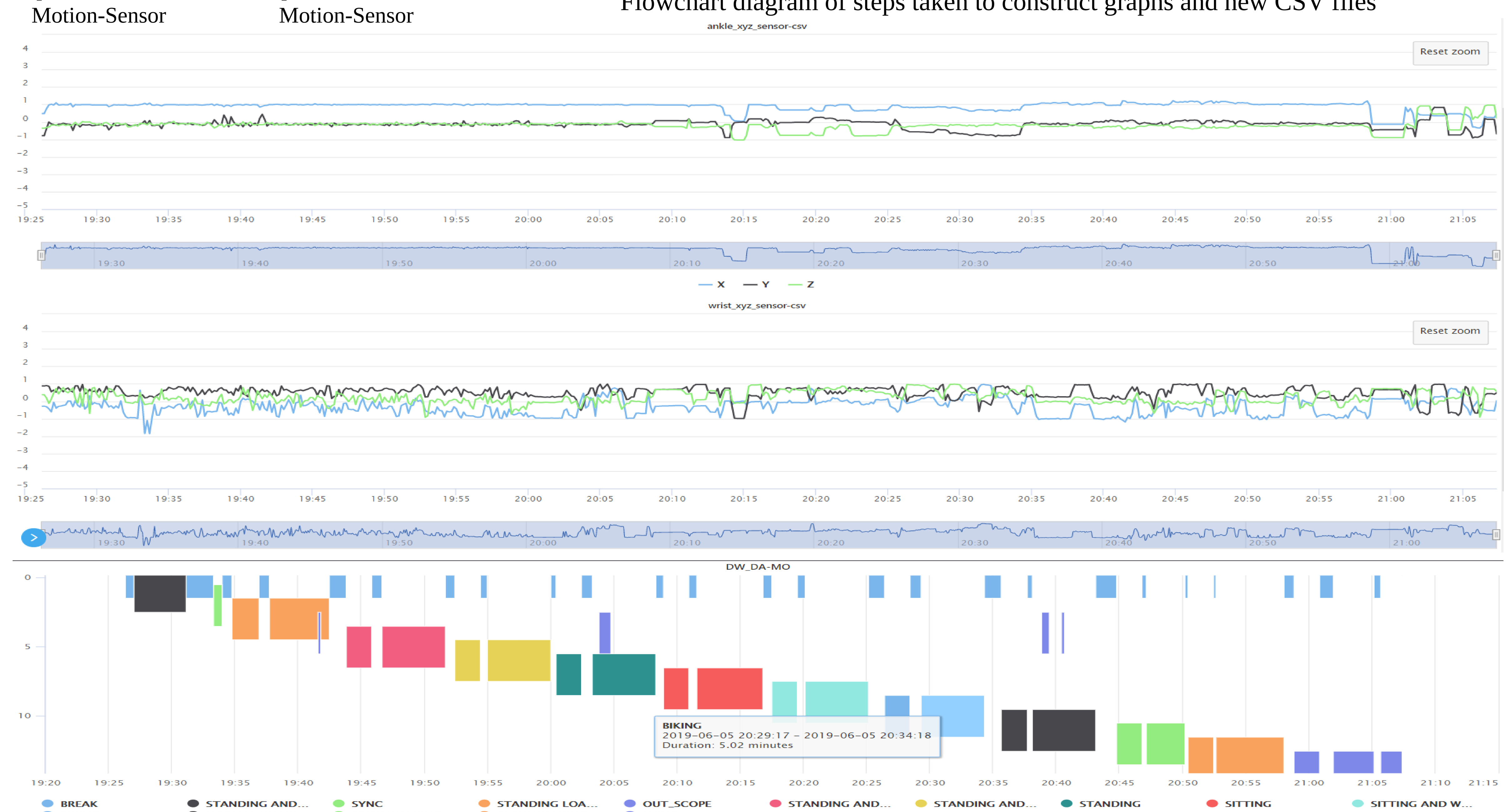

Figure 6: Ankle Sensor | Wrist Sensor | Activity Annotation Graph (Activities that were performed with the corresponding time and data above)

Results

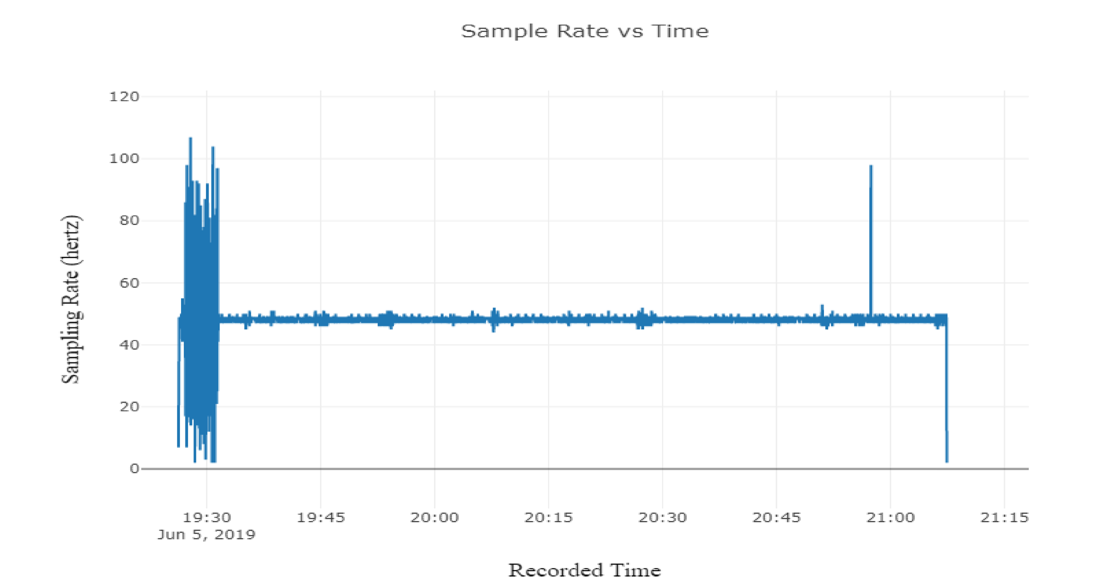

Figure 7: Sample-rate Wrist Sensor Graph (multiple errors)
Abnormal sample rate occurring during the first 5-8 minutes of this experiment due to proximity of the sensor being too far from the connected computer and orientation of the person to the computer

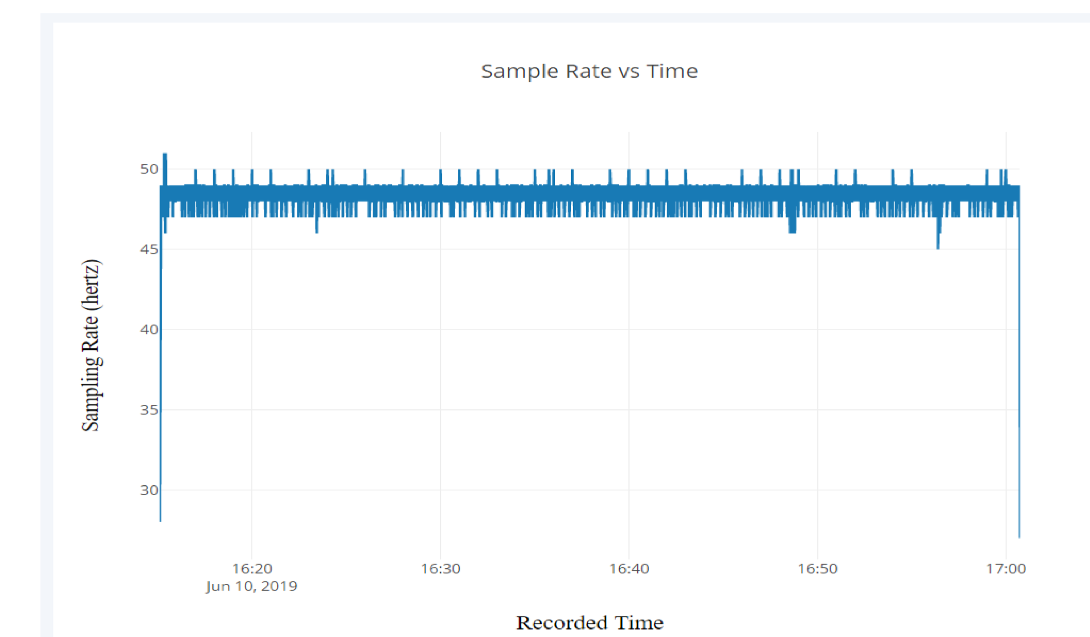

Figure 8: Sample-rate Ankle Sensor Graph (minimal errors)
Sampling rate during this trial was relatively normal, averaging about 49 hertz

Conclusion

Multiple accelerometer sensors were used to collect data on people performing daily physical activities. The sampling rate per second of the data recorded, was calculated, graphed, and compared to the set frequency of the sensors, which was 50 hertz. The abnormal sampling rates were determined by the visual representation from the graphs, allowing researchers to better understand where and why the data error(s) were occurring. Within this specific experiment trial, abnormal sampling rates were recorded during the first few minutes of the experiment due to the wrist and ankle sensor being too far away from the computer that it was connected to and possibly that the participant wearing the sensor had their back constantly facing the computer as well, effecting the rate at which the data was being transmitted/received by the Bluetooth accelerometers.

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