Activity Detection and Exercise Routine Optimization via Sensor Fusion

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***Abstract*—Internet of Things (IoT) has enabled a plethora of applications related to data analytics. In this paper, an intuitive method for optimizing exercise routine data, and then providing feedback for future workout routines is presented. This method utilizes various Microcontroller Units (MCUs) with a variety of embedded sesnors for activity detection Additionally, this method also incorporates supervised and unsupervised learning algorithms, including multi-class Gaussian Support Vector Machine (SVM) and K-Means Clustering, to generate a predictive model for exercise routine optimization.**

INTRODUCTION

Technological advances in microprocessor technology and IoT wireless connectivity have allowed for many consumer-based devices to be utilized in a vast array of applications. In particular, this breakthrough in wireless technology has allowed for data analytics to be procesed on a widescale basis on different platforms, including cloud/server-based computing and microcontrollers. With the recent upsurge of machine learning algorithms being utilized in order to classify such data into meaningful states, interest has been shown in using classification methods within various realms. This paper demonstrates the feasibility of utilizing such a technology for the purpose of quantitative exercise routine optimization by interfacing with a multisensor microcontroller unit, and extracting features from multiple sensor datasets in order to generate an accurate predictive model which can monitor future workout data and quantitatively determine an ideal workout routine.

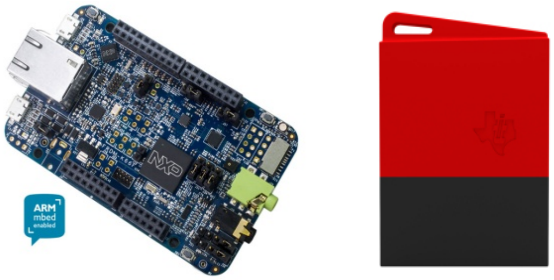

Fig. 1 - Picture and Description of NXP Freedom K66F MCU and other peripherals [6].

This project paper will first provide a brief description of the methodology utilized in obtaining a predictive model for preprocessing, feature extraction, and algorithmic training of this predictive model. The tools utilized in this multistage process were: the NXP Freedom K66F and TI CC3200 SensorTag MCUs (shown in Fig. 1), along with a sampling datalogger used in order to collect discrete-time accelerometer, gyroscope, and temperature data. Multiple features, including the mean, standard deviation, variance, and total energy of each dataset, were calculated. Principal Component Analysis (PCA) was used in order to reduce the dimensionality of the feature-based dataset and simplify the predictive model while capturing maximum variance.

For this investigation, MATLAB will be used for machine learning analysis. After collecting discrete-time values with known labels, the aggregate dataset will be analyzed by various supervised machine learning algoritms, namely the linear and Gaussian Support Vector Machine (SVM) in order to cluster data points into n states for n activities during detection. However, in most real-world situations, labeled datasets are not available. In this case, the unsupervised k-means learning algorithm will be utilized in order to mathematically group points from an unlabeled dataset into k clusters. In both situations, data collection and features extracted using a sensor fusion paradigm is said to yield much more promising results.

Previous papers show that similar methodologies which utilize single-sensor data allow for accurate activity detection. Along these lines, other researchers have demonstrated that a sensor fusion scheme, as opposed to a single gyroscopic sensor approach, yielded greater accuracy for orientation estimation [10]. Given this information, utilizing a sensor fusion-based approach for more complex tasks, such as multi-state activity detection and similar activity detection, is promising.

Using these tools, techniques, and inferences from past research investigations, this project paper aims to analyze the following: the effect of feature analysis on activity detection, and whether or not features obtained from combined sensor data can yield greater detection accuracy and optimization.

By the end of this REU project, we will have demonstrated the feasibility and desirability of incorporating a sensor fusion-based framework in activity detection. This will be done by creating an accurate predictive model by utilizing machine learning algorithms and specialized features extracted from a multi-sensor dataset.

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