



UNIVERSITY OF  
**TORONTO**

ECE 1778

CREATIVE APPLICATIONS FOR MOBILE DEVICES

FINAL REPORT

---

## Fit-Tune

---

*Programmer 1 :*

Zichuan WANG

1000474300

*Programmer 2:*

Zhaohui QU

1005783127

*Instructor:*

Prof. Rose JONATHAN

Submitted on April 15, 2020

Word Count: 2276

# 1 Introduction & Motivation

## 1.1 Can Music Improve Your Workout?

Listening to music while exercising doesn't just relieve boredom, but also helps improve the quality of your workout by increasing your stamina and putting you in a better mood [1].

Several studies have shown that music can help improve physical performance either by increasing workout pace, distance travelled or repetitions completed [2]. For instance, a 2006 research investigated the effect of music tempo on the selection of treadmill speed revealed that while listening to uptempo music, participants increased their pace and distance travelled without experiencing extra level of fatigue [3]. Similar results were observed by other studies, indicating that listening to music with more beats per minute can boost athletic performance [4].

Researchers have begun to pursue more detailed explanations as how the exact music tempo affects individual performance level during exercise. Ideal tempo necessary for maximum workout output varies based on the type of exercise as suggested by these studies. A reasonable explanation for why different types of exercise have different ideal tempos is related to one's ability to sync up with the beat of the music [2].

Besides physical enhancement, music is proven to have positive psychological effect. A 2010 research led by sport psychologist Karageorghis found that music can improve athletic performance either by delaying fatigue or increasing work capacity [1]. According to this research, the positive psychological effects of music have led to "higher-than-expected levels of endurance, power, productivity, or strength" [1]. Similar study conducted by North and Hargreaves showed that music distracts from pain endured during exercise through competing sensory stimuli, because it is easier to forget about pain or fatigue when a song you enjoy is distracting you [5].

## 1.2 Identifying the Problem

Often times, people can get more out of their exercise experience by choosing music that they find enjoyable and that fits their exercise style. But usually your favourite music style might not be of the ideal tempo for the exercise you are performing. Also, adapting a playlist to fit the needs of various exercise is impractical. Moreover, it's common for people to experience different workout intensity during one gym session, constantly having to manually change music due to frequent workout intensity change can get frustrating.

## 1.3 The Goal of Fit-Tune

Past research revealed that listening to well-synchronized music during workout can enhance overall exercise effectiveness. The goal of Fit-Tune is to improve user workout experience by providing real time smart music tempo and style adjustment based on sensor readings from your smart phone. Key features of the app are listed as follows:

- **Running Cadence Detection:** Fit-Tune conducts real time running cadence detection to translate running speed to optimal beats per minute (BPM) for music.
- **Music Tempo Adjustment:** Based on translated optimal BPM, the tempo of music with the closet base BPM will be adjusted to match the optimal BPM in order to provide the

best exercise performance boost.

- **Statistical Feedback:** After each exercise, detailed exercise metrics such as distance travelled, exercise duration, average pace, calories burnt will be presented back to the user with various interactive charts for the purpose of progression tracking.

## 2 Statement of Functionality

The following sections describe the functionalities of the app along with corresponding screenshots

### 2.1 User Authentication and Registration

User can either log in using existing account or register new account as shown in figure 1. User credentials are managed using Firebase Authentication.

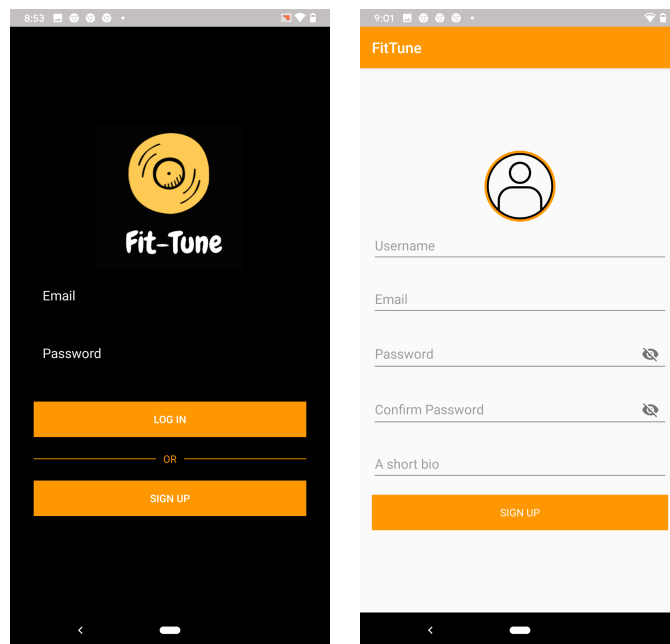


Figure 1: User Authentication and Registration

### 2.2 Music Adjustment

After user successfully logged in, a Tap to Start screen will be presented as shown in figure 2. After tapping the screen, user can select from two different workout scenarios, namely, treadmill running and outdoor running. Real time exercise stats display section on the top of the screen can be customized by clicking the edit button on the top right corner. There are 4 different stats to choose from including distance travelled, calories burnt, running pace and exercise duration.

Our app also provides different types of music at user's disposal. Currently the app supports three music styles such as pop music, rock music and EDM music. Each music style contains 20

different music with various base beats per minutes (BPM) stored on the cloud. Our app will determine which music to play based on selected music style and detected exercise intensity. If the detected workout intensity doesn't translate exactly to base BPM of any music, the time stretch functionality of SoundPool Android Library is applied to the music with the closest base BPM to changes the music to play at faster or slower tempo than originally without affecting the sound pitch. Therefore, no matter how fast or slow you run, our app ensures the music tempo is synced to your running cadence providing you with the best performance boosting effect.

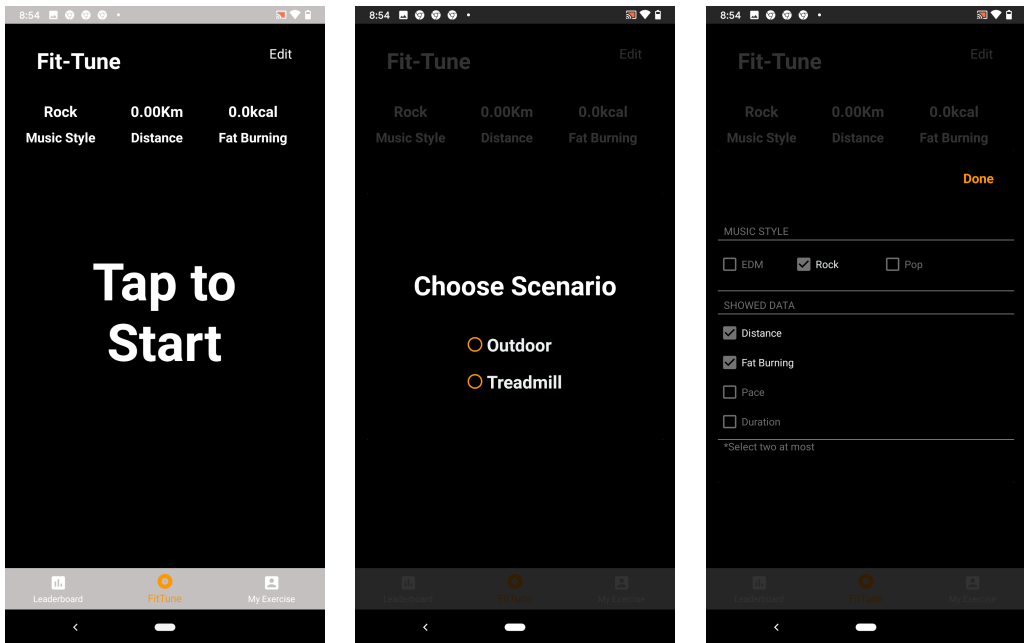


Figure 2: Start the Workout

For the treadmill running mode as shown in figure 3, since the running speed is determined by the treadmill, our app provides user with a slide bar to match the treadmill speed setting. This frees the users from constantly having to scroll over their playlist to find the optimal music to play based on their running speed. They merely need to tell our app the current speed setting of the treadmill and the app automatically finds the optimal music for them. This enables users to focus on the exercise itself while our app takes care of the rest. Also, music style can be changed on the fly if the users ever decide to change it.

For the outdoor running mode, since the running speed is not as easily accessible as treadmill running, a running speed detecting mechanism is needed. Our app uses variation of vertical acceleration to detect running cadence based on smart phone accelerometer readings. In order to filter out high frequency noise embedded in sensor readings, a low pass filter with a 3.5Hz cutoff frequency is applied. The running cadence is determined by the amount of peaks in vertical acceleration history over the past 6 seconds. Then the detected running cadence is translated to optimal BPM, our app can use the translated BPM to choose the best music for play.

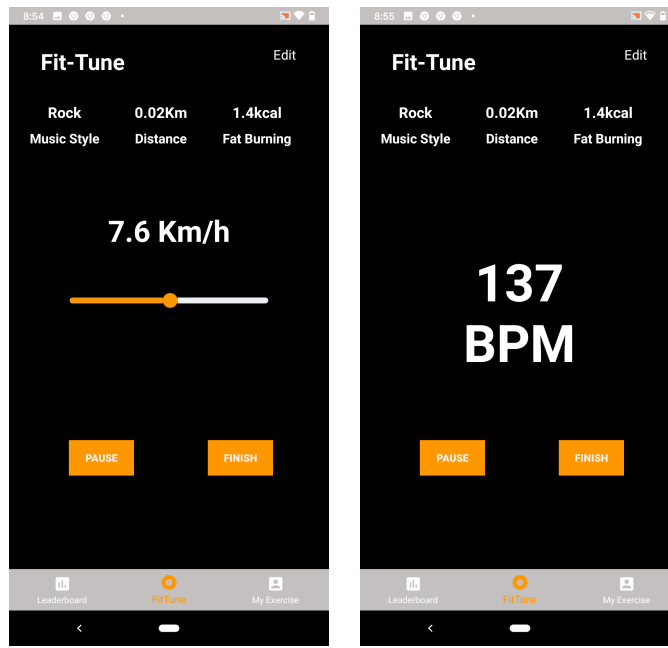


Figure 3: Treadmill and Outdoor Mode

## 2.3 LeaderBoard

Leaderboard feature can be accessed by clicking the Leaderboard icon on the bottom left corner of the screen as shown in figure 4. Leaderboard offers a way to share your progress amongst friends. Completing against each other also provides extra level of motivation. Users also have the ability to check the detailed workout distribution over the week by clicking the detail button.



Figure 4: LeaderBoard

## 2.4 Exercise Stats

Exercise stats feature can be accessed by clicking the My Exercise icon on the bottom right corner of the screen as shown in figure 5. All exercise performed within current month will be displayed in this section along with date, exercise type, distance travelled and average pace. More detailed metrics for each exercise can be accessed by clicking on the detail button.

Workout intensity composition is presented using a piechart. Running speed history is presented using a line chart. Line chart can be zoomed in if user would like to take a closer look at specific time interval of the workout. Total distance travelled, total workout duration, total calories burnt and average pace information are displayed at the bottom.

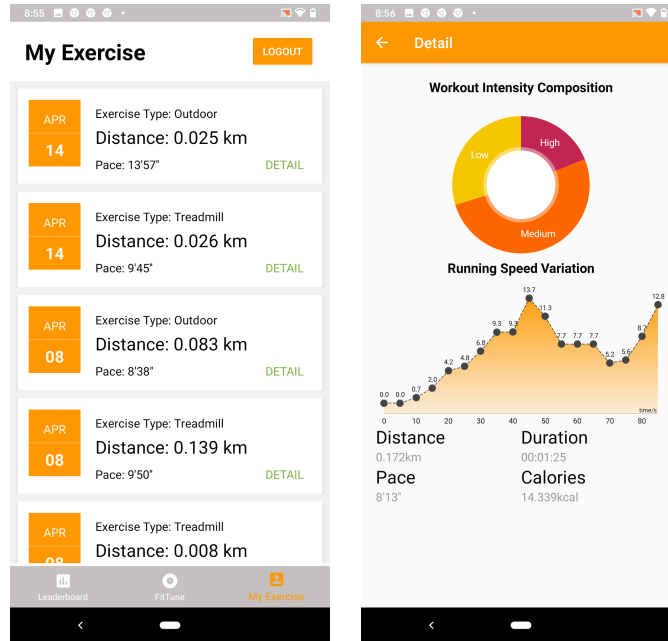


Figure 5: Exercise Stats

## 3 Software Architecture

The app consists of three blocks including user interface, control and database as shown in figure 6. After user is authenticated, user interface is presented with three different sections. Dashboard section includes outdoor running mode and treadmill running mode. My exercise section includes detailed exercise stats. Exercise metrics are presented back to users using various interactive charts. Leaderboard section includes weekly running distance ranking amongst friends and detailed daily running distance break down.

Functionalities of control block mainly include real time running cadence detection using accelerometer and music tempo adjustment using SoundPool library. Corresponding exercise metrics such as running distance, duration, calories and pace are saved onto firebase.

Database block is responsible for storing user credentials, user exercise data and music bank for different music with numerous style over a variety of base BPM. Centralized database is implemented for weekly running distance leaderboard ranking among all users.

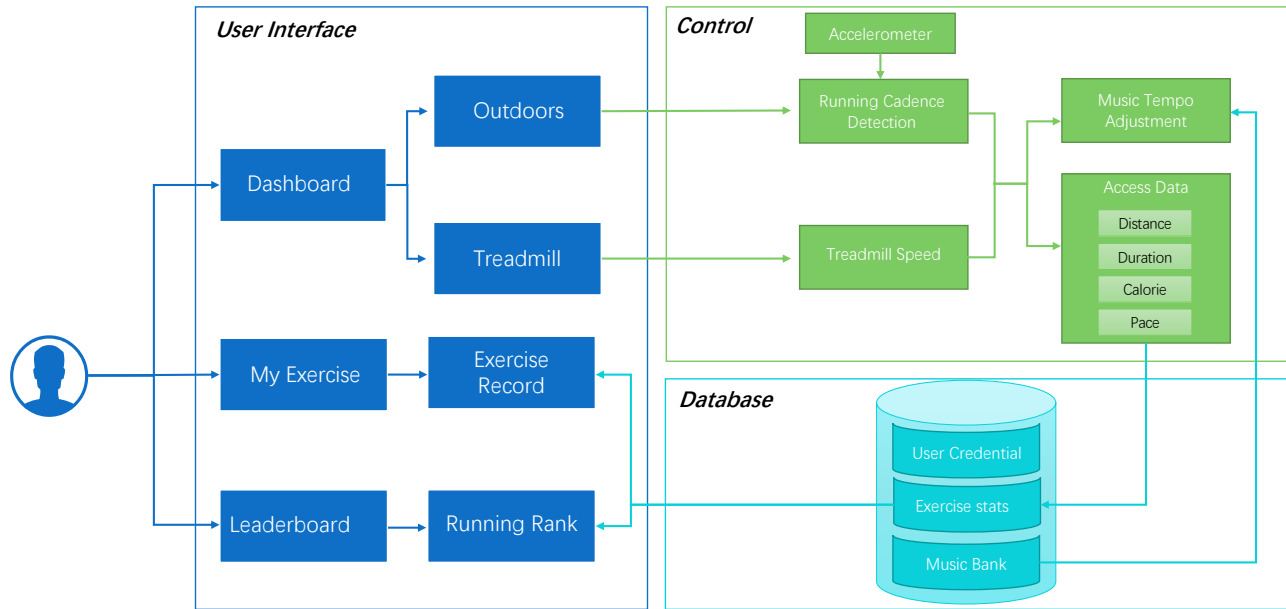


Figure 6: Block Diagram

## 4 Reflection

Since our group only consists of two programmers with no specialist, we have more freedom to choose our project topic without having to constrain ourselves within the area of the specialist. But at the same time, it is a lot easier to get distracted with too many options without a clear direction. It is essential to find a focus early on and figure out a realistic target under time and manpower constraint. Also, having to be our own specialist helped us to learn to think as specialists. This allows us to practice idea creation, and to learn how to use an app user interface design package such as Marvel, and practice in gaining feedback from users.

From a programmer perspective, we honed our Android development skills to solve practical challenges such as user interface design, database manipulation, project version control, native and foreign API implementation. In addition to technical knowledge, we also learned that agile development approach is important for project management as it allowed us to divide project into distinct and achievable small targets. This spiral development pattern actually allowed us to develop more than we initially thought would be possible in the timeframe. This approach is also quite satisfying to execute as it was exciting to see every small idea being transformed into a functional unit. And then we could work on connecting them together.

From a group standpoint, communication is one of the most important aspects of team working. We learned that all team members must be able to say what they think, share their ideas, ask questions if in doubt. In addition, providing honest feedback to each other is essential for us in order to grow as a team. Moreover, It is crucial for all team to be committed to the overall progression of the project. But at the same time be considerate if team members fail to meet expectation and help each other as needed.

## 5 Individual Contribution

Zichuan Wang:

- Finished user interface design for account login & registration, leaderboard and exercise stats including interactive charts with pinch zoom capability.
- Implemented centralized database for leaderboard ranking and distributed database for user account information and user exercise detail.
- Created real time running cadence detection functionality using accelerometer sensor readings with low pass filtering for inherent noise suppression.
- Deployed background exercise metrics calculation with rolling average to prevent real time sensor data flooding the memory.

Zhaohui Qu:

- Designed user interface for dashboard including custom exercise metric display, music style selection, treadmill speed adjustment.
- Implemented time stretch functionality of SoundPool Android Library to change music playback tempo without affecting sound pitch.
- Created exercise metrics calculation functionality based on detected running speed including distance travelled, exercise duration, average pace and calories burnt.
- Deployed background music service for cloud based music loading, music start, music stop and music pause.

## 6 Future Work

- **User Customized Playlist:** Currently our app only supports native playlists which are custom picked to include music from a wide range of base beats per minute (BPM). The challenge of having a user customized playlist is that the music user pick might be clustered within a narrow range of BPM, limiting the app's ability to tailor music based on workout intensity. A music selecting tool, which can detect the base BPM of the music, could be introduced so that the playlist user generated is more spread out across the BPM spectrum.
- **Utilize Different Wearable Sensors:** Accelerometer is well suited to represent workout intensity for cardio exercises such as running which involve a lot of body movement. But accelerometer readings could be a poor intensity indicator in terms of weight training where body doesn't move as much. In this case, heart rate monitor would be a better alternative. By incorporating a variety of wearable sensors such as heart rate monitor, the scope of our app could be broadened to include more exercises such as weight training.
- **Machine Learning for Music Creation:** Rather than adjusting existing music tempo to fit our exercise need, it would be real cool if we can use machine learning to create our own music based on various sensor readings. Sensors on your mobile phone detects every single movement and translate them into BPM and gait that modulate the tempo, melody and effects for AI composing. Every moment, your music is unique.



## 7 Group Consent

All team members, Zichuan Wang, Zhaohui Qu, give full consent to publicly post the following project related content on the course website:

- Video of the final presentation
- Final report
- Source code

## References

- [1] Costas I Karageorghis, DavidLee Priest, LS Williams, RM Hirani, KM Lannon, and BJ Bates. Ergogenic and psychological effects of synchronous music during circuit-type exercise. *Psychology of Sport and Exercise*, 11(6):551–559, 2010.
- [2] Costas I Karageorghis and David-Lee Priest. Music in the exercise domain: a review and synthesis (part i). *International review of sport and exercise psychology*, 5(1):44–66, 2012.
- [3] Judy Edworthy and Hannah Waring. The effects of music tempo and loudness level on treadmill exercise. *Ergonomics*, 49(15):1597–1610, 2006.
- [4] Susan Hallam, Ian Cross, and Michael Thaut. *Oxford handbook of music psychology*. Oxford University Press, 2011.
- [5] Alexandra Lamont. Review of north, a.c. & hargreaves, d.j. (2008). the social and applied psychology of music. oxford: Oxford university press. *Musicae Scientiae*, 13(2):463–466, 2009.
- [6] Costas I Karageorghis, Peter Cheek, Stuart D Simpson, and Marcelo Bigliassi. Interactive effects of music tempi and intensities on grip strength and subjective affect. *Scandinavian journal of medicine & science in sports*, 28(3):1166–1175, 2018.