PRO-Fit: Exercise with friends

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ABSTRACT—The advancements in wearable technology, where embedded accelerometers, gyroscopes and other sensors enable the users to actively monitor their activity have made it easier for individuals to pursue a healthy lifestyle. However, most of the existing applications expect continuous commitment from the end users, who need to proactively interact with the application in order to connect with friends and attain their goals. These applications fail to engage and motivate users who have busy schedules, or are not as committed and self-motivated. In this work, we present PRO-Fit, a personalized fitness assistant application that employs machine learning and recommendation algorithms in order to smartly track and identify user's activity, synchronizes with the user's calendar, recommends personalized workout sessions based on the user's preferences, fitness goals, and availability. Moreover, PRO-Fit integrates with the user's social network and recommends "fitness buddies" with similar preferences and availability.

KEYWORDS—wearable technology, activity tracking, classification, recommendations, personalized assistant

I. INTRODUCTION

Fitness-related smartphone applications have gained popularity in the recent years as they help users integrate healthier behavior into their daily lives creating better personal health engagement and raise health adherence. For those with busy schedules, finding a convenient time slot to fit in for a workout session is very often challenging. Moreover, it is observed that due to lack of company in performing a fitness activity, people get complacent and lose interest. Existing fitness applications require constant input from the user, in order to keep track of the user's activities and health goals. Moreover, the social element, if available, is limited to in-app challenges (e.g. compete on number of steps taken over the weekend).

In this paper, we present PRO-Fit (standing for Personalized Recommender and Organizer Fitness assistant), a personalized fitness assistant application, that integrates multiple sources of information, including the user's preferences, their calendar, and their social network, and proactively pushes notifications to the user, in an effort to keep her motivated and focused on her goals. PRO-Fit is powered by machine learning and recommendation algorithms to enable the identification of user activity, identify the user's availability, and recommend fitness

buddies, as well as new activities. In what follows, we discuss the core modules of PRO-Fit, namely the activity classifier, the activity recommendation system, and the fitness buddy recommendation system, as well as the technologies used to implement this prototype.

The rest of the paper is organized as follows: In Section II we provide an overview of the high-level system architecture and describe the main functionality of the system. In Section III we discuss the technical details of the prototype implementation. In Section IV we provide a sample usage (demonstration) scenario. Section V discusses briefly the state-of-the-art in health and fitness tracking applications. We conclude with our plans for future work in Section VI.

II. SYSTEM ARCHITECTURE

The high-level system architecture is shown in Figure 1. We identify four main modules, namely the *Front-end*, the *Activity Tracking & Classification* module, the *Calendar Integration Manager*, and the *Social Recommendation System*. The application collects and generates various types of data; it collects and analyzes accelerometer data, integrates the user's external calendar data, as well as their contacts (address book and social network-derived data), GPS signal, but also stores profile and preference data as input by the user through the application. All the data are stored in the application's data store.
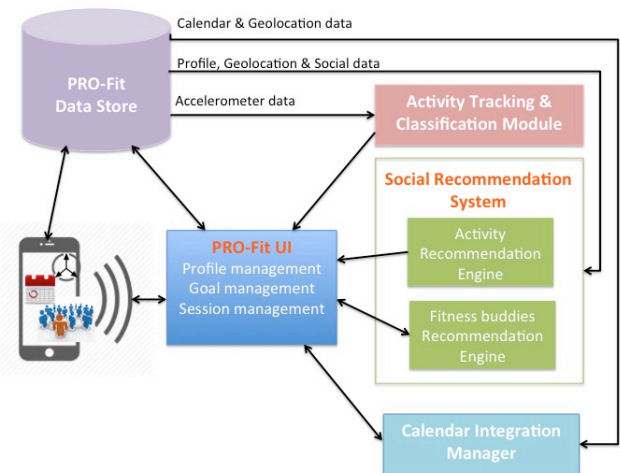

Figure 1: PRO-Fit architecture

A. PRO-Fit User Interface and front-end

Once the user logs in to the system for the first time, the system requires from them to build their profile, by providing demographic information, such as age, gender, location, etc., as well as their health and fitness goals, such as times of exercise per time period t, calories burnt per time period t, etc[1]. Most importantly, the users are provided with a list of activities and are asked to rate them, in a scale of 1 to 10, in terms of how much they enjoy to participate in each activity. This process, handled by the *Profile Manager* and the *Goal Manager*, needs to be performed only once, unless the user wants to update their profile or set new goals. The third component of this module, the *Session Manager*, is responsible for pushing notifications to the user regarding available time slots, fitness buddies, etc., as discussed in the following subsections. It also allows the user to set his own schedule manually.

B. Activity Tracking and Classification Module

The system collects accelerometer data from the user's phone and feeds them into a classifier that has been trained to recognize and classify the user's activity into one of the following: *Walking, Jogging, Running, Sitting, Standing, Step up, Step down.* The Classification Module automatically updates t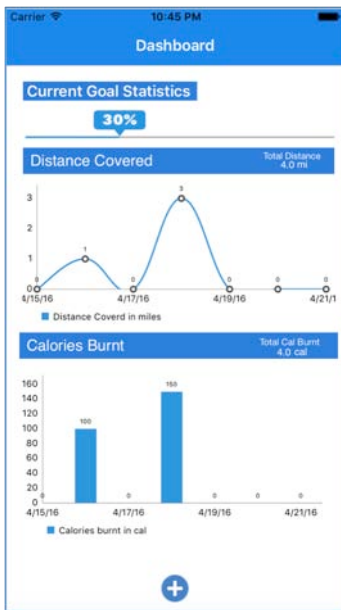he user profile and logs her activity. The updated profile data is fed in the Activity Recommendation Engine, that recommends new activities to the user, when applicable (more details on this are discussed in Section II.D). After experimental evaluation, we have concluded that the most appropriate machine algorithm for this type of input data is gradient boosted trees, which is the one implemented in the current system prototype. The details of the activity classification module and the experimental evaluation are described in detail in [1]. A sample screenshot of the user's dashboard is shown in Figure 2.

Figure 2: User Dashboard

C. Calendar Integration Manager

The Calendar Integration Manager takes care of the user's external calendar accounts' integration with the PRO-fit application. PRO-fit application syncs all the events from all integrated calendars and recommends the best time for the workout as per the goal set by the user. The user can add and delete calendar accounts into PRO-fit application through the UI. Credentials are stored securely in PRO-fit data store to access user's calendar data offline. Calendar events from all integrated calendars are used as input to recommend fitness sessions. The details of this module are described in [1].

D. Social Recommendation System

This module incorporates two sub-modules: the *Activity Recommendation Engine* and the *Fitness Buddies Recommendation Engine*. The Activity Recommendation Engine takes as input the user activity profile, including their pre-set preferences as well as their logged activities, and through the use of item-based collaborative filtering techniques on the profiles of all application users, identifies and recommends new activities. These recommendations are sent as push notifications to the user's profile dashboard. The user is given the option to add them to her activity profile.
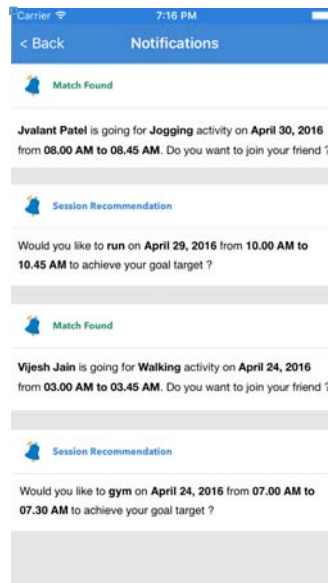

Figure 3: Session and fitness buddy recommendations

The Fitness Buddy Recommendation Engine employs user-based collaborative filtering techniques to identify similar users. It then ranks them based on their geo-location and calendar availability, and recommends (if available) fitness buddies, with similar activity interests, close location, and calendar availability. Both components are supported by the baseline collaborative filtering algorithms, as well as their socially - enhanced counterparts, where users who have stronger ties with the active user (as identified by their social network connection or their contacts), are given higher similarity values and thus priority in the recommendation output. The details of the social recommendation engine are presented in [2]. Figures 3 - 5 show the fitness buddy recommendations, as shown on the user's screen.

III. IMPLEMENTATION DETAILS

In this section, we briefly discuss the implementation details of the four main modules identified in system architecture in Figure 1.

A. PRO-Fit User Interface

The user interface/front end is provided by an iOS application that can be installed on user's cellphone with iOS operating system. It is developed in Swift language. The user interface provides simple and intuitive way to interact with application functionality and perform tasks related to user profile, fitness/workout goal and fitness session. Also, the

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[1] For this prototype implementation, the user may log in to the application using their Facebook credentials, in which case the system will auto-complete any profile data it can fetch from the user's Facebook profile.

cellphone application is essential to provide notification of recommendation to the user and track accelerometer data.

B. Activity Tracking and Classification Module

This module is implemented to perform three tasks:

1. Data collection: PRO-Fit cellphone application collects accelerometer data and sends to web service that stores the raw data in a Cassandra cluster.
2. Feature calculation: To classify activity based on raw accelerometer data, we calculate various features from a set of accelerometer readings collected in intervals of 5 seconds. Based on experimental evaluation, the following features are being calculated: average acceleration, variance, average absolute difference, average resultant difference and average time between peaks. This calculation is performed as a Spark job every 15 minutes.
3. Activity Classification: The final step is to feed the features into classification model to predict the user activity. The model, built using the scikit-learn library in Python, is trained using historical data. The predicted activity is then stored in the application data store.
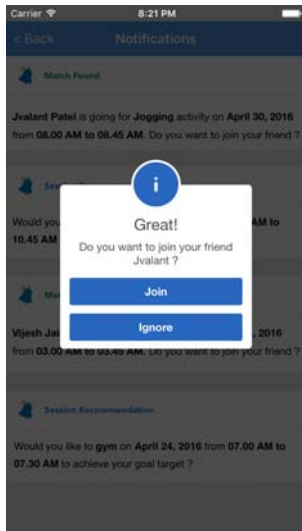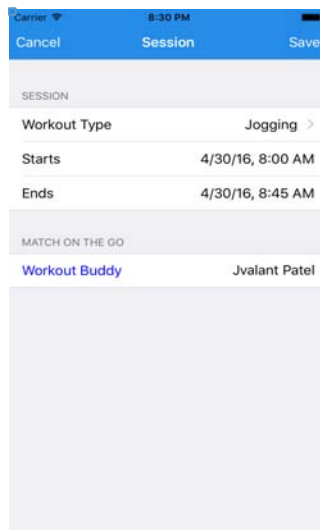

Figure 3: Confirmation   *Figure 5: User Session Detail*

C. Calendar Integration Manager

The Calendar Integration Manager module enables the PRO-fit application to add external calendar accounts into the system. PRO-fit supports the integration of many popular calendar service providers like Google, Yahoo and Hotmail etc. Adapter design pattern is implemented so that support for all service provider would remain unchanged in future. The system can be modified easily by introducing a new adapter for new service provider. Authentication and authorization is implemented using OAuth 2.0 protocol. Once the user adds the calendar into system, the system acquires offline access to all calendar events (read-only). During recommendation algorithm run-time, it fetches all calendar events from all added accounts and takes them into consideration to find best time for workout.

D. Social Recommendation System

As described in Section II.D, this module has two sub-modules. The Fitness Buddies Recommendation engine recommends user with a partner to work out with, which depends on factors such as geolocation, user's activity preferences, and their calendar availability. Once the user rates their favorite activities, we use Pearson correlation coefficient to find similar users. The similarities are re-calculated when the users' profiles are updated. Users are ranked based on the calculated similarity. Once users are ranked based on activities, we update the rank based on their geo-location and their calendar availability, to recommend "fitness buddies". The recommendation system will recommend users who are located closed to the user and available at the same time slot for exercise. We mainly used the numpy library in Python, to implement this recommendation engine. For the activity recommendations, we have used user-based and item-based collaborative filtering, using as input the utility matrix including the user's preferences on activities [2]. Both User-based and Item-based Collaborative Filtering are implemented in Java using Apache Mahout library.

IV. DEMONSTRATION SCENARIO

In order to demonstrate the machine learning and collaborative filtering-fueled capabilities of the system, we will employ simple scenarios with existing users, who have previously logged activities and friends who are also users of the application. We will demonstrate below functionalities that an existing user can perform in the application after successful login.

1. User profile management: User can navigate to settings and update the demographic information and activity preference.
2. Goal Management: User can create, view, update or delete a health goal specifying start date, end date, target calories to burn or target distance to cover with preferred activity.
3. Fitness session management: User can view fitness calendar and create, update or delete a fitness session specifying start time, end time and preferred activity to perform during the session.
4. View recommendation: User can view the "fitness buddy" recommendation provided by system and accept or reject the recommendation. Upon acceptance, the recommendation session will be added in fitness calendar.
5. Activity Analytics or Dashboard: User can view details of calories burnt and distance covered during present week, month or year in graphical representation.

The fitness buddy recommendations and session recommendations are calculated in batch. Hence for demonstration, we will show the recommendations computed based on the most recent data in the system.

We will also demonstrate the process of enrolling a new user for the first time, where content-based recommendations will be employed to help the user establish a fitness routine.

V. RELATED WORK

Most of the research projects related to activity tracking focus on determining the type of activity and fitness level of an individual by applying machine learning algorithms [9-11] on past user activity data [3, 8], heart rate data [4], and accelerometer data [1, 5-7]. Most require extensive user profiling and interaction throughout the day.

In recent years, big technology companies as well as wearable device companies have launched fitness-related applications and devices. Popular applications include Google-Fit[2] and Apple-Health[3]. These apps track all the user's activities based on the data collected by using mobile sensors such as GPS, accelerometer, gyroscope etc. Based on the data tracked data the apps provide simple analytics of the user's activities, tracking activities such as running/walking distance, steps climbed, etc.

In this Social Networking era, the world is more connected than ever, each and every individual is connected. Many apps are integrating other services alongside fitness that would help a user carry out fitness sessions in an effective manner. Such examples include reward system/challenges, incorporating the social/community aspect which allows users to share fitness related activities or information among likeminded people (e.g. Fitbit[4]), geo-tagging, where the user is able to share information such as tracked activities or photo while they are working out (e.g. MapMyRun[5]), and personalized music, based on the heart rate (e.g. RockMyRun[6]). Other apps like Nike+ Running[7] is an iOS app which tracks the user's distance, pace, time and the burnt calories count while running. This app allows the user to post and share progress in form of a graph stats or a path map on Facebook and have his/her friends react on it. Similarly, RunKeeper[8] app is one of the most popular fitness app for tracking the running activity. It leverages the GPS feature of the smartphone device to analyze and generate the stats of the activity. It allows the user to invite his/her friends from phone's contact list or Facebook to friendly complete and earn points/badges [12].

Two other noteworthy applications in terms of features they offer are MapMyFitness[9] and Endomondo[10]. MapMyFitness allows users to feed in their goal and help them to track their progress while achieving their goal. It also gives the option to input nutrition information to get a complete picture of the user's health and to select a route to perform fitness sessions from over 70 million routes. Endomondo provides the facility to track over 40+ activities including the sporting activities, which are not provided by any other app. It also includes an

audio feedback while performing workout session, which many of the users consider as a good assistance system.

VI. RELATED WORK

In this paper we presented PRO-Fit, a personalized fitness assistant that recommends fitness sessions, new activities, and fitness buddies to its users. Powered by classification and recommendation algorithms PRO-Fit automates the process significantly, reducing the amount of effort required from the user's end in an attempt to keep them motivated and engaged for a long period of time. As part of our ongoing work, we focus on incorporating the social element in the recommendation process, by integrating the application with social networks and updating the recommendations in ways that reflect the users' friendship ties. We also plan to deploy a user study to measure more systematically the effect of the usage of this application, as compared to existing ones.

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