Demo Abstract: Mobile Sensing to Improve Medication Adherence

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ABSTRACT

One of major challenges in chronic disease self-management is the lack of medication adherence. Despite the proliferation of mobile technologies, the potential of using pervasive computing solutions for improved medication management has remained almost unexplored. In this paper, we present a smart-phone based system capable of delivering adaptive activity-aware medication reminders by learning the user's activity of daily living and detecting the most appropriate and effective timing for medication reminders centered around the initial user-specified schedule.

KEYWORDS

medication adherence, activity learning, prompting

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1 INTRODUCTION

Effective medication self-management in individuals with chronic disease who need to take one or multiple medications on daily basis has remained a challenge. The majority of these individuals are older adults in need of palliative care. Due to rapid growth in the older adult population, shortages are emerging in the health-care workforce. This warrants considering innovating health-care options to provide quality care. The recent advances in mobile technologies lays the groundwork for automated health monitoring and intervention [3]. The prior studies suggests the we can leverage smart-phones together with machine learning techniques to learn and further detect the user contextual information such as their routine daily activities and frequent locations [1, 2]. This user-specified contextual information can be leveraged to develop both generalizable and user-specific pattern recognition algorithms that can effectively learn and recognize the appropriate times for medication reminders.

In this paper, a smart-phone based system for intelligent medication notification delivery is presented. Our system is composed of smart-phone applications, a smart pillbox, and a cloud server. It provides a user-friendly and mobile interface for adaptive medication reminders. By learning the context in which the user is more motivated to adhere to medication, our system picks the best time to deliver the medication reminder within the 3-hour adherence window. The center of each adherence window is determined by the user according to his/her daily medication schedule.

2 SYSTEM OVERVIEW

Our system consists of four main components: Activity Learning (AL) app, Medication Tracking (MT) app, a smart pillbox, and a cloud server. We refer to the first three component as the front-end as users will be interacting with each one and refer to the last component as back-end that will only interact with the front-end system. An overview of the proposed system is shown in Fig. 1.

2.1 Front End

This part is consisted of two Android-based apps and a commercially available medication dispenser, namely Pillsy (https://pillsy.com).

Pillsy: we use an ultra low power commercially available smart pillbox. It stores every lid event (i.e., lid open/close) and when connected to the MT app, transmits the new events to the phone with their corresponding timestamps. The communication is established via BLE. The battery in Pillsy lasts around six months. With Pillsy, the system can precisely keep track of user's medication adherence.

AL app: activity learning app has been designed to capture various sensor data (e.g., accelerometer, gyroscope, GPS) and occasionally prompt the user for an activity label. The collected raw data and its corresponding label (if provided by the user) will be transmitted to the back-end for either

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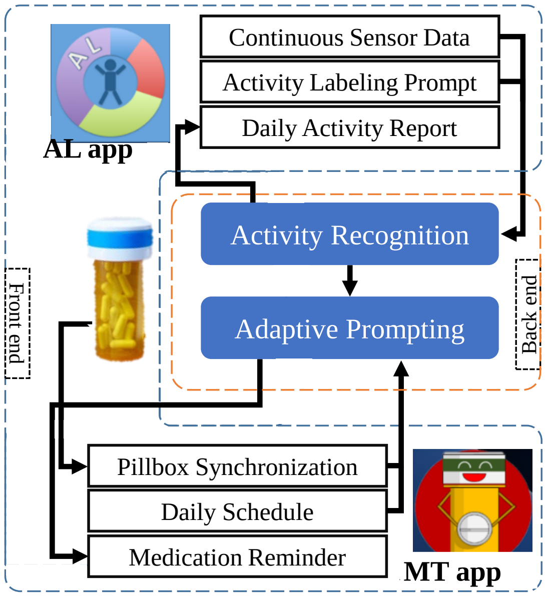
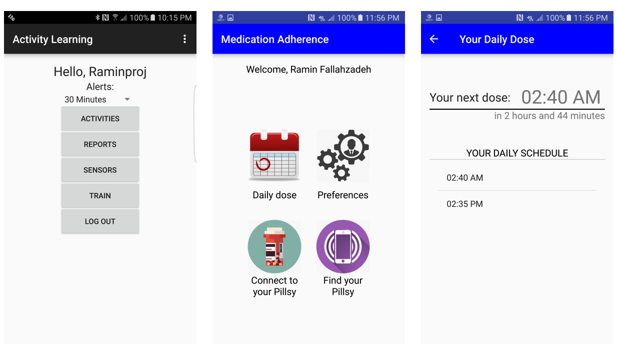


Figure 1: The overview of the proposed adaptive medication system.



(a) AL homepage (b) MT homepage (c) MT daily schedule page

Figure 2: Few screen shots of AL and MT apps.

training the activity recognition (AR) model (if a label is provided) or for detecting the corresponding activity label, using the trained AR model. The effectiveness and robustness of AL app in learning and recognizing the activities of daily living has been shown previously [2]. While, AL provides a list of suggested activity (e.g., watching TV, cooking, work), the user can also define his/her own preferred label. The frequency of AL prompts can be set through the app.

MT app: in addition to subscribing to Pillsy events, MT enables the user to view their daily medication schedule as well as sending medication reminders in the form Android notifications. MT app depends on the back-end for medication reminders. Instead of relying on user input medication times for sending the reminders (static reminders), MT app communicates with the back-end to deliver the most timely appropriate reminders for the purpose of improved medication adherence.

2.2 Back End

The back-end system is comprised of two machine learning algorithms: activity recognition and adaptive prompting.

Activity Recognition Model: we use the raw sensor data received from AL app to extract features including max, min, sum, mean, deviations, zero crossings, skewness, kurtosis, correlation, signal magnitude area, spectral energy, and signal energy. Using this feature vector, we employ a decision tree model to learn a mapping from a sequence of raw sensor readings to an activity label. After enough labeled data has been collected, the model can accurately detect the type of physical activity which will be used as a part of contextual information to train the adaptive prompting model.

Adaptive Prompting Model: using the activity label provided by AR model and several other features such as time, day of week, and location, we create a feature vector mapped to a binary label which indicates the occurrence of a Pillsy event (i.e., taking medication). This mapping will be fed to a binary machine learning algorithm to learn the user-specific rules that can determine the likelihood of adherence given a feature vector of contextual information. Upon detection of an appropriate time, it will notify the MT app to deliver a reminder if it is within the 3-hour window of an scheduled medication.

3 CONCLUSIONS

An intelligent medication reminding system was proposed in this paper. We use smart-phone based applications to learn the most appropriate timing to deliver a medication reminder based on the contextual information learned from the user. As a result, instead of less-effective static reminders, our machine learning algorithm can adaptively pick the best time to notify the user to achieve higher medication adherence.

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