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Integrating IoT Wearable Devices in Telemonitoring Platforms for Continuous Assisted Living Services

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Abstract. Assisted living services have become increasingly important in recent years as the population ages and the demand for personalized care rises. In this paper, we present the integration of wearable IoT devices in a remote monitoring platform for elderly people that enables seamless data collection, analysis, and visualization while in parallel, alarms and notification functionalities are provided in the context of a personalized monitoring and care plan. The system has been implemented using state-of-the-art technologies and methods to facilitate robust operation, increased usability and real-time communication. The user has the ability to record and visualise their activity, health and alarm data using the tracking devices, and additionally settle an ecosystem of relatives and informal carers to provide assistance daily or support in cases of emergencies.

Keywords. Gamification, PBL, coaching, elders, eHealth, mHealth, IT systems

1. Introduction

Assisted living services have become increasingly important in recent years as the population ages and the demand for personalized care rises. To address this need, there has been growing interest in integrating Internet of Things (IoT) technologies with mobile applications to provide advanced assisted living services [1]. This integration has the potential to greatly enhance the quality of life for seniors and people with disabilities by enabling remote monitoring and real-time feedback, promoting independence and safety, and reducing healthcare costs. Several platforms have been implemented previously to support assisted living services using innovative features to enhance patient adherence [2-6]. In this paper, we present the integration of innovative IoT devices in a

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remote monitoring platform for elders that enables seamless data collection, analysis, and visualization.

2. Materials and Methods

The system follows a microservices architectural design in order to provide the required levels of scalability, modularity and extensibility. At the core of the system is a socket based communication service which is capable of supporting different types of devices, each with different configurations and communication protocols [2,4]. A *NoSQL database* was used in order to store the recorded data from IoT devices. The system's structure is presented in Figure 1. The wearable devices (trackers) are equipped with GPS/LBS tracking modules which provide location reporting and support the geo fencing service of the system [6]. Their purpose is to collect data that concern the physical status of the user, such as biosignals (heart rate, oxygen saturation etc.), as well as data for automated fall detection and SOS signalling. Samples of supported trackers are displayed in Figure 2.

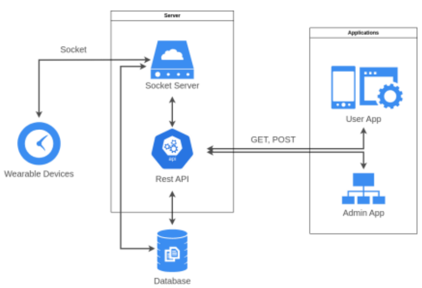

Figure 1. System architecture and components

Figure 2. Template tracking devices

For each device type a different instance of the socket server is deployed dynamically which contains a distinct driver. Each driver adapts to a device's specifications and produces information based on specific standards and models, designed in a way to provide efficiency, concerning the system's functionalities and management. For example, some devices have the ability of measuring a person's blood pressure, while others cannot. The approach of data transferring between a device and the system through the sockets is based on predefined messages which are part of each device's specification and in turn of each driver. A message transfers information, which can represent a command sent to the device in order to be executed, information about the outcome of a performed action, measurement data or significant events, such as a fall detection [7]. The most significant messages provide information about:

- **Location and alarm reporting:** The device can record its exact location with its GPS/LBS tracking function. Otherwise it records the nearby mobile antennas or WiFi hotspots, without recording the exact location coordinates. In this case, the system receives the WiFi spots' data and mobile antennas and generates the exact location. If an alarm situation is spotted by the tracker, then the alarm is reported alongside the incident's location. Geo-fencing utilises this information, by comparing a geofence area with the provided coordinates.
- **Heart data & Oxygen saturation:** Device reports the user's heart rate and blood pressure, as well as oxygen saturation following a measurement.

- **Configuration data:** Messages regarding configuration and firmware.
- **Device link:** Used for establishing and also maintaining the connection between the server and the device. Performed steps and battery status are also reported.
- **Alarms:** Used for setting reminders and notifying users about events.

3. System and Features

The proposed solution is realized through a cross platform application, which can be used via any computer device, portable or not. For the system's implementation the *Flutter, Express JS, Node JS Sockets* and *Firebase* technologies were used. The users have the ability to record and visualise their activity, health and alarm data using their tracking device. In order to generate data, the user has to register a device to the application. After the registration, the devices can be managed through the app, as seen in **Figure 3**. Additionally, they are able to allow other people to access or monitor these data, when setting them as their contacts. By setting third parties as their contacts, users can monitor e.g. relatives or loved ones, in order to act proactively as far as health issues or other cases of emergencies go.

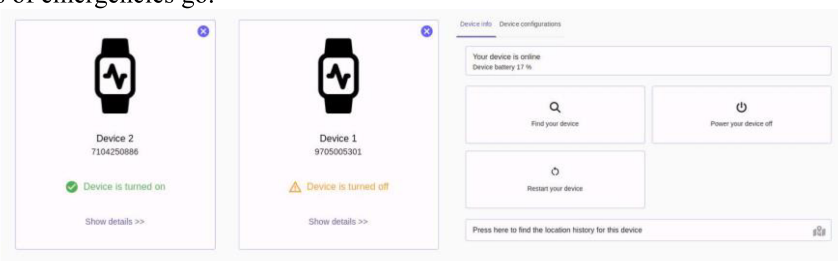

Figure 3. View of the registered devices and the respective configuration options.

Location and alarm reporting, indicate whether a user is in an emergency situation, or is just walking or using a vehicle. This kind of data is visualised using maps, so the users can understand the location and the situation for each event, as can be seen in **Figure 4**. Furthermore, users can set geographical fences, for themselves or for a contact of theirs. For setting a geofence, maps are utilised, in order to be simpler for the users to add and adjust geofences. An example is displayed in **Figure 5**.

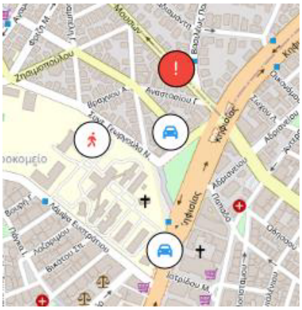

Figure 4. Reported location and alarm data

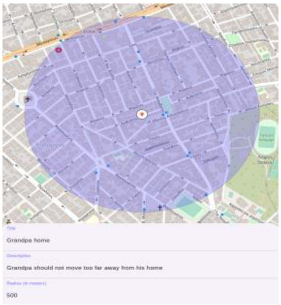

Figure 5. Setting up a geofence through the app.

In addition, when the users violate the geographical fence, an alarm is generated and the concerned users and contacts are notified. Each user can monitor all the alarms, which are organised and grouped by date criteria and are visualised using calendars. In the same manner, the implementation for health data monitoring is using calendar visualization and charts, for a consistent user experience and user-friendliness. When abnormalities, such as too fast or too slow heartbeat, overly high or low blood pressure and low oxygen saturation, are detected, the concerned users are notified via push notifications, emails or sms.

4. Conclusions

This paper presents a prototype implementation of IoT devices integration with health monitoring platforms. The feedback on the prototype operation and performance from internal testing is very positive and indicates the value and the wide applicability of the approach to several assisted living and remote care scenarios. Further extensions are foreseen for the next releases of the system to further improve its usability through the implementation of mobile apps, exploiting also the sensors and communication capabilities of the mobile devices as well as the integration of additional IoT devices which may cover additional requirements and extend the types of sensing data. The prototype will be applied to pilot activities with the involvement of a number of real-users to validate extensively all operational and usability aspects of the system.

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