Daily Life Activity Tracking Application for Smart Homes using Android Smartphone

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Abstract—**Smart home is regarded as an independent healthy living for elderly person. Advances in phone technology and new style of computing paradigm (i.e., cloud computing) permits real time acquisition, processing, and tracking of activities in smart home. In this paper, we develop android smartphone application to assists elderly people for independent living in their own homes. It reduces the health expenditures and burden of health care professionals in care facility units. We assume smart home as an intelligent agent to perceive the environment and process the sensory data on cloud. Smartphone application communicates with cloud through web services and assists the elderly person to complete their daily life activities. It facilitates the care giver assistant by tracking the elderly persons in their own homes and avoids certain accidents. Furthermore, it also helps the family members to track the activities, when they are outside from homes.**

***Keywords*— Daily Life Activities, Activity Tracking, Smart H omes, Android Smartphone**

I. INTRODUCTION

The emerging demographic change towards an ageing population is introducing drastic changes into our society. Nursing homes and care facility units are renowned solution for elderly people. A person who lives in these units becomes depress due to lack of independence. Aging society demands a reliable solution to stay active for a long time, prevent social isolation and assistance for performing daily life activities independently in their own homes. The advancement in wireless and ubiquitous technologies offers a unique opportunity to create pervasive environment and applications to support elderly people. Smart home is conceived as one strategy to provide a level of independence at homes and improve their quality of life [1]. It provides a platform to reduce the health expenditures and burden of health care professionals.

In both developed and developing countries, numbers of smartphone users are increasing day by day. For example, there are more than 16 million smart phones owned by Koreans and 100% of the population has access to a mobile phone network. Smartphone runs a complete operating system and provides a platform for application developers and users. Google Android is one of the most competitive markets due to its open source platform. Hundreds of applications have been developed ranging from the interactive games to healthcare domain. Especially the medical domain applications enable the users to interact with the system to provide real time user assistance and help to improve the people life's style [2].

To take the advantage of assistive technologies in smart home and smartphone, we develop a daily life activity tracking application for the wellness of ageing society and care givers. It helps the elderly person to complete the activities independently in their own homes and at the same time facilitates family members and care givers to track inhabitants. It may help to reduce the burden of care givers when the elderly persons stay in the home and performs daily life activities. This paper presents the details of development and prototype of proposed architecture.

We structure our paper as follows: Section II outlines relevant research projects of smart homes and the ability of smartphone to develop different kind of health care applications. In section III, we present architecture for activity tracking application and identify a number of requirements the system should fulfill. Section IV describes the testbed implementation details and application interfaces. Finally conclusions are reported in Section V.

II. RELATED WORK

A large number of smart homes have been developed as a physical testbed to support the elderly society. Chowdhury et al. [3] developed a RFID-based hospital real-time patient management system. They developed the system by following Agile System Development Methodology (ASDM) using C# in Microsoft Visual Studio.net 2003 environment. It facilitates automatic streaming patient identification in hospitals with the help of mobile devices like PDA and smart phones.

The Harvard University research project, CodeBlue [4], deploy low-power wireless devices to provide ad hoc sensor network infrastructure for emergency medical care. They developed patient triage application in .NET compact framework, running on an iPAQ PDA with Windows CE. The application is capable of operating as active tags to store the information of a patient's identity, status, and history.

Oresko et al. [5] implemented a prototype system for wearable Cardiovascular Disease (CVD) detection on Windows smartphone. It is capable of performing real-time ECG acquisition and display, feature extraction, and beat classification. They developed two smartphone-based platforms for continuous monitoring and recording of a patient's ECG signals. Application successfully detects real-time CVD and generates personalized cardiac health summary reports.

John K. et al. [6] developed a smartphone application Wedjat, to avoid in-take medicine mistakes. It can remind its users to take the correct medicines on time and keep an in-take record for later review by healthcare professionals. It was developed on a Windows Mobile 6.0 with the help of built in calendar of .NET framework.

Haghigh et al. [7] developed a mobile data mining for intelligent healthcare support on Nokia 95 phone to facilitate blood pressure patients. A general approach for Situation-Aware Adaptive Processing (SAAP) of data streams that incorporate situation awareness into data stream processing using fuzzy logic. Their prototype system can reason about situations of normal, prehypotension, hypotension, pre-hypertension and hypertension.

As discussed above, smartphone has already been used for the provision of health care applications. In the context of aging society, we present a daily life activity tracking application over android smartphone to enhance their independence and quality of life.

III. Proposed Activity Tracking Architecture

We investigate the requirements in terms of communication, storage, processing and smart phone development platform to make it an acceptable solution. The proposed architecture of activity tracking application is illustrated in Figure 1. It is divided into three layers smart home, cloud computing and application layer.

A. Smart Home Layer

Smart home is ubiquitous sensing technology to recognize and track the daily life activities of inhabitants. Sensors are deployed on different objects and locations to sense the environment. It periodically sends the collected data to the server. For its processing, many machine learning and probabilistic models are developed for recognize the daily life activities [8] [9].

In proposed architecture, smart home is viewed as an intelligent agent that perceives its environment through different kind of sensors. We deployed RFID Tags, Biosensors, Micaz and Masol [1] on different objects and locations to track inhabitant's daily routines. Our developed smart home has certain overall goals, such as minimizing the cost of maintaining the home and maximizing the comfort of its inhabitants. To achieve these goals, we take the advantage of new style of computing paradigm (i.e., cloud computing). It is an effective solution for providing flexible, cost effective and ease of use for different services.

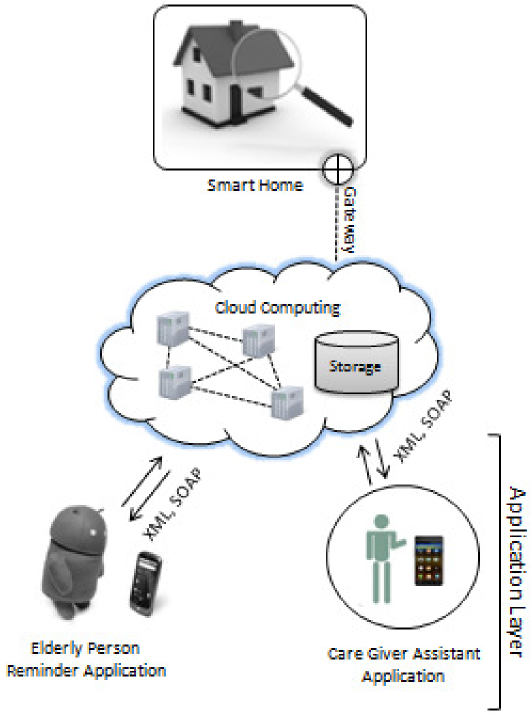


Figure 1. Architecture of Activity Tracking Application

B. Cloud Computing Layer

Cloud computing is new paradigm that can provide dynamically scalable and virtualized resources as a service with pay-as-you-go manner [10]. By pooling the various life care IT resources into clouds, hospitals can reduce the cost and increase utilization as the resources are delivered only, when they are required. We utilized cloud computing as Infrastructure as a Service (IaaS) to provide processing power and storage space for sensory data. A smart home sensed the environment and sends the data to cloud that is stored in a database as a sensor log. On cloud, our activity recognition algorithms process the sensor logs intelligently to recognize the daily life activities. We already developed real time accurate algorithms for activity recognition. The recognized activities are 'cooking', 'laundry', 'restroom', 'relaxing', 'watching TV', 'cleaning' and many other low level activities. The details of activities and evaluation of these algorithms are available in [11] [12] [13]. This layer is also responsible to provide ubiquitous access for any connected device (PCs, laptops, smart phones and PDAs) through internet.

C. Application Layer

We have developed *Elderly Person Reminder Application* and *Care Giver Assistant Application* for tracking of the daily life activities. The details are given bellow.

[1] MASoL is our own developed sensor logger

1) Elderly Person Reminder Application: Elderly people lives alone in their own homes and perform daily life activities. There are possibilities to involve in more than one activity and also a chance of forgetting the previous one. Our smartphone based application is attention capturing application and activated when a critical running activity needs to be complete first for avoiding any sort of accident. For example; a person started cooking activity and engages in watching television, so running stove may cause an accident. In this case, developed application notifies the elderly person about incomplete activity with attention gaining music. It also generates soft reminders to do certain activity at specific time (For example, elderly person needs to take medicine after eating meals). If the attention to complete critical activity is ignored more than three times by the elderly person, then the application notify care giver or family member for assistance.

2) Care Giver Assistant Application: The smartphone application also facilitates the family members of elderly person to keep track their activities when they are outside from home. The goal of this application is to enhance the level of awareness of care givers by notifying them when critical activity left unintended. The notification activate customized application interface with elderly person picture and current atmosphere (including humidity, temperature, location, and gas usage) readings of smart home. Care giver can query about current status, last performed activity of elderly person with atmosphere readings. In order to make sure, the elder take medicine dosage according to the schedule to ensure medicine works effectively and illness is properly treated

IV. IMPLEMENTATIONS

We developed the android smartphone application in open source development tool Eclipse Ganymede JDK 6 with standard android platform 1.6 and API level 4. Application is synchronized with cloud server through web services. An API ksoap2 (Simple Object Access protocol) is utilized for communication between application and web services. It is an open source API that provides a lightweight and efficient SOAP library for the communication to android platform applications.

Our system deployment in *uLCRC* (u-Life Care Research Center) is shown in Figure 2. It comprise of three main sites, namely smart home, hospital and office environment. The smart home includes a kitchen, a bed-room, a living room and rest room. In normal situation, the daily life activities of elderly person are collected through deployed sensors and stored on cloud server (main lab) via an in-home WSN-Cloud Gateway [14]. Activity recognition algorithms recognized the activities from stored sensor logs. The results of recognition algorithms are stored in active track table, where our smartphone application can get the input and response accordingly. The family members in the offices and care givers in hospitals can track the activities and give some suggestions or prescriptions according to track situations and environment observations.

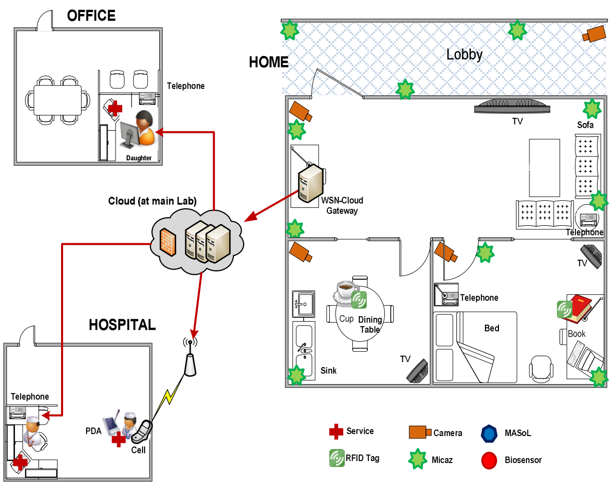


Figure 2 A Top View of *uLCRC*

Web services are the communication bridge between the home, office and hospital via cloud server. The identification of the roles is based on user IDs registration for care givers and family members for corresponding response. To interact with the android application soap messages are developed. These messages are conveyed using HTTP with XML serialization. Web services contain different functions which are called by smartphone application to track the activities.

Table 1. Functions of web services

Function Name	Method	Function Details
fSensorLogs	POST	Add sensory data into cloud DB.
fRegisterUser	POST	Registers new user with its role.
fAuthenticateUser	GET	Validate the users and grant access.
fTrackActivity	GET	Get the person current activity information
fLastActivityTrack	GET	Gets the person last activity information
fEnvironmentValues	GET	Gets current humidity, temperature, location and gas values.
fElderlyScheduleReminder	GET	Gets the schedule reminders from DB
fCriticalActivityReminder	GET	Gets the unintended incomplete activity information.
fElderlyActivityList	GET	Gets all the elderly list for finished / performed activities.

In Table 1, our application and cloud server communication interaction functions are shown. Smart home sensory data is stored in cloud DB through 'fSensorLogs' function. Users are registered based on their IDs and roles. After validating the user identification, functional access is granted according their roles. The other functions are to track the current activity, last performed activity, environment values (humidity, temperature, location and gas usage). In addition, reminders are generated for scheduled and unintended activities in case of elderly person. For care givers and family members elderly person activity list and reminder views are available to track the activities. User-friendly interfaces are developed for elderly person reminder application as shown in Figure 3.

(a) Reminder for stable incomplete laundry activity

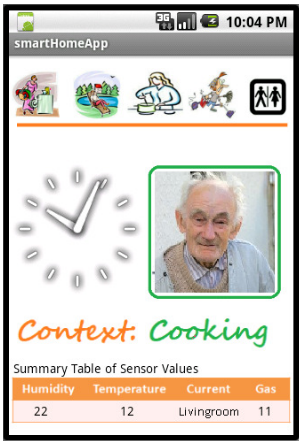
(b) Reminder for critical incomplete cooking activiy

(c) Reminder for scheduled cleaning activity

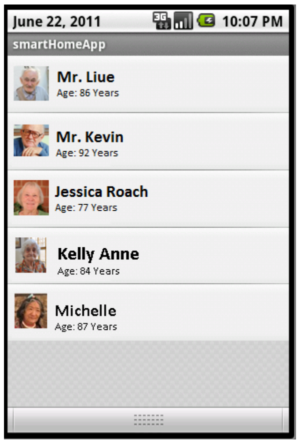
(d) Reminder for overlook medicine activity

Figure 3. Interfaces for Elderly Person Reminder Application

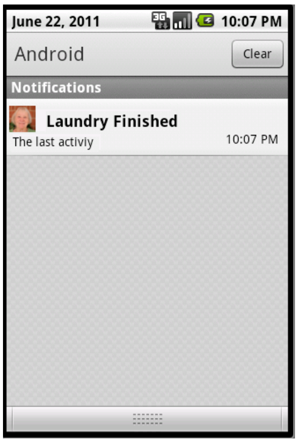
Incomplete activities are of two types critical and stable. If incomplete activity is identified as stable activity then generated alerts repeated three times after thirty minutes as shown in Figure 3(a). In case of critical activity sound of generated alerts is loud as compared to stable and repeated three times after five minutes as shown in Figure 3(b). Soft reminders are generated for scheduled and overlook activities. In case of scheduled activity, alert is generated on fix time while overlook activity time is fifteen minutes and alert is generated after every five minutes for three times as shown in Figure 3(c) and 3(d) respectively.



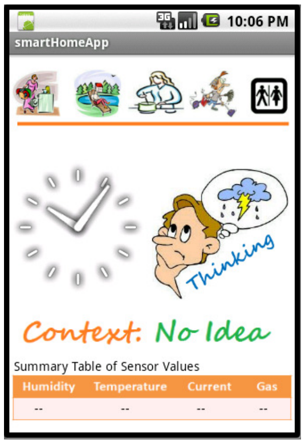
(a) Reminder for critical incomplete cooking activity



(b) List of elderly under care giver assistant



(c) Last completed activity



(d) Handling of uncertain situation

Figure 4. Interfaces for Elderly Care Giver Assistant Application

After no response from *Elderly Person Reminder Application* for cirtical activity, alert is generted for *Care Giver Assistant Application*. In order to inform the care givers and family members to handle the situation accordingly as shown in Figure 4(a). A care giver is facilitated to manage all subscribled elderly people through an interface as shown in Figure 4(b). Last completed activity is tracked by care giver for casual montioring through interface as shown in Figure 4(c). Activity tracking response time for each request takes ten seconds. In some situations, if tracking time exceeds to expected response time then interface shown in Figure 4(d) helps the users to keep themselves in a waiting mode.

V. Conclusions

To provide mobility for tracking the daily life activities, smartphone is a convenient and suitable device due to its rich functionalities. In this paper, we have utilized the smart phone, smart home, and cloud computing services that may help to reduce the demands on elder's attentions and effort while performing daily life activities. It generates separate alerts for incomplete critical, stable, scheduled and overlooks activities for elderly persons. List of subscribed elderly persons, their last completed activities and alerts for critical situations are generated for care givers and family members. It reduces the health expenditures and burden of health care professionals. Our application is well integrated with smart home environment and hospital infrastructure.

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