How to cite this paper:

Lim Poon Koon, Lau Khai Shien, & Manmeet Mahinderjit Singh. (2017). Smart home and location positioning system (SLOPS): an ambient intelligences service in Zulikha, J. & N. H. Zakaria (Eds.), Proceedings of the 6th International Conference on Computing & Informatics (pp 675-682). Sintok: School of Computing.

SMARTHOME AND LOCATION POSITIONING SYSTEM (SLOPS): AN AMBIENT INTELLIGENCES SERVICE

Lim Poon Koon, Lau Khai Shien , Manmeet Mahinderjit Singh

School of Computer Sciences, University Sains Malaysia (USM) , 11800 Penang, Malaysia
limpoonkoon@gmail.com, lkshien.ucom12@cs.usm.my, manmeet@usm.my

ABSTRACT. SmartHome and LOcation Positioning System (SLOPS) is a two-in-one monitoring system that aims to support home movement of occupant and track their wellbeing. The system consists of two major modules. The first one is an indoor and outdoor tracking system. This module's goal is to securely and cost-effectively track the elderly indoor and outdoor movement and provides notification functionality when the elderly needs help. The technology used behind this module includes Windows Phone application, RFID tracking, GPS and NFC tags. The second module of the SLOPS involves daily activity monitor and prediction system. The goal of this module is for non-invasively monitor the elderly behavior pattern and to notify the caregiver upon abnormality detection in the pattern. This enhances the safety of the elderly so that he or she could live independently. The technology behind this includes Arduino-based ambient sensors, Case-Based Reasoning prediction algorithm and Pebble wearable application.

Keywords: Global Positioning System (GPS), RFID, Arduino, Biometric, Fall Detection, Case-Based Reasoning prediction, Smart homes, Smartwatch

INTRODUCTION

In June 2016, during a climate summit in Paris, U.N World's Meteorological Organization data has shown the warming of the Pacific due to natural El-Nino causes the earth to become so hot (Doyle, 2016). Recording 2016 as the hottest year, many efforts such as shifting from fossil fuels in reducing global temperature and effort to plant more trees are seen by almost 200 nations. The fluctuation of environment temperature is a danger sign to the world population, especially the children and the elderly. A new record show, a high number of fatalities due to temperature related diseases such as heat stroke or better known as hyperthermia. As Malaysia is preparing itself in term of social through its healthcare services and infrastructure to tackle the nation aging society by 2030, the need to prepare our household with technology capable of tackling context changes such as fluctuating temperature. A study shows how health factors which may increase risk of hyperthermia, such as poor circulation, diseases such as lung, kidney or high blood pressure, which may present general weakness and fever (Ganti et.al, 2011). Poor diet and lifestyle pattern such as being underweight or overweight does contribute to the increase of fatality according to hyperthermia. The lack of automated surrounding or ambience in which sensors acting as proxy and presenting critical information capable of being alert if any abnormality on human behavioral occur. Imagine a scenario, in which changes in temperature of room due to the heat outside able to provide optimal surroundings and able to eliminate the possibility of any current of other health risks. Imagine of

cost-sensitive sensors capable of providing diet change in home occupant and provide future prediction and distinguishing poor/good lifestyle. The aim of this paper is to present an indoor and outdoor tracking system with smart home features SmartHome and Location Positioning System (SLOPS). Our goal is to provide a non-invasive protection with real-time monitoring system for elderly. We will focus on emphasizing how the combination of multiple sensors improves the locate occupants without boundary. Besides that, by utilizing ambient sensors such as motion sensor and weight sensor and placing them correctly into the elderly's environment, the system is able to analyze the daily activity pattern of the elderly and it can inform the caregiver upon abnormality detection such as a missed event or fall. Using the same prediction feature, the system can also intelligently control the home appliances. The objectives of SLOPS system:

i. To provide a non-invasive monitoring of occupants behavior pattern and robust notification engine which react upon abnormality detection for enhancing safety and independent living.
ii. To provide a secure and cost-effective tracking module covering indoor and outdoor movement of elderly.
iii. To secure sensitive information, data exists in device by avoiding masquerade user access application.

This paper is organized as follows. Section II reviews background study. In section III will describe the system implementation of system and introduce the predictive and the fall detection algorithm and hardware implementation of this project. Section IV describes system testing. Section V contains discussion of the system. Finally, section VI contains the conclusion and draws some guideline for the future works.

II. BACKGROUND STUDY

Based on the requirement of the project, study of related technologies has been done. The study can divide into four sections:

A. Smart Home, Ambient Intelligent and Prediction
B. Android based Fall detection
C. Indoor and outdoor positioning
D. Biometrics Technology

A. Smart Home, Ambient Intelligent and Prediction

Smart Homes. Researchers around the world have been focusing on the development of the smart home that could potentially assist the daily activities of people. As early as 2002, one of the ideas and product discussed in Das et.al (2002), the MavHome is a smart home that uses prediction algorithms to predict and thus automate those activities. In the paper, an example is given that the smart home is able to warm the heater prior to the waking up of user and ready the coffee maker once the user wakes up. This particular smart home uses four layers of agent architecture. The first layer is the physical layer which consists of the sensors, actuators, networks and agents. This is the layer of physical hardware within the house. The second layer is the communication layer where operations such as formatting and routing data done by software to different agents for different needs. The third layer is the information layer that gathers, stores and generates knowledge useful for decision making. Lastly, the decision layer selects actions to execute upon receiving information from other agents.

Besides its architecture, the specialty of MavHome is the three algorithms used for it to accomplish the prediction and automation. The first algorithm is LeZi-update. It is an approach to the location management problem which uses movement histories to learn likely future locations. The second one is SHIP (Smart Home Inhabitant Prediction). The algorithm uses

sequence matching with inexact allowances and decay factors to determine the most likely next inhabitant interaction with the home. Instead of automating all the activities, MavHome uses Episode Discovery (ED) to determine which episodes (activities) in an inhabitant are significant and automates them.

Ambient Intelligence Concept. Ambient intelligence is an emerging discipline that brings intelligence to our everyday environments and makes those environments sensitive to us (Cook, Augusto, & Jakkula, 2009). Ambient intelligence (AmI) research builds upon advances in sensors and sensor networks, pervasive computing, and artificial intelligence. There are five major contributing technologies to AmI: sense, reason, act, secure and HCI. Since AmI is designed for real-world, physical environments, effective use of sensors is important. Some examples of sensors used are strain and pressure sensors on floors, sound sensor for security and speech recognition, image sensor for context understanding. To further categorize them, the wired sensors are often cheaper, robust and use power sources while wireless sensors are more expensive, without wiring and relies on batteries. Another important aspect of AmI is reasoning, without proper model and algorithm to make reason of the collected sensor data, the data are useless. There are different activities to be recognized for different environments. For instance, lifestyle patterns recognition is more suitable in smart home while medicine intake pattern analyzing should be designed for hospital usage. Very often these pattern recognitions are highly related to spatial and temporal reasoning, very little can be done within an AmI system without an explicit or implicit reference to where and when the meaningful events occurred. For a system to make sensible decisions, it has to be aware of where the users are and have been during some period of time. Apart from the reasoning, HCI (Human-computer interaction) is another big field in AmI as many believe that it should be made easier to live with. While AmI offers great benefits to users by customizing their environments and unobtrusively meeting their needs, privacy and security challenges still exist. The current applications of AmI include smart homes, health monitoring and assistance, hospitals, transportation, emergency services, education, and workplaces.

Ambient Intelligence Prediction. In the paper of Akhlaghinia et.al (2007), a few soft computing prediction techniques in ambient intelligence are discussed. One of the major technique is Case-Based Reasoning (CBR). As discussed in the paper, CBR relies on the analysis of data of the sensors to determine the best case to represent the daily activities undergone by the monitored person. The components of CBR consist of case representation, case retrieval, case reuse, case adaptation, case storage and the case base. Case representation will use the sensor data to generate a case based on it and the case retrieval will match the generated case using cases from the case base. User actions will influence the case adaptation process and case storage will store the adapted case.One example of this will be assuming a person goes to a lounge in a predictive building at 7pm and sets his or her favorite light intensity and temperature. In this case, the system will generate a new case in the database for the situation. When the same person goes to this location at the same time in the future, the favorite light intensity and temperature will be set automatically by the system as an existing case in the database matches this situation.

B. Android-based Fall detection

As proposed and tested in Cao et.al (2012), an Android-based smartphone fall detection application is able to detect a fall event with high efficiency. In the paper, the hardware used is a HTC G8. It is a smartphone that is equipped with MSM7225 ARM CPU and most importantly a tri-axis accelerometer that is used for the fall detection. For the software of this system, Android 2.2 Platform is used and the application written is based on Java and runs on Dalvik virtual machine. The equation used in the smartphone application is a threshold algorithm which is most classical in fall detection. However, the algorithm is made to be able to dynam-

ically adjust its threshold value and time window according to user information such as the ratio of height and weight, sex and age. The algorithm is tested with real data of 400 falls and 1200 ADLs and hence the sensitivity of the algorithm is calculated to be 92.75%. The sensitivity of the adaptive algorithm is higher than the classical algorithm by 6%.

C. Indoor and outdoor positioning

Global Positioning System (GPS) tracking system. GPS is a satellite positioning system developed by the U.S. government, and has widely applied around the world. But GPS mainly used for tracking a person's outdoor position, it already widely used for GPS based tracking system. We would focus discuss on elderly GPS tracking system. Generally, elderly GPS tracking systems provide devices such as wearable that receive/send signal for real-time tracking purpose. Besides that, devices also include additional security or health-related which provides relief and comfort to those worried about a parent or family member. A useful feature of those systems is alert/panic buttons on devices for elderly ability contact caregivers immediately. On the other hand, those devices have disadvantages such as cost and stability of the GPS signal at indoor coverage (Pocketfinder, 2015; GPS Tracking SilverCloud Sync Fleet GPS Tracker, LandAirSea Systems, 2015).

D. Biometrics Technology

Biometric systems make use of physiological and behavioral traits of individuals, for recognition purposes. The well-known biometrics for identification is face and fingerprinting. Because the traits measured by biometrics are unique to each individual, it made the authentication strength much bigger in security. Generally, biometric system consists four modules, namely sensor module, feature extraction module, matcher module and decision module. Sensor module is recorded or save the trait by using sensor and digitize into raw data. The raw data commonly are image form which will be extract data by using a sequence of algorithm or technique to build uniqueness of the traits. The extracted data will be stored in a database and will be used for do matching when doing authentication process. The system will make a decision after matching the extracted data. Multimodal biometric recognition systems are expected to be more reliable due to the presence of multiple, fairly independent pieces of evidence [3]. Fusion can be performed depending upon the type of information available in any module of biometric systems. Feature extraction for each trait can still be same as single modal biometric but the fusion schema must applied as early as possible in the recognition system is more effective. The challenging aspect in the design of a multimodal biometric system is developing an efficient matching algorithm and fusion at the sensor or feature levels introduces additional processing complexities.

III. SMARTHOME CARE AND LOCATION POSITIONING SYSTEM (SLOPS) IMPLEMENTATION

This section will present the implementation of SLOPS. Figure 1 shows the overall system architecture design. Basically, the system divides into 4 parts which are users, indoor, outdoor and server.

User. The caregiver and admin can access the web application through computer, whereas caregiver and elderly are access mobile application through Windows Phone devices. Besides that, elderly required to wear a Pebble smart watch and attached RFID wearable tag with a unique ID. The fall detection algorithm is implemented in the Pebble smart watch.

Indoor. The active RFID readers are located at indoor coverage, which responding to elderly's wearable for indoor tracking purpose. The Arduino-based ambient sensors include different kind of sensors and are placed at different locations for different purposes. For example, motion sensors placed at each location are used to determine the presence of elderly while

weight sensors placed on the bed or sofa determine if the elderly is using the particular furniture. All of these ambient sensors transmit data to the Arduino-based parent node in which the node will propagate the data to the web server via Internet connection.Raspberry Pi is configured to simulate different home appliances. It allows real-time changes made to the home appliances' settings to be reflected immediately as the Pi constantly fetch the settings from web server.

Outdoor. As a priority, GPS will be used as outdoor tracking purpose which responding to Windows Phone devices that belong to elderly. Besides that, NFC tags contains geolocation data that deployed at outdoor coverage will be alternative choice to record outdoor position by occupants.

Server. The web server will host bunch of RESTful Web services that responding to web and mobile application.The prediction service and notification service are also hosted in the server. A scheduler is used to run the prediction algorithm daily to update the adapted cases to the latest.

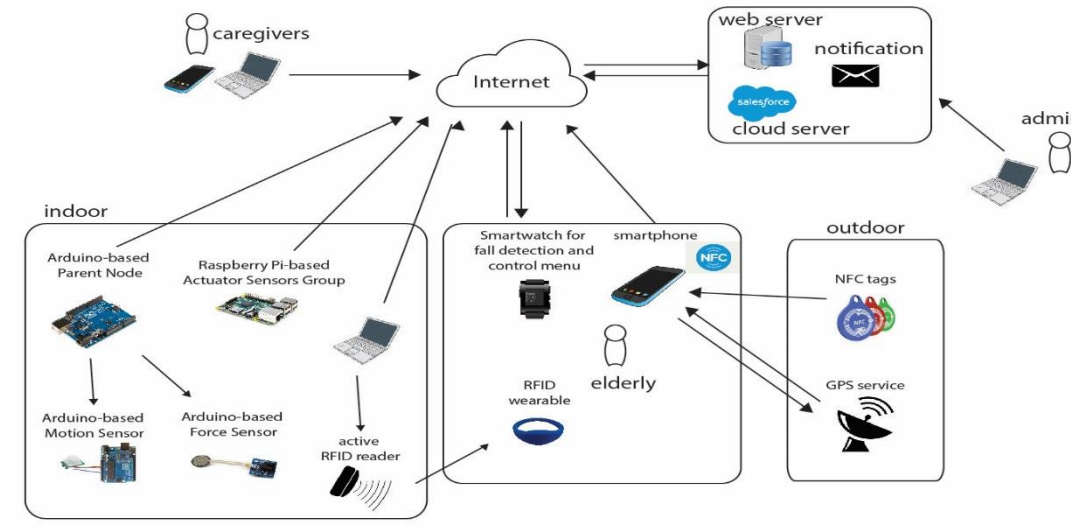


Figure 1. Overall SLOPS architecture.

IV. SYSTEM TESTINGS FOR SLOPS

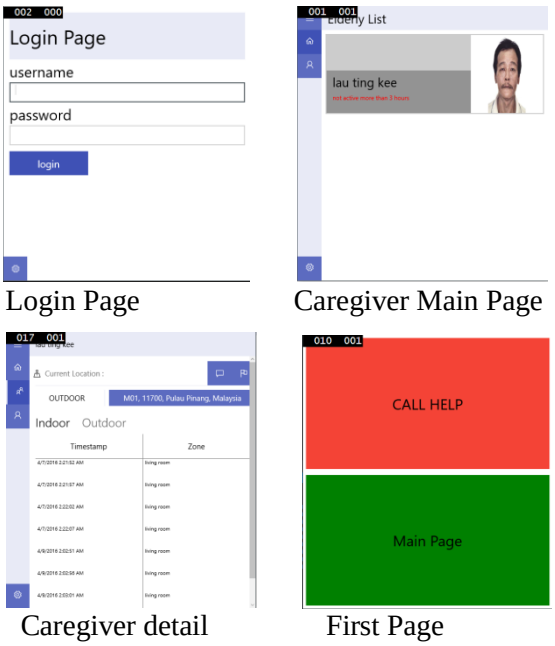
There are several cases will be discussed as follows:

Scenario of an occupant face emergency problem when at outdoor. When an occupant was going to outdoor for some purpose, then something happened where elderly need help immediately. He/She can launch the mobile application and click on the help button. System will send notification to corresponding caregiver. Caregivers will be notified by the notification, and launch the mobile application to check latest position of elderly and use map navigate function towards to elderly's position.

Scenario of the an occupant lost signal more than an hour. System will send notification to the corresponding caregiver to alert current status of elderly and caregiver can check the latest position of elderly or check the featured location of elderly. The system based on historical geolocation data, process the places visited by elderly previously. The featured location will list out the higher visited places of the elderly, so it will help caregiver smaller the searching area for looking for elderly.

Scenario of occupant moving from one location to another. In this scenario, the elderly will move from bedroom to living room. He or she has just wake up from a nap and would like to watch TV in the living room. Upon reaching the living room, the motion sensor in living room is triggered. The system will determine if the trigger is fresh (firstly triggered) and will automatically turn off appliances such as light and fan in the bedroom. At the same time, the light and fan in the living room will be turned on with the favorite settings analyzed by the prediction algorithm. When the elderly proceeds to sit on the sofa, the weight sensor on the sofa will be triggered, as set using the automation feature, the activity will switch on the TV along with his or her favorite channel.

Scenario of occupant abnormal behavior at indoor. The abnormal behaviors include fall or missed activity. If the Pebble smart watch detects if there is a fall and signal will be sent to the web server. The web server will send notifications such as SMS or email to the caregiver as configured. Figure 2 shows the user interface of SLOPS.



Login Page | Caregiver Main Page

Caregiver detail | First Page

Figure 2. User interface of SLOPS mobile application.

V. SYSTEM DISCUSSION

SLOPS provides the non- invasive protection without limiting his/her freedom. By detecting abnormal behavior it can enhance the safety of occupant.. Besides that, the fall detection of smartwatch can acknowledge by caregiver immediately and allow the caregiver react in time. However, system provided the monitoring and tracking platform on elderly for the caregiver, but the limitation of this system is still exist:

Mobile Phone

For outdoor coverage, GPS and network access are required to track elderly position and exchange data to cloud server. But there are some places is not coverage of internet and GPS.

Therefore, we assume that mobile phone is connected to network, no matter is mobile data service or public Wi-Fi. Besides that, the alternative of outdoor tracking service, NFC tags that contain geolocation data assuming deployed around the home region or the city by assuming the smart city concept achieved. Mobile devices using the GPS and mobile service data is high consume battery life of device which will limit elderly movement at outdoor. Therefore, system cannot ensure that elderly be tracking and monitoring in 24/7.

Ambient Sensors

Despite the ability of ambient sensors to detect the environment, they cannot differentiate if there are more than one person in the location. For example, motion sensor in living room can only detect the presence of people but they cannot determine the exact person in the room. To make sure the fall detection work, the watch app needs to be activated 24/7. This limits the ability of the elderly to use another watch apps as he or she will need to switch the running app back to the SLOPS watch app in order to let the fall detection works correctly. Besides, the Pebble smart watch relies on mobile device to send data to web server. Hence the overall cost of implementation has increased but since there are high possibilities that elderly will have at least a smartphone with them, the impact is reduced.

VI. CONCLUSION AND FUTURE WORK

As a conclusion, this system is able help occupant live independently by monitoring and tacking elderly real-time. This project definitely can provide the bigger convenient to caregiver and elderly as well. As part of the future plan, there are couple of ways to improve this system:

- Replace smartwatch that consist fitness medical check sensors to monitor heartbeat of elderly as medical alert device
- Include a specialized GUI to let caregiver create custom automations to suit each adapted case from the prediction algorithm according to his or her preferences

REFERENCES

Akhlaghinia, M. J., Lotfi, A., & Langensiepen, C. (2007, July). Soft computing prediction techniques in ambient intelligence environments. In 2007 *IEEE International Fuzzy Systems Conference* (pp. 1-6). IEEE.

Cao, Y., Yang, Y., & Liu, W. (2012, May). E-FallD: A fall detection system using android-based smartphone. In *Fuzzy Systems and Knowledge Discovery (FSKD)*, 2012 9th International Conference on (pp. 1509-1513). IEEE.

Chaudhary, S., & Nath, R. (2009, October). A multimodal biometric recognition system based on fusion of palmprint, fingerprint and face. *In Advances in Recent Technologies in Communication and Computing, 2009. ARTCom'09. International Conference* on (pp. 596-600). IEEE.

Chawathe, S. S. (2008, October). Beacon placement for indoor localization using bluetooth. In 2008 *11th International IEEE Conference on Intelligent Transportation Systems* (pp. 980-985). IEEE.

Cheffena, M. (2015). Fall detection using smartphone audio features.

Cook, D. J., Augusto, J. C., & Jakkula, V. R. (2009). Ambient intelligence: Technologies, applications, and opportunities. *Pervasive and Mobile Computing*, 5(4), 277-298.

Das, S. K., Cook, D. J., Battacharya, A., Heierman, E. O., & Lin, T. Y. (2002). The role of prediction algorithms in the MavHome smart home architecture. *IEEE Wireless Communications*, 9(6), 77-84.

Doyle, A. (2016, August 13). As Earth Swelters, Global Warming Target in Danger. Retrieved from http://www.climatecentral.org/news/as-earth-swelters-global-warming-target-in-danger-20597, Accessed 15 August 2016

Ganti, R. K., Ye, F., & Lei, H. (2011). Mobile crowdsensing: current state and future challenges. *IEEE Communications Magazine*, 49(11), 32-39.

GPS Tracking SilverCloud Sync Fleet GPS Tracker, LandAirSea Systems (2015). Retrieved from https://www.landairsea.com/gps-tracker/gps-tracking-silvercloud-sync. Accessed 20 April 2016

Moen, H. L. (2007). A study of Wi-Fi RFID tags in citywide wireless networks. Norwegian University of Science and Technology June.

Pocketfinder. (2015). GPS Senior Tracker. Retrieved from http://pocketfinder.com/. Accessed 20 April 2016

Shchekotov, M. (2014). Indoor localization method based on Wi-Fi trilateration technique. In Proceeding of the 16th conference of fruct association.

Zhao, J., Zhang, Y., & Ye, M. (2006, October). Research on the received signal strength indication location algorithm for RFID system. In *2006 International Symposium on Communications and Information Technologies* (pp. 881-885). IEEE.