Trajectory Based Activity Monitoring and HealthCare Provisioning

Muhammad Aamir Saleem, Iram Fatima, Kifayat Ullah Khan, Young Koo Lee ,Sungyoung Lee
Department of Computer Engineering
Kyung Hee University
South Korea
Email: {aamir, iram, kualizai,yklee,sylee}@oslab.khu.ac.kr

Abstract— **Pervasiveness of location acquisition technologies such as GPS, GSM, and Wi-Fi are growing swiftly. This opens the doors to use these technologies for ease and advancement in the lives of human. Human daily routine trajectory activities like visiting different places (e.g., Office, Restaurant, and Sports Club) for performing particular tasks have significant impacts on life. In this paper, we propose Daily Activity Monitor (DAM) which is a GPS based real time trajectory based activity analysis system for user monitoring. To achieve real time and accurate outcome in tracking movement activities, we have used an approach of Personal tracking using static trajectory locations. DAM tracks the complete movement activity of a user/patient and shares it with physicians for analysis and updated recommendations. To verify and validate the working of DAM, we have implemented a proof of concept prototype that reflects its complete working.**

Keywords : Personal Tracking; Behavior mining; Frequent static trajectory location; Trajectory Activity monitoring

I. INTRODUCTION

Satellite based Global Positioning System (GPS) technology is used to find a location more accurately and efficiently than ever before. A huge category of devices is enabled with this technology like smart phones, PDA's, automobile theft protection systems, navigation systems of vehicles, marines and aircrafts. In recent years, people have focused on GPS to resolve different daily life problems that may vary from environmental monitoring to the traffic control [15, 16].

A recent study [1] used GPS for finding people preferences regarding attractive areas and movement patterns, which can lead to instructive insight to transport management, urban planning, and location-based services (LBS). Automatic Identification System (AIS) uses trajectory mining techniques for finding the ship movement paths [2]. Its purpose is self-navigation and collision avoidance. In [4] a trajectory based tracking system, Captain is proposed. This system is designed for tracking of short, yacht trajectories. The focus of this system is to record the movement path of the person by using the parameters of the pictures, temperature, and coordinates of the locations; however not the place of a particular activity. This makes it highly unsuitable for recording complete daily life activities of a person.

Similarly, the contemporary innovations in GPS enabled smart phone technologies and low-cost internet availability has tiled the way for development of mobile healthcare applications [3]. These applications provide a convenient, safe, and reliable way of monitoring movement related activities. A fundamental aspect of development of mobile healthcare services is the use of technological innovation to support continuous user monitoring [13]. Reviewing recent works in mobile healthcare reveals that most of the projects [5-8] have mainly focused on using, enhancing or combining existing technologies and context-aware projects [9-13] mostly deal with a limited scope. However a general approach for modeling and reasoning about uncertain health situations using GPS technology in real-time has still not been addressed. User daily life movement activities can be easily tracked by using location aware technologies. Monitoring of these activities by healthcare experts can reduce the chances of health complications, as well as help user to adopt a better lifestyle. However, according to the author's knowledge there is not any existing system which utilizes location based activities for a context aware healthcare monitoring and recommendations. We have tried to target this problem in our proposed method.

We used the GPS technology to track and control movement activities of users and provide context aware recommendations for user health improvement. The life span of a person is composed of a number of routine activities, such as lunch, exercise, and office work. These activities have positive and negative implications for human life. For instance, heavy eating habits have bad effects while exercise has good effects. Thus by monitoring and controlling these routine activities, decent improvement in health can be attained. The impact of these routine activities increases vigorously in case of a contaminated or diseased person [14]. Usually a patient is prescribed to follow a particular schedule from practitioner based on ailment e.g., it may contain suggestions of daily exercise, avoidance of alcohol, and of timely medication. According to a study [14] about 14-21% of patients never fill their original prescription and approximately 125,000 people with treatable ailments die each year in the USA because of carelessness in prescriptions. Negligence in following of prescription is observed as one of the main causes of bringing severity in disease [14]. Thus by focusing on proper carrying out of prescription can help us to resolve severe health worries also in the case of patients.

In this paper we propose DAM (Daily Activity Monitor), a GPS based real time trajectory pattern analysis system for a user's health care. It tracks all the movement related activities of a user and compare them with the prescribed activities to find out the discrepancies. DAM architecture divides it into two main modules, 1) Mobile Clients and 2) Cloud Server. Mobile Client of user is responsible for tracking outdoor activities on the basis of location of performed activities. GPS technology and personal tracking using static trajectory location approach are used for recording these activity locations. Semantic tags of locations are also acquired by a user for contextual information.

The comparison of user performed activities and practitioner's prescription is performed on Cloud Server. Inconsistencies in activity patterns are then carried out to both user and practitioner for result analysis and updated suggestions respectively. DAM stores three kinds of data, 1) Performed Activities of user, 2) Practitioner's prescriptions and 3) Recommendations for imminent activities. User imminent activities are predicted based on his/her historic data. Analysis of these historic patterns and correlated suggestions conferring to practitioner's advice for imminent activity are also encompassed by our Cloud server. A proof of concept prototype to reflect complete working of DAM has been implemented. Based on trajectory activity monitoring DAM offers healthcare provisioning and thus can be considered as a service for bringing betterment in health.

The rest of the Paper is organized as follows. In Section II, and III we discuss the key concepts and Proposed DAM system respectively. In Section IV, we describe the results achieved. Section V concludes this research work and gives future directions.

II. KEY CONCEPTS

In this section we describe the key prerequisite related to DAM.

A. *Imperative Location*

The location at which some significant activity occurs, having considerable importance in user daily life schedule is termed as Imperative Location. Only activities performed at these Locations are recorded by DAM for user monitoring. Activities can be performed at other places as well; however but only those locations which satisfy parameters, according to the approach of personal tracking using static trajectory location (explained in Section III) are termed as Imperative locations. GPS coordinates of these locations are recorded and then converted into Geo tags. An example scenario is given in Table 1. Geo tags of imperative locations are exposed in Column *Imperative Locations/Geo Tags* e.g., GS-25, SK-Gas Station, and Samsung Head Office.

B. *Performed Activities*

The activities which are performed at imperative locations are named as Performed Activities. It consists of all the activities which hold significant importance in the routine life of the user e.g. (A_{PER} = {A_1, A_2, A_3,…, A_{iPER},…, A_K}) Where, A_{PER} is the set of Performed Activities and A_{iPER} is an activity performed at imperative location. It may also include those activities which are not related to healthcare. The examples of Performed activities are given in Column *Performed Activities/Semantic Tags*, of Table 1.

C. *Semantic Tag*

Semantic tag is the contextual name of Performed Activity. Visited place of the user is recorded using GPS enabled smart device. These GPS coordinates are then converted into Geo-tags using Google API. On the basis of these Google tags, user is asked to choose semantic tags for corresponding visited places. Semantic name for each corresponding imperative location is given in Table 1, For example GS-25 is named as Department store shopping and Samsung Head Office as Office work.

TABLE I. IMPERATIVE LOCATIONS, FOLLOWED ACTIVITIES, FOCUSED ACTIVITIES, AND SEMANTIC TAGS

Act. #	GPS Coordinates (Lon., Lat.)	Spent Time T_{MIN} (Minutes)	Imperative Locations/ Geo Tags	Performed Activities/ Semantic Tags	Focused Activities
1.	37.725825, 127.865742	35	GS-25	Department Store Shopping	-
2.	37.790144, 127.541269	32	SK-Gas Station	Fueling	-
3	37.854123, 127.784563	27	-	-	-
4.	37.220047, 127.758014	250	Samsung Head Office	Office Work	Office
5.	37.510943, 127.059765	49	Pizza Hut	Lunch	Lunch
6.	37.778501, 127.741562	28	-	-	-
7.	37.784512, 127.896742	400	I-Park Apartments	Home	Home
8.	37.741253, 127.965214	36	GS-25	Shopping	-
9.	37.885623, 127.002584	55	Boboose Sports Complex	Exercise	Exercise
10.	37.123987, 127.756932	220	I-Park Apartments	Home	Home

D. *Focused Activities*

Those activities of the user which are directly related to healthcare are labeled as Focused Activities. These activities are extracted from Performed activities based on physician prescription e.g., {A_{iFOC} € A_{FOC} : $P_{PresSchd}(A_{iFOC})$}. Thus Focused activities are considered as a subset of Performed activities e.g., { $A_{FOC} \subseteq A_{PER}$ } Where, A_{FOC} is the set of Focused Activities and A_{iFOC} is the Activity which is included in the Prescribed Schedule of practitioner ($P_{PresSchd}$). Only these focused activities are compared to a prescribed schedule added by the practitioner for finding discrepancies in the user schedule. On the other hand, comparing all activities is computationally intensive and will be prone to compromising the privacy of users. Table 1 explains that Fueling at SK-Gas station and Shopping at GS-25 are present in Performed activities; however are not included in the Focused activities because of not having significant importance from the healthcare point of view.

III. Proposed System (Daily Activity Monitor)

Daily Activity Monitor (DAM) is a healthcare service which monitors user's routine activities and assists to follow prescribed schedule. Detailed architecture of the proposed DAM is shown in Figure 1. The figure indicates that system is divided into two main components Mobile Clients and Cloud Server. In the following subsections, we provide details on different components of DAM.

A. DAM Mobile Clients:

DAM Mobile Clients are GPS enabled location aware mobile devices, such as smart phones, with the availability of internet at every imperative location. There are two types of mobile clients used in DAM, User Mobile Client and Practitioner Mobile Client. Details of both of them are provided below.

1) User's Mobile Client: Mobile Client for user plays as an agent for recording all the required trajectory data of the user which includes GPS coordinates, date, time, and duration of stay at a particular location. The approach used for tracking of imperative activity locations of the user is Personal tracking using static trajectory location. In this approach we focus on recording of static or rest positions by tracking GPS coordinates. The parameters used for identifying an imperative location are distance and time spent in performing the activity. Detailed working and algorithm of the approach is given below.

In routine life the importance of a specific task is measured by the amount of time spend to perform it [17, 18]. So one of the parameters, considered by DAM, for recording of imperative location is time. Spent time at a particular position is tracked on the basis of change in GPS coordinates. User position status is checked after a threshold, Coordinates checking time interval (T_{CC}). Getting same or different coordinates as compared to last recording tells us the spent time of current or last activity respectively. This small interval of time after which GPS coordinates are checked is affected by two main factors, location accuracy and battery life of the recording device. Normally this time interval varies from a few seconds to minutes [20-21]. More frequent recording of GPS coordinates gives more location accuracy but on the other hand puts a bad impact on battery life of recording device. In case of DAM our focus is on recording of position of activity but not the trajectory path observed. Thus in order to avoid missing of any imperative location, the GPS recording time interval used by our system is considered a little less than the time threshold for satisfying an imperative location (T_{min}).

Algorithm 1: Personal Tracking using Static Trajectory Locations

Input: GPS coordinates, Coordinates Checking Time Interval T_{CC}, Minimum time threshold T_{min} Minimum distance threshold D_{min}

Output : Imperative Location, Start Time , End Time, Geo tag

```
Begin
TempC_GPS = Fetch GPS coordinates
    While (true)
        Wait (T_CC)
        if GPS not available
            C_GPS = Last stored GPS coordinates // inside some building
        else
            C_GPS = Fetch GPS coordinates
        end if
        if TempC_GPS is equal to C_GPS
            SpentTime + = T_CC
        Else
            if (SpentTime > T_min)
                if Distance (TempC_GPS , C_GPS ) < D_min
                    ImperativeLocation= ConvertToGeoTag (TempC_GPS)
                    ImperativeLocation.Start Time= Start Time;
                    ImperativeLocation.End Time= System Time;
                    Start Time= System Time;
                    Spent Time =0;
                end if
            end if
            return ImperativeLocation
        end if
    end While
End
```

Spending sufficient time at a place makes it vital likewise, short time interval at a particular place is considered as a sign of insignificance of the place e.g., stay at a department store or gas station is not such a significant activity which affect healthcare. In order to differentiate between imperative and insignificant activities a time threshold T_{min} is defined. To make a location imperative user's spent time at that location should be more than this threshold value i.e., Location is recorded only if; $T_S \geq T_{min}$ Where, T_S is the total time spent at a particular place. According to a survey [19] the minimum time for performing some significant activity is approximately 30 minutes, so by default this is considered as T_{min}. Table 1 show that GPS coordinates of activity number 3 and 6 are recorded because their spent time is greater than T_{CC} (25 min); however could not satisfy imperative location of minimum threshold T_{min}. Thus not converted to GPS tags and these activity places coordinates are ignored.

After satisfying time threshold another measure, distance is used for finalizing imperative location. Usually tasks are performed either at rest position or by movement

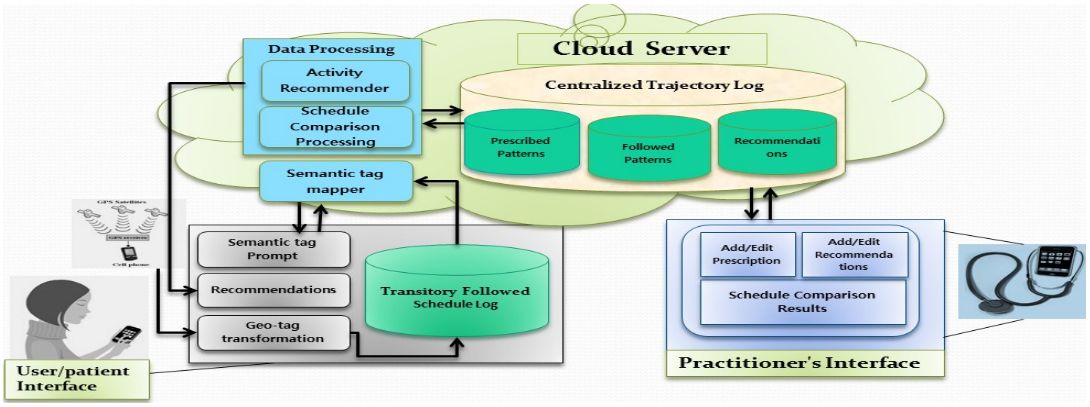

Figure 1. Architecture of Daily Activity Monitor(DAM)

within a particular area. For example, during office hours people don't always stick to a place but move within a certain area. This tiny movement changes the co-ordinates but not the activity which is being performed by a person. This variation in distance measure is handled by a distance threshold D_{min}. Coordinates of new locations are recorded only if $D_c \geq D_{min}$. Where D_c is distance of current position from last recorded vital position and D_{min} is a distance threshold which can be covered without triggering new imperative location. In Algorithm 1, line number 4 to 13, time and distance parameters for imperative location are being checked. The conversion of GPS coordinates to Geo-tags and the recording of required parameters of imperative activity are shown in line 14-22. Required parameters include date, start time, and end time.

After satisfying parameters, GPS coordinates of the place are recorded. In case of unavailability of GPS at particular area e.g., inside the buildings, the last recorded location prior to entering into the building is considered as position of activity. Recorded GPS points are converted into Geo-tags by using Google API e.g., Geo-tags of corresponding coordinates are shown in column *Imperative Locations* of Table 1. However same geographic locations may have different significances for different persons. For example, the restaurant is a workplace for a cook and a lunch place for customers so Geo-tag information is not sufficient to know the context of location for a particular person. To resolve this issue semantic tags have been introduced. For every new location, users are required to add semantic tags by prompting geographic tag and visit time of location. After getting semantic tag for a location it is linked to corresponding GPS co-ordinates, Geo-tags, and parameters of the activity like start time, end time, and date and sent to Centralized Server for storage. User has to add semantic tags only once and on revisiting of the same location its semantic tag will be fetched from database. If same place is visited with different intentions, the user has to update semantic tag for new purposes. For future visits updated tag is used.

2) Practitioner's Mobile Client: The role of this mobile client is to interact with centralized server to show a report on user's schedule with all the discrepancies to his/her practitioner. Results are presented in the form of comparison of followed schedule and practitioner's Prescribed schedule. The prescription is also added or updated by the practitioner using this mobile client which includes activity name, spent time, and frequency of doing the activity. This prescription illustrates the way user has to perform the activities. All the data of prescribed schedule are stored in Prescribed Patterns, located in the Centralized Trajectory Log on Cloud Server. On request of viewing user schedule report, data stored in Prescribed Patterns and Followed Patterns are acquired by Schedule Comparison Processing module and after processing results are sent back to the user mobile client. The practitioner is also required to add recommendation about each activity e.g., Food to be included and avoided in a lunch. This information is stored in the Recommendations and corresponding recommendations are sent to the user prior to performing an activity.

B. Cloud Server

Storage, processing, and analysis of huge trajectory location data are compute intensive tasks and cannot be executed on smart phones. So, we use a Cloud Server. A web service consisting of a Semantic tag mapper and the Data Processing module is deployed over the cloud for processing of all data. Each of these modules is explained briefly.

1) Semantic tag Mapper: After submission of user followed activities into Cloud Server semantic tags of each activity is checked by the Semantic tag mapper. This process is repeated after a fixed time interval and by default this interval is considered as one complete day (24 hours). If any of semantic tag is found missing, the user is again asked to add this by an alert prompt. This message contains the information about Geo-tags and visit time of tag missing visited location. After getting semantic tag it is linked with its corresponding values of GPS coordinates, visit time, and duration of activity and sent to Followed Pattern for storage. Xml representation of semantic tag is given in the Figure 3, which shows the values of different parameters.

```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<SemanticTag id="1">
    <VisitDate>12:10:45</VisitDate>
    <VisitStartTime>12:10:45</VisitStartTime>
    <VisitEndTime>13:05:55</VisitEndTime>
    <GPSCordinates>
        <Latitude> 37.511944</Latitude>
        <Longitude>127.058889</Longitude>
    </GPSCordinates>
    <GPSTags>COEX Mall</GPSTags>
    <SemanticTagValue> Lunch </SemanticTagValue>
</SemanticTag>
```

Figure 2. XML representation of Semantic Tag

2) Data Processing module: All the processing of data is done by this module. This module is further divided into a Schedule comparison module and Upcoming Activity Recommender which are discussed below in detail.

a) Activity Recommender: Suggestion of some useful information prior to happening of activity is much more valuable than stating it afterwards [22,23]. This module predicts forthcoming activities of users based on past data analysis. On every change of position, historical statistics are checked to find out the activities of the user in this period. Generally, the duration of an activity is strongly dependent on weekdays and weekends. Thus the schedule of activities varies for holidays and weekends e.g, In weekdays office or other work effect routine activities. Thus for forecasting activity, only corresponding time interval is considered. On the basis of historical activities and their occurrence time, the probability for each activity is calculated. Suggestions and recommendations corresponding to activity having maximum probability are fetched and sent to the user via a prompt message.

b) Schedule Comparison Processing: One of the most important tasks of this application is to make an accurate comparison of practitioner prescribed and user followed schedule (Performed Activities) to obtain useful results. Comparison schedule data includes semantic tags of all the Imperative locations triggered by User's Mobile Client application and Practitioner's prescribed semantic tags for activities. Algorithm of the Comparison schedule module is given below.

Each imperative location of user's schedule is compared with corresponding entry of practitioner Prescribed schedule along with the parameters of total spent time and frequency of visiting of locations. E.g. it is checked that how much time user has spent in doing an exercise activity and how actually he/she was supposed to and also either he is going for doing exercise as many times as prescribed. Fetching of required activity is shown in lines 2-5 of Algorithm Followed and Prescribed Schedule Comparison. Lines 6-8 are supervising occurrence frequency and spent time of activity. After reviewing these comparison results if practitioner finds some inconsistencies, he/she can update suggestions and recommendations for upcoming days. For future user will get updated notifications and alerts.

Algorithm 2: Followed and Prescribed Schedule Comparison

Input : Followed Patterns P_F, Prescribed Patterns P_P, Time Interval

Output: List of Activities, Frequency Count F_C and Spent Time T_S

1. Begin
2. for each Activity A_{PERi} in P_P // each activity in prescribed patterns
3.   for each Pattern P_i € P_F // each pattern day routine in followed pattern
4.   for each day in Time interval
5. A_{FOCi} = Find A_{PERi} in P_i // find prescribed activity in followed
6.   If A_{FOCi} is non empty // if found
7.   Increment Occurance Frequency of A_{FOCi}
8. $A_{FOCi} . T_S$ + = Spent Time of A_{FOCi}
9.   end if
10.   end for
11.   end for
12. A_{FOCi}.frequency = Comparison (Occ. Frequency of A_{FOCi} , Prescribed Frequency of A_{PERi})
13. A_{FOCi}.TSi = Average ($A_{Fi} . T_S$, Total number of days in Time interval)
14.   Activities List = A_{FOCi}
15. end for
16. Return (Activities List);
17. End

3) Centralized trajectory log: A database schema is designed to store three kinds of logs; Followed Patterns, Prescribed Patterns, and Recommendations. Followed Patterns contain all the information of Performed activities and user biographic information e.g., user name, email id, user id, visiting location co-ordinates, Geo-tag, semantic tag, total time spent, visiting time, and date.

Prescribed Patterns have information related to Prescribed schedule. This information is added by the practitioner of the user and contains detailed information of carrying out activity e.g., visiting places that are required for the user, spending time and frequency of visiting that place. User followed schedule is compared with this information.

Third kind of repository (Recommendations) is for storing recommendation for each activity which is used in suggestion of imminent activity. This information is also added by practitioner and contains suggestions for each activity e.g. Suggestion for lunch may contain non-alcoholic or non-spicy food for a particular user.

IV. Implementation and Results

For prototype implementation of Mobile Clients we have used a SAMSUNG Nexus S running Android 4.04, equipped with 1 GHz Cortex-A8 CPU, Power VR SGX540 GPU and 512 MB of RAM. The phone has 3G/Wi-Fi network interfaces and a built-in GPS receiver. Mobile Clients are developed using Android and for Centralized Server C# running on Microsoft.Net Compact Framework 4.0 is used. Interfaces of DAM Mobile Clients are discussed below.

A. *User Mobile Client Interface*

The purpose of this client is to record all the movement related activities of users. Figure 3(a) illustrates the main interface and all the functionalities provided by the DAM mobile client of users. First Comparison Results is to show the comparison of user Followed schedule and Prescribed Schedule. The user is required to specify a date interval of viewing the comparison results. Results are shown in Figure 5(b). The example has been taken of Exercise activity. Prescription parameters show the Prescribed schedule of exercise activity. Followed Schedule in Figure 5(b) shows the actual routine followed by a user regarding exercise activity. It displays that frequency as well as time spent in performing an exercise activity both are less than prescribed one. At the end of the snapshot suggestion field point out the inconsistency and give the suggestion of making it according to the prescription. According to which user should do exercise more frequently and also time of activity should be increased.

Prescribed schedule is to show the prescription added by practitioner about all the activities. Recommendations also show kind of suggestions, but this is specifically for upcoming activities. These are also added by the practitioner. The difference between Prescribed schedule and Recommendations is that Prescribed schedule shows the prescription of daily routine activities for example how much time and how frequent user has to visit a particular place. However Recommendations are concerned about individual activity e.g., what kind of food user should take and what kind of exercise is recommended. Recommendations are provided for forthcoming activities and shown to the user using alert messages. A snapshot of this alert message is shown in figure 4(b)**.** Change of location of the user is detected on the basis of alteration of GPS coordinates. Then its corresponding movement activity is checked from historical data to predict forthcoming activity. Here in the snapshot (Figure 4(a)) past records tell that the user usually goes for lunch at this time. So corresponding recommendations for lunch activities are fetched from the repository and shown to the user e.g. non-alcoholic and non-spicy food. The last option Edit Profile is used to update biographical information by a user such as name, email id, user id, practitioner id, and practitioner email id.

Figure 4(a) describes alert message for adding Semantic tag. This message is prompted to user when a new place is visited and tag for this place does not exist in repository. So the user is asked to provide semantic tag by giving Geo tag and visit time of that location. The example in Figure 4(a) includes a lunch activity which user performed at Coex mall at 13:30.

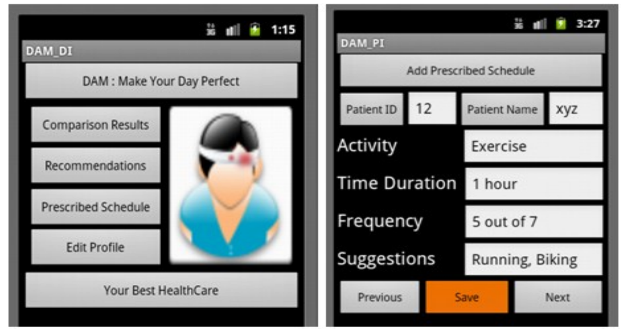

Figure 3. (a) User Interface (b) Prescribed Schedule

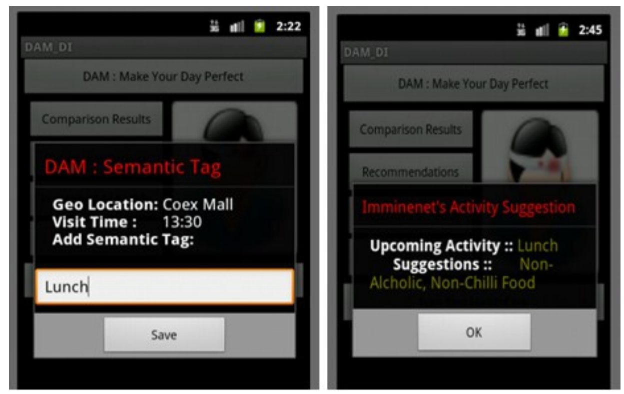

Figure 4. (a) Semantic Tag (b) Recommendations

B. *Practitioner Mobile Client Interface*

The second mobile client of DAM is designed for practitioners to assist them in user monitoring and controlling (add/edit) of prescribed schedule. A snapshot of this interface is shown in Figure 5. The *Comparison Schedule* option is for showing comparison of Prescribed Schedule and Followed Schedule of the user. It is exactly the same as described in the *Patient Mobile Client Interface* and shown in Figure 5(b). The purpose of this is to update practitioner regarding the status of users.

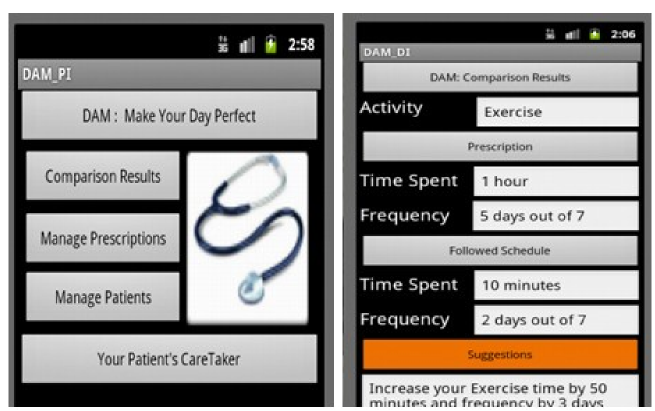

Figure 5. (a) Practitioner Interface (b) Comparison Result

Manage Prescription provides the option of adding a new prescription for a particular user. Figure 3(b) illustrates it in details. *User id* and *User name* is information of user for which practitioner is going to add prescription. *Time duration* tells the amount of time for which user has to perform this activity and *Frequency* expresses how frequent user has to do the upper mentioned activity. *Suggestion* contains the values which are shown to the user in the form of alert message when the exercise activity will be next upcoming activity for the user. *Manage Patients* is just for adding new users/patient with data and prescription.

Information obtained as a result of this monitoring can also be very useful to observe user behavior in detail. The analysis of historical activities of the user which are stored in Followed Schedule e.g., the user is habitual of missing lunch or of taking too much alcohol can help to identify the root cause of some problem or disease. Especially when a patient comes for treatment of a particular disease, analysis of his historical activities can help practitioners to identify the main issue which is the cause of this problem, thus help him in proper treatment of patients.

V. CONCLUSION AND FUTURE WORK

In this paper we proposed a GPS based real time trajectory analysis tool for improvement of health care. This approach significantly enhances a range of mobile healthcare applications. The system developed (i.e. DAM) in this paper explains the way to control the trajectory patterns of a person and assists in bringing betterment in healthcare. It also discovers a new direction for practitioners to monitor their users in better and more accurate ways. For future work we are working on extensive testing of our prototype in real-world situations. Healthcare professionals and domain experts are being concerned in order to develop and understand more real-life scenarios for monitoring patients.

ACKNOWLEDGEMENT

This work was supported by a grant from the NIPA (National IT Industry Promotion Agency) in 2012. (Global IT Talents Program)

REFERENCES

[1]. Yang Yue,Yan Zhuang,Qingquan Li,Qingzhou Ma,o” Mining time-dependent attractive areas and movement patterns from taxi trajectory data”, In: Proceeding of 17th International Conference on Geoinformatics, Fairfax, VA 2009”

[2]. Zhu Feixiang, Navig. Coll., ,” Mining ship spatial trajectory patterns from AIS database for maritime surveillance”,In: Proceeding of 2nd IEEE International Conference on Emergency Management and Management Sciences (ICEMMS), Beijing,China 2011”

[3]. Haghighi, P.D., Zaslavsky, A.,Krishnaswamy, S.,Gaber, M.M., “Mobile Data Mining for Intelligent Healthcare Support”, In: Proceeding of 42nd Hawaii International Conference on System Sciences, Big Island, HI, 2009.

[4]. BRAGA, R. B., MARTIN, H. (2011). CAPTAIN: A Context-Aware system based on Personal TrAckINg”, In: Proceeding of the 17th International Conference on Distributed Multimedia Systems / DMS 2011, Florence, Italy. DMS 2011”,

[5]. D. Konstantas, V. Jones, and R. Bults, “MobiHealth- Innovative 2.5/3G Mobile Services and Applications for Healthcare”, IST Mobile & wireless telecommunications Summit 2002.

[6]. P. Rubel, J. Fayn, G. Nollo, D. Assanelli, B. Li, L. Restier, S. Adami, S. Arod, H. Atoui, M. Ohlsson, L Simon- Chautemps, D. Te´lisson, C. Malossi, G. Ziliani, A. Galassi, L. Edenbrandt, and P. Chevalier, “Toward Personal eHealth in Cardiology: Results from the EPI-MEDICS Telemedicine Project”, Journal of Electrocardiology 2005.

[7]. K. Laerhoven, L. Benny, J. Ng J., S. Thiemjarus, R. King, S. Kwan, H. Gellersen, M. Sloman, O. Wells, P. Needham, N. Peters, A. Darzi, C. Toumazou, G. Yang, "Medical healthcare monitoring with wearable and implantable sensors", In: Proceeding of the International Workshop on Ubiquitous Computing for Pervasive Healthcare Applications UbiHealth 2004

[8]. P. Leijidekkers, and V. Gay, “Personal Heart Monitoring and Rehabilitation System using Smart Phones”, In Proceedings of the International Conference on Mobile Business (ICMB'05), Copenhagen, 2005.

[9]. P. Vajirkar, S. Singh, Y. Lee, “Context-Aware Data Mining Framework for Wireless Medical Application”,Lecture Notes in Computer Science (LNCS), Volume 2736,Springer-Verlag. ISBN 3-540-40806-1, 2003.

[10]. B. Jansen, and R. Deklerek, “Context-Aware Inactivity Recognition for Visual Fall Detection”, In Pervasive Health Conference and Workshops, Innsbruck, Austria , 2006.

[11]. Kim, H., and Jo, H. “A Context-Aware Traveler Healthcare Service (THS) System”, In Pervasive Health Conference and Workshops. November-December, Innsbruck, Austria, 2006.

[12]. M. Becker, E. Werkman, M. Anastasopoulos, and T.Kleinberger, “Approaching Ambient Intelligent Home Care Systems”, In Pervasive Health Conference and Workshops, Innsbruck, Austria , 2006.

[13]. H. Mei, I. Widya, A. Halteren and B. Erfianto, “A Flexible Vital Sign Representation Framework for Mobile Healthcare”, In: First International Conference on Pervasive Computing Technologies for Healthcare, Innsbruck, Austria 2007. 29 Nov - 1 Dec 2006,

[14]. Wertheimer, A., and Santella, T.M. "Medication Compliance Research: Still So Far to Go." “The Journal of Applied Research in Clinical and Experimental Therapeutics”.Cited May 20, 2005.

[15]. Paul Wright, “Mobile century: using GPS mobile phones as traffic sensors" CITRIS - ITS seminar, UC Berkeley, CA, February 8th, 2008.

[16]. Industry and government talks, ”Mobile Sensing for traffic, environmental monitoring and emergency response”. Department of Homeland Security, Moffett Field, CA, February 11, 2010,

[17]. Thomas Mccurdy, Stephen E Graham, “Using human activity data in exposure models: Analysis of discriminating factors”, Journal of Exposure Analysis and Environmental Epidemiology, 2003

[18]. Neil E. Klepeis ,Andy M. TsangJoseph V. Behar , “Analysis of the National Human Activity Pattern Survey(NHAPS) Respondents from a standpoint of exposure assessment”, Sptember 1995,

[19]. Ulf Blanke, Bernt Schiele, “Daily Routine Recognition through Activity Spotting”, “Proceedings of the 4th International Symposium on Location and Context Awareness” LoCA, 2009.

[20]. Dustin D. Johnson, David C. Ganskopp, ”GPS Collar Sampling Frequency: Effects on Measures of Resource Use”, RANGELAND ECOLOGY & MANAGEMENT 61(2) March 2008

[21]. Microsoft Geolife project, GeoLife GPS Trajectories http://research.microsoft.com/en-us/downloads/b16d359d-d164-469e-9fd4-daa38f2b2e13/

[22]. Jane Jack Collins, The Importance of Medication Reminders, http://ezinearticles.com/?The-Importance-of-Medication-Reminders&id=5129852

[23]. Press Release, Text Message Prescription Reminders Significantly Improve Patient Adherence to Oral Diabetes Medication, May 24,2012, http://www.marketwatch.com/story/text-message-prescription-reminders-significantly-improve-patient-adherence-to-oral-diabetes-medication-2012-05-24