Detecting and Sharing Multiple Activity-infused Crystal Presence Information with Social Interaction Tools

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ABSTRACT

Humans are engaging in information exchange related to their activities using a wide range of social interaction tools. There is a need to automate this process of exchanging information as manual updates are time consuming and intrusive. In our research, we aim to solve the problem of detecting and inferring a user's multiple activity infused presence information and then share this with the correct social interaction tool. Humans also inherently multitask in varying time spans and their higher level activities can be formed by different types of lower level activities which can be shared with different social interaction tools accordingly. We propose a system which can infer these multiple activities from wearable sensors as well as other context information, then determine a user's multiple presence information, i.e. crystal presence based on these activities by spatio-temporal analysis and then automatically share the correct presence information with the correct social-interaction tool automatically.

Categories and Subject Descriptors

C.2.4 [**Computer Communication Networks**]: Distributed Systems - Distributed Applications, Network Protocols.

General Terms

Design, Experimentation, Human Factors

Keywords

Activity analysis, presence, social networks, context, prototype, test-bed

1. INTRODUCTION

We are witnessing an ever increasing use of the Internet for social interaction such as social networking sites, blogs, micro-blogs, instant messengers (IM), online photo sharing sites, video sharing sites, citizen journalist sites, etc. We together call them as social-interaction tools (SIT). For the purpose of our research, all the people that a user shares information with using these SITs are further termed as the audience. These are all those people who are in some or the other way interested in the information related to the user. Humans are continuously sharing aspects relating to themselves and their daily life with people using these social interaction tools. These widely range from the activities the user undertakes during the day, the places visited, and the happenings or events in the surrounding environments. This process of sharing such information is an on-going process in time and space. This real-time information exchange and the time and energy spent at sharing this information is the motivation behind our research.

At the same time, the sensor web is also being developed; this includes web portals like Sensor Planet [13], Sense Networks [12] and Pachube [9]. All these aim at uploading sensor data in to the portals and then sharing these streams for further analysis of this data by researchers from everywhere. Location is becoming the most important context parameter, and geo-tagging is on the rise, for example, portals like Locify [7], Latitude [4] and Plazes [10] are being used for location based applications and activities. Alongside this, activity analysis research has shown promise in the field of healthcare [33, 35], industry and workshop settings [25, 26, 31, 34] , defense [24] and sports [32, 8]. An increasing number of sensors are available to detect user's physical and physiological activities as well as their environmental context information.

In this research we aim to automate the process of detecting and sharing user's multiple activity based presence via SITs to eliminate the amount of time people spent in updating this information. We believe that this opens a lot of opportunities for providing services to the user based on their activities in real-time. In order to build this intelligent system which updates presence information we use a variety of context information such as, location (both indoor and outdoor), activity analysis based information collected mostly from on-body sensors as well as from devices and objects used by the user. Thus in this research we investigate how context information can be intelligently fused with user's presence information and further share this presence information appropriately with the user's audience. We present our proposed approach which firstly detects the user's multiple activities using context information collected continuously in real-time. Secondly, determines the user's multiple activity-infused multi-faceted presence information based on the user's activity analysis. Thirdly, this user presence de-

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tected by the proposed system is then shared with people intelligently and seamlessly using multiple SITs. Lastly, this approach to presence determination also leads to the detection of any false updates the user inputs by overriding the system generated presence information. This helps in creating more transparency and prevents the audience of the user from being misled by any user. For the purpose of our research we look at user activity from a real-life perspective where user's multi-task and usually perform more than one activity simultaneously or intermittently. Based on real-life scenarios and the activities of daily living, we state that the user can have multiple presence information at one point in time. In other words, a user's presence information can have multiple facets which are directly linked to their multiple activities.

1.1 Motivating Scenario

Iris is a student at university who lives away from family. From the time she wakes up in the morning, till she sleeps at night, she performs a wide range of activities. She usually makes updates of random activities, thoughts, moods, news/articles which she has read, study or research related documents read or experiments conducted to her social-networking sites, IM presence, micro-blog, and blog. These updates are read by a number of people which include as mentioned earlier, her family members, friends, colleagues, advisors and seniors, students, and the general public depending on where the updates are made and which tool she uses to make a particular update. This is a time consuming job and can also be distracting when you have too much work on hand.

2. SYNOPSIS OF RELATED WORK

2.1 Fusion of Activity and Presence

We furnish here a discussion of academic work related to our research. Existing literature suggests that there is recent growth of interest in the research community to infer a user's presence information from wearable sensor information as well as other user and environmental context.

In [29], the only sensed information is location information, all other aspects of rich presence such as activity, mood, social context are taken as input from the user and saved as the rich presence information relating to that particular location. Based on this location database, the user's presence information is predicted in the future when the same location is detected. This raises the obvious problem that the user does not always have the same presence information at the same location.

Rich presence information is inferred using accelerometer and audio sensor as well as event detector on a mobile phone in [27, 28] but the system does not deal with higher level activity inferencing. The mobile phone based sensing equipment suffers from limitations inherent with mobile phones such as battery, API and operational limitations. The performance analysis of the classifiers shows that the conversation classification used to detect social context reports conversation even if there is background noise and thus suffers from high rate of false positives. The activities inferred are mostly lower level activities.

In PEIR [17, 16] and MetroSense Project [21], researchers try and leverage the vast number of mobile phones present everywhere as a means to sense information which can be used for the community. Though, this can have a largely positive impact on applications based on vast sensory information from vast number of people and their environment, it does not consider the fusion of presence and activity. The data is simply collected from user mobile phones and then processed at a centralized location and the results are shared with all the users of the system. Such an opportunistic sensor network requires setting up of large scale infrastructure. The system is used specifically for skiers and bikers. The system is not meant for inferencing a large variety of higher level activities.

The MSP [19] is a system mostly used in encouraging physical fitness as well as green transportation habits. A variety of sensor information is used to infer activities in semi-supervised conditions. It is an advanced customized activity inference platform which addresses the challenge of scalability in activity inferencing. The authors in this research have not considered some of the other challenges such as multiple activity inferencing and only infer basic low level activities. In [22], the geo-tagging of micro-blogs generated by the user and then the utilization of these micro-blogs by other users in relation to specific location based queries is a novel concept. The authors feel the need to leverage on an existing social network for faster adoption and broader evaluation of the system. We believe this study validates the need for an automatic status update system based on activity analysis which can be used when users are busy in work and do not find time to make manual updates. A major concern is to identify a misbehaving user who misleads people with false information. Though the size of the study conducted by the authors is small and they confirm that it is not conclusive, we feel it throws light on some of the areas relating to our research.

R-U-In? [18] is of interest here because activity updates are manually made to the various social-networking sites as well as IMs that the user uses. Though, the concept of forming real-time activity groups is novel, but the system does not provide users with the capability of automatic updates of activities for forming these groups. The system does not consider any sensor or context information to determine current or future activities.

3. AIM

3.1 Objectives

This research aims to investigate the fusion of user's activities with his/her presence within SITs. In doing so, we will merge the fields of activity analysis and presence. In our research we focus on using information about a user's activities at higher granularities and share it in the form of multi-faceted presence information using the different SITs in real time. We highlight three main objectives of our research below:

1. We propose to redefine presence in the new context of social networking and devise a way to share user's multi-faceted presence across multiple social networking tools;

2. In this research, we propose to build a system which detects a user's multiple (overlapping and parallel) activities at one point in time using sensor information as well as other user and environmental context information; and

3. Our research will also further focus at validating the correctness of a user's manual presence update based on the automatic updates.

3.2 Research Challenges

The following research challenges are identified as the focus of our research project. Firstly, the definition and structure of presence information as it exists in the current domain of IMs needs further improvement to include social networking, blogging, micro-blogging sites and the status updates made in these sites. Presence information also needs to consider that the proposed presence aggregation and federation of presence [1, 23, 11] may not lead to the desired presence status of the user in different social-networks and IMs. We also argue that every user has multiple presence information at any point in time. Secondly, since the user's can make manual updates to all these social interaction tools at all times of the day, the user's can deliberately or inadvertently mislead their friends, family and colleagues by making false updates by choice or inadvertently. In social networks such updates can be a problem, for example, when a user states that they are in an official meeting located in a particular location, but in reality the user's are not attending their work and might be at another location trying to mislead colleagues. Thirdly, we state that there are no systems in place which can be used by users in their daily lives to infer their multiple, overlapping or interleaved activities at higher levels of granularity, i.e., those types of activities which the user usually shares with people around them using various social interaction tools [19, 30, 20].

3.3 Research Questions

Motivated by our objective to develop a real-time activity infused presence inference and dissemination system for people in different environments and bearing in mind the requirements stated above, our research questions are formulated here. How can wearable sensors and other context be used to detect activities of the type which the users like to share using different SITs? How can we fuse activity and presence to help a user communicate efficiently and effectively with people? How can we recognize multiple activities of a user at a point in time and thereby gaining insight towards the fusion of these multiple activities with the multiple facets of a user's presence. Finally, how do we determine across which social tool this can be shared and can we validate the user's manual presence update using our activity-infused presence determination system?

4. GENERAL APPROACH

4.1 Proposed Methodology

4.1.1 Crystal Presence

In this section, we present the following definitions and terminology related to our proposed research approach.

Definition 1: Crystal Presence (CrysP) - *is defined as the activity-infused, multi-faceted presence information of a person shared with the relevant audience*, i.e. CrysP (at time t) $= \{P_1, P_2, ..., P_N\}$ which is inferred from the multiple activities set MA $= \{A_1, A_2, ..., A_N\}$.

Definition 2: Audience - *is defined as the user's contacts on multiple social-networking sites such as his/her family, friends and colleagues, as well as those who read the user's blogs and follow him/her on micro-blogging sites such as twitter and contacts on IMs are all together termed as the user's audience*, i.e., Audience $= \{Au_1, Au_2, ..., Au_N\}$.

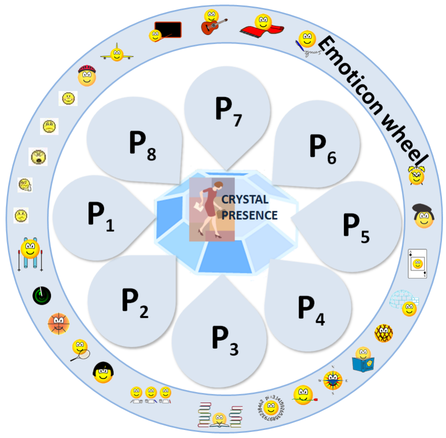

Figure 1: Crystal Presence (CrysP).

CrysP[1] is derived from the user's activity, availability, moods, and thoughts. Figure 1 shows a user's CrysP. A user's CrysP is the multi-faceted presence information which is determined using user and environmental context information and user audience consists of everyone who is interested in this real-time information related to the user. A user's CrysP can be of many types at different points in time, for example based on personal activity information such as "Cooking Pasta" and "Reading a Novel". Similarly, this can be based on professional activity information such as "Working on research project" and "Writing thesis". In figure 1, we assign P_1="Cooking pasta", P_2="Reading references", P_3="Baking cake", P_4="Watching news", P_5="Writing code", P_6="Listening to Pink Floyd", P_7="Uploading images to Flickr", P_8="Out for a jog", P_9="Traveling in tram" and P_{10}="Eating food".

At one point in time, the user's CrysP can now be a combination of these different types of activities (every facet of the crystal depicts a different activity within some time duration); for example, CrysP $= \{P_1 \wedge P_2\}$, CrysP $= \{P_3 \wedge P_4\}$ and CrysP $= \{P5 \wedge P_6 \wedge P_7\}$. These activities can overlap with one another. For example, we can start cooking pasta at time, t_1=1min, and at time, t_2=5min we can be reading a reference paper, then resume to cooking pasta at time t_3=10min, at time t_4=12min we resume reading the reference paper while the pasta cooks on till time t_4=20min. Thus, from time t_1=1min to time t_4=20min, we were involved with two activities which were not related to each other, but overlapped each other in time slots. So, CrysP for the user will be "Cooking Pasta" and "Reading References". Also, it is important to note that CrysP cannot be formed by some activities together for example P_9 and P_8 or P_8 and P_3 cannot occur at the same time.

A wide-array of SITs is available to the user to share his/her multi-faceted presence information (CrysP) with the audience. Some of these tools can be put into broad categories like, social networks, corporate social networks, social bookmarking sites, interest networks, blogs, micro-blogs, video-

[1]When the term CrysP is used alone by itself, it always implies as CrysP (Crystal Presence) information

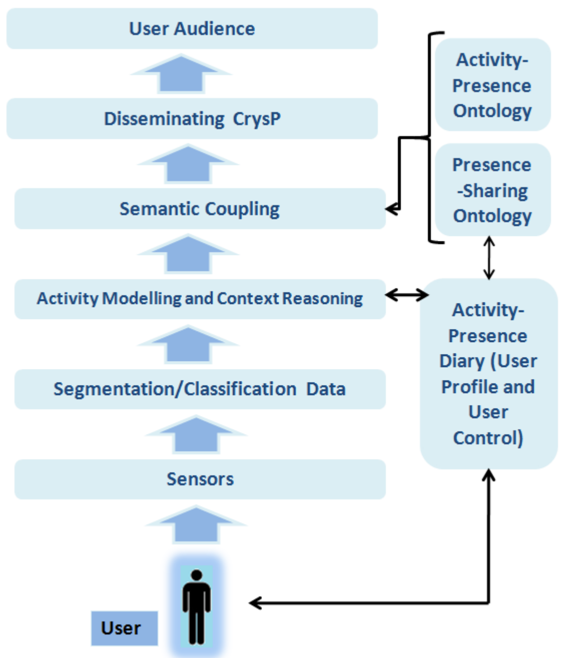

Figure 2: Our approach for CrysP.

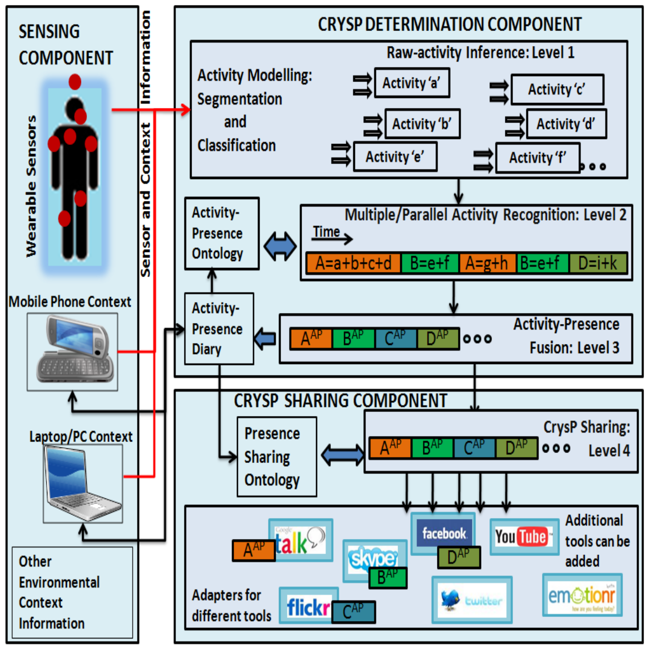

Figure 3: Preliminary architecture of CrysP System.

blogs, photo-blogs, voice-blogs, email and instant messengers. The user shares certain types of information on each of these networks depending on what type of network it is, what type of relationships he/she shares with people on that network along with what type of information related to the user are people in that network interested to see.

Therefore, our proposed CrysP System (CrysPSys) can be seen as having a number of benefits and thus, also highlights the reason for bringing together activity and presence. It helps to reduce the amount of time people usually spend in making status updates. Also, many people who are unable to update their status information as often as they would like are able to do so via CrysPSys. A user can send different updates to different social-networking sites sharing only that information which is of interest to a particular set of people. The previous point helps in privacy concerns of the user as well. This provides an interesting means of passively communicating what you want to with whom you want to in real-time. It also opens a lot of opportunities for providing value-added services to the user based on their activities in real-time and such updates can also help in increasing the revenue of telecom companies, when the updates are made from mobile devices.

Figure 2 shows our approach for determining and sharing CrysP. Sensors placed on the user and surrounding environment are used to collect activity data. This is followed by segmentation and classification of this data on top of which activity modeling and context reasoning are applied. The user is provided with an activity-presence diary which contains the profile information and provides the user with control over the CrysP information. Two ontologies Activity-Presence Ontology (APO) and Presence-Sharing Ontology (PSO) are used to infer activity at higher granularities and to share them correctly with the SITs. The CrysP information then reaches the correct user audiences on SITs.

The preliminary CrysP architecture contains three components as shown in figure 3, the sensing component, the CrysP determination component and the CrysP sharing component. The next section gives details about current implementation of the test-bed and prototype for CrysPSys.

4.2 Evaluation Method

4.2.1 Preliminary Test-bed and Prototype Implementation

We have built a test-bed, as shown in figure 4, comprising of several sensors such as accelerometer (body motion), indoor and outdoor positioning systems (location), temperature sensor, RFID tags and reader (object interaction) and other sophisticated software based context collection threads (user's activity on devices such as laptop and mobile phone). We place a Mulle v3 sensor [2] (which has on it an accelerometer and a temperature sensor) on the user's waist to gather information about user body motion. Based on previous research in body motion detection using accelerometer, we chose the waist of the user as the most appropriate position for mulle placement[19]. The Mulle sends data at 15Hz which is collected on our laptop where we use Java based Weka API to process the acceleration data. We use J48 decision tree which is an extension of C4.5 to infer three body motion related low-level activities such as sitting, standing, and walking. We achieved an accuracy of 92.56%[2].

An RFID reader is attached to the user's wrist which detects RFID tagged objects such as coffee mug, lunch box, etc. The RFID reader scans for tags once every second. Each tag is labeled in terms of an activity, and the RFID readings are inferred as activities using varying time windows for different activities. This eliminates the problem of reading a tag when the object is not intentionally been touched. Multiple readings of an object over time are in-

[2]This was achieved by using a single user.

ferred as an intentional activity. The user's activity on the laptop and the mobile phone are inferred using both Java and .Net based plug-ins. A .Net based hook is used to infer the user's interaction with an application running on the device by logging mouse clicks which log current activity on the laptop such as the current application (adobe reader, word document, power point presentation, eclipse, etc). A URL logging tool Slogger is used to log URLs visited by the user in a text file and are retrieved every second to monitor user's browsing activity such as email, online news, Google search, Google scholar search, library website, airline booking site, Flickr photos, etc.

Location information is collected using three methods, GPS (outdoor), Wi-fi positioning (Ekahau WLAN positioning is deployed on university campus office of the user), and RFID based location (at home). We use the inbuilt AGPS on an android development phone (ADP1) to gather the location, speed and temperature. The RFID smart home helps in locating the user at home using multiple fixed tags. We have built a web-based GUI as shown in figure 4 to view the user's CrysP information along with the sensor/context streams. In order to share CrysP we infer activities of the user with varying time windows. The user's current location and activity can be viewed in the pop-up on a map. Also, the user's movement patterns and activities at different locations and time can be viewed by clicking anywhere on the user's path. We are further building the web-interface to make it more interactive as well as to get user feedback. We are working towards running longer experiments on a variety of users to gather different types of information. We are also building the adapters on the mobile phone to infer activity and send updates to the correct social-network/blog directly from the mobile phone.

It is also important to note that these activity updates could be shared with devices and services that the user uses in different locations and at different times in the day. Currently we share these updates only in the social networking domain. Adapters for sharing CrysP were written for a number of social-networking tools like LinkedIn [6] (using OpenSocial Java API) and Facebook [3] (using Facebook Java API); micro-blog like Twitter [15] (using Twitter Java API, twitter4j); IM like Skype [14] (using skype_win32.jar API) and GTalk [5] (using smack.jar API). We send CrysP updates to each of these tools depending on the preliminary presence sharing ontology (PSO). The PSO is written to classify the various tools and various categories of CrysP information along with the relationships between them and the user. We have only assumed five categories, personal, very personal, work, private work and public at present. We send personal updates to Facebook, very personal updates to GTalk, private work updates to Skype, public work updates to LinkedIn and public updates to Twitter. We use the Jena API to interact with the two ontologies and they are written in OWL 1.0 and RDF.

4.2.2 Discussion (Problems faced and experiences)

CrysP System (CrysPSys) is currently tested in a scenario limited to a student's life. We used a specific set of sensors to infer our activities; there is a need to build the system further so that more different types of sensing technology can be incorporated into the same test-bed. There is also a requirement that labeling of activities and creating the relationships between higher and lower level activities can be easily done with limited user interaction. The higher level activity models should be built using these relationships. In our test-bed we currently inferred activities using a small laptop (Asus Eee-PC) but we intend to use the mobile phone for inference and sharing of higher level activities, though this would significantly affect the battery life of the mobile phone. The system needs to be further evaluated on multiple sets of users on longer periods of time. Further evaluation on reducing user interaction is also important to the success of such a system.

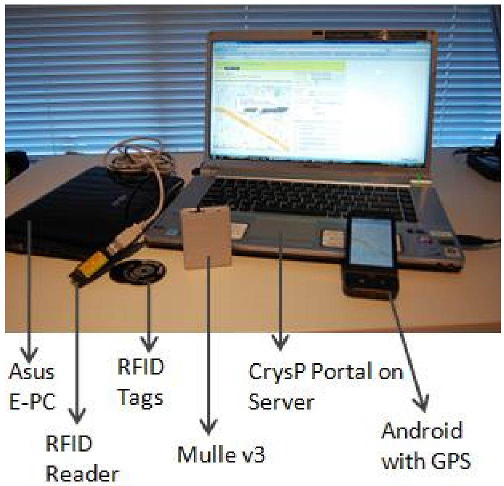

Figure 4: CrysP test-bed and web portal.

5. CONCLUSION

This paper presents an outline of the doctoral research in the field of activity analysis, context-awareness and presence. A synopsis of the related work is presented along with the objectives of our research to better understand the problem domain. We further highlight the key research challenges and questions which are the focus of this doctoral research. The goal of this research is to detect user's multiple activities and fuse them with their presence. This presence needs to be shared with the right social interaction tools. Such a system if implemented can also help in validating the correctness of a user's manual update. A preliminary architecture and test-bed is built and is also presented.

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