Towards Detecting Social Situations with Bluetooth

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Abstract

Social context is an important but fuzzy concept in the research on ubiquitous computing. This paper seeks to substantiate the notion of the social situation *by an exploratory analysis of interpersonal proximity data collected by Bluetooth device inquiries.*

1 Introduction

Context awareness in general is recognized as an important factor for the success of ubiquitous computing applications and devices. The relevance of social context in particular was also noted, including the identities and roles of nearby persons (e.g. co-worker or manager) as well as the social situation [1]. Several works picked up the concept of sensing identities and used this information to annotate meeting recordings [2] or to facilitate information exchange [3].
However, less is known about the recognition of the broader social situation. This paper undertakes an initial exploration in the detection of such situations by examining a visit to a computer conference. The focus is on social contexts that do not presume knowledge about the identities and roles of individuals.
With a robust classification of social contexts, an application would be able to detect meaningful episodes for a user while moving in different social circles and circumstances. Knowledge about these episodes could in turn be used to automatically adapt input and output modalities of a device (e.g. silent mode for mobile phones), or to group events and recordings according to episodes.

To characterize the broad social situation of a person, it is not necessary to recognize the particular identities of persons in the proximity. Instead it is interesting, e.g. if the person is with the others, or just passing them by, and if they are encountered regularly or not. Key to the proposed analysis is the distinction of familiar and unfamiliar persons. For this first step, a broad categorization is carried out where persons regularly in the proximity are classified as familiar. In the context of a city, such persons are called familiar strangers [4]. Paulos and Goodman presented a concept to recognize these persons with a device [5].

2 Experiment

An experiment was carried out to gather real-world data for an exploratory analysis. A Nokia 6630 mobile phone was programmed to perform periodic Bluetooth device inquiries every 30 seconds. Since a notable amount of peoples' phones is configured to answer these inquiries, it is possible to detect other phones and thus the related owners in a proximity of approximately ten meters. The same method was already used to measure the social network of students and staff on a university campus [6]. The data was recorded in the phone memory and later transferred to a computer for analysis. The Ubicomp conference 2005 in Tokyo together with the workshop "Metapolis and Urban Life" was selected as a social event for the experiment for its varied program schedule, and because it was expected that a large proportion of the conference attendees had a detectable Bluetooth device with them. One of the attendants was carrying a prepared device during the entire time of the conference to collect the data. Additionally, he took photographs with the same device to document his activities.

3 Data Analysis

Each device inquiry returns a set of unique device identifiers and additional information about the class of the devices. This data was recorded along with timestamps. The device class was used to filter out non-personal devices, like laptops and network equipment. In the next step, a set of quantitative features was extracted from the sets of device identifiers by a sliding time window of five minutes.
The features are independent of the percentage of people that can be identified by the device inquiries. Otherwise a comparison would be difficult, because the amount might change from situation to situation, with the particular mentalities of the people, cultural differences, and the general Bluetooth penetration in a country among others.
Let F_t be the set of all detected familiar persons in the time interval $[t, t+1[$, and S_t the set of strangers respectively. Persons are classified as familiar if they were met more than five times. Meetings are separated by periods of at least five minutes of absence. The parameters were chosen by determining the knee point in the histogram of meeting counts. The number of arriving familiar devices is $f_t^+ = |F_t| - |F_t \cap F_{t-1}|$ and $f_t^- = |F_{t-1}| - |F_t \cap F_{t-1}|$

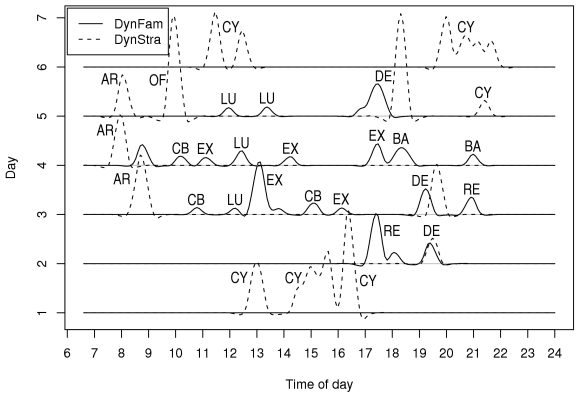

Figure 1: Feature data of six days in Tokyo (smoothed by splines). Day 1 and 2: workshop; day 3, 4, 5: conference; day 6: day off. The peaks indicate social events or situations the test subject attended. CY: moving through the city, RE: conference reception, DE: departure from conference, AR: arrival at conference, CB: coffee break, LU: lunch, EX: exhibition (posters and demos), BA: banquet, OF: off the conference.

is the number of leaving familiar devices. s_t^+ and s_t^- are defined correspondingly. The analyzed features indicate the dynamic in the group of familiars and strangers. They show how much an individual moves in accordance with the surrounding people:

1. $DynFam(t) = \frac{(f_t^+ + f_t^-) - ||F_t| - |F_{t-1}||}{|F_t|}$
2. $DynStra(t) = \frac{(s_t^+ + s_t^-) - ||S_t| - |S_{t-1}||}{|S_t|}$

4 Results and Discussion

There were approximately 650 registered conference visitors. 69 devices were classified as familiar and a total of 290 as strangers for the whole data set including conference and city encounters.

The peaks in figure 1 show the different social activities the test subject was engaged in. The conference activity shows up clearly in the data. Arrival is indicated by a peak in DynStra that is triggered during the movement through the crowded city. Coffee breaks, lunch and visits to the exhibition are indicated by peaks in DynFam. The workshop during day one and two is not detected, since the group behavior was rather homogeneous and did not exhibit the measured dynamic. The city exploration as part of the workshop on the other hand is clearly indicated. The arrival to the workshop did not require movement through crowds.

The peaks vary in width and height. The height relates to the frequency of the changing of people in the surrounding and the width to the duration of the changing. With the knowledge of the general context—the conference visit in this case—it is possible to assign meanings to the individual peaks.

There were a couple of problems encountered with this experiment. First, Bluetooth is generally unpopular in Japan. Anyhow, most times there was enough reception in the city for this analysis. Only the movement in the night was not detected, although there were strangers on the streets. Inaccuracies in Bluetooth device inquiry were also discovered, but seem to have no significant negative effect (compare to results of [6]).

The processing of the features was carried out in two passes. In the first pass, the familiarity of devices was determined. The features *DynFam* and *DynStra* were calculated in the second pass. Thus, effects of the process of getting familiar are not addressed here and the analysis has to be adapted, if the features should be determined during the measurement.

5 Conclusion and Future Work

The analysis suggests, that the presented features are suited to indicate situations with a high dynamic in the movement of surrounding people on the basis of data collected by Bluetooth device inquiries.

The conference was a well suited setting, since there was contact with a lot of different persons. Social relations are not very differentiated in this situation, since most persons are strangers at the beginning. The familiarity classifier indicates mainly, if someone is a regular conference attendee or not. In daily routine, a detailed discrimination of social roles, like family, friends and working colleagues would help to identify meaningful situations and episodes. As an alternative to the personal inquiry device, stationary devices could be used to measure the quality of a conference, e.g. to measure if sessions start on time, how popular individual sessions are, or how masses of people move through the conference space.

To further study this topic, it is necessary to determine the significance of these findings by comparing them to other persons, places, and scenarios. More features need to be developed and tested to account for other situations. Further, this method could be used in combination with location recognition technologies. Correlation with a calendar could also yield interesting results. A learning algorithm could determine the usual daily routine of a person and automatically detect meaningful deviations.

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