A Framework for Group Identification using Smartphone and Wearables

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Biographical Sketch
I am currently pursuing PhD from Department of Computer Science and Engineering, Indian Institute of Technology Kharagpur, India. I received M.S.(by Research) from School of Information Technology, Indian Institute of Technology Kharagpur, India, in 2015. I have joined the current course in July 2016. I expect to complete my degree in the next two years. My current research interests include mobile systems and ubiquitous computing.

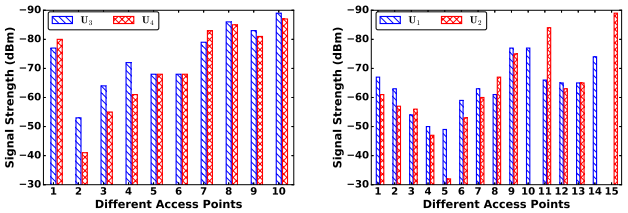
Objectives for Attending the Broadening Participation Workshop
Ubicomp is one of the premium conference (now Journal) which is exactly aligned with my research interest. Broadening participation workshop is hosted by that premium conference. Therefore, there are many objectives for attending such a workshop. Firstly, this is the place where we can reach several renowned researchers. Being an early stage of my research career, it will be really important for me if I can communicate with those people. I expect that such communication leads to the future collaborations. Secondly, I can meet a group of early career researchers as well and discuss our nascent ideas. Thirdly, as the wearable device community is participating, I get to know the

recent advancement of the devices. Furthermore, I can use any of them in my research as well. Finally, I can showcase my early finding to the ubiquitous research community.

Research Plan

Abstract: Human beings are social by nature and like to form the group with the similar minded people. Therefore, for understanding the behaviour of an individual, besides the information of the individual, we need to look at the interaction of the individual in physical world groups. Likewise, the workers form various formal and informal groups in the organization for mutual interactions. For monitoring context as well as behaviours of the workers, identification of such groups and understanding their dynamics are essential. Moreover, this information is used for analysing the organizational efficiency. In an institutional environment, the knowledge of the student group formation helps the instructor to the analyse the performance of the students. On the other side, the proper selection of groups leads to the improvement of the students. Understanding the group dynamics in sports is also important. The proper interpretation of the group dynamics reveals the strategy of the team. Hence, for the future sports event, it is useful to the opponent team.

Challenges: Study of the group detection along with its dynamics is challenging in many aspects. First of all, group members are not always previously known to each other. Moreover, the participants of the group may not follow any prior history or pattern. Hence any supervised learning framework will be unsuitable to solve this problem. Secondly, in an organization, it is more likely that the subjects carry smartphone devices of different make and model. Due to the different sensitivity of the sensors across models, differences in receiver gain and calibration offsets, a significant amount of error may get introduced. Thirdly,



(a) WiFi Signal Similarity: U_3 and U_4 in G_3

(b) WiFi Signal Dissimilarity: U_1 in G_1 and U_2 in G_2

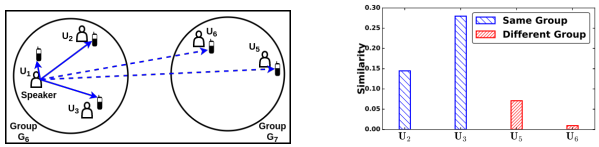
Figure 1: Deviation of WiFi signals in various groups

the participants may co-locate in the noisy indoor/outdoor environment. Fourthly, the group detection problem conceptualises as the localization problem. However, retrieving highly precise location information and identifying the group is challenging. Finally, one group may transit to another group. Identification of such group transitions is also a difficult task. Looking at the current challenges, we now discuss our current and future works in the next section.

Completed Work: Passively Encountering Group Detection In day-to-day life, every human being encounters several individuals while travelling on public transport, waiting at the bus stop, moving at shopping mall etc. Although these groups of individuals spend a quantitative time together at the same place, they hardly interact among themselves. We categorize this meeting as the *passively encountering group (PEG)*[1]. Precisely, this indicates the group of strangers who share proximity for a significant time. Detection and analysis of such groups are essential for providing services like targeted advertisements, supply chain management, information broadcasting and so on.

GPS is an important modality for localization and detecting

[1] This work is accepted in Globecom 2018.



(a) Two groups - with and without speaker

(b) Single Speaker Multiple Groups: Similarity with U_1

Figure 2: Impact of Acoustic Context in various groups

population within proximity. Although GPS performs well in outdoor environments, its accuracy sharply falls in indoor environments. Besides this, the current literature highlights the discoverability issues of Bluetooth in the community used devices. Hence, we select the WiFi [2] as proximity indicator. Our primal intuition is that the users in proximity share the similar set of WiFi access points (APs) and also the signal strength of those APs are similar. A sample outcome of same group and different groups, demonstrating this fact, are shown in Figure 1. However, the signal strengths are highly impacted on device heterogeneity and user mobility. Considering these facts, we define the pairwise proximity feature using the overlapping WiFi APs (Jaccard similarity) and WiFi Signal Strength (receiver gain factor). Finally, we apply the random walk based community detection algorithm âĂŞ Walktrap on the pairwise proximity for measuring the similarity between the subjects to infer the *PEG*. We evaluate the performance of the proposed *PEG* framework by developing a smartphone-based application and deploying it over IIT Kharagpur campus which is WiFi covered. The study over 25 subjects for six months reveals that the proposed model can detect passively encountering groups with more than 90% accuracy, even with heterogeneous devices under various real-life scenarios.

Continuing and Future Work: Meeting Group and Group Role Identification Team building and meeting among the individuals are key factors behind organizational efficiency. In organizations, people formally as well as sporadically meet, interact and form groups for various purposes, which include information sharing, socializing and learning etc. Tracking the dynamics of group formation facilitates various utilities; for instance, organizational leaders may prefer to monitor the formation of teams, which benefit the overall efficiency and activeness of the organization. Identification of the group primarily relies on the location proximity which we have discussed in the *PEG* framework. However, in the meeting group, co-located group members occasionally (or frequently) interact with each other. Hence, we explore on additional modality and find that audio-based acoustic context, extracted from the audio signals [1] received by individual smartphones, plays a key context indicator.

We have started with exploring the physical audio based feature for computing the pairwise acoustic context similarity. However, we observe that due to the device heterogeneity and environmental noise, those features are not adequate. Therefore, we move to the perceptual audio feature – *tone* (measured using cepstrum) based correlation similarity. Figure 2 shows the impact of the feature on intra as well as inter group members. Based on the pairwise proximity and acoustic context, we further explore the community detection algorithm for detecting the meeting group. In future, we further plan to emphasize the group role and type detection using the lightweight framework. We would analyze the role of the participants in the group. Specifically, we plan to identify the active and passive participants in the group. From the definition of the meeting group, it is known that at least one participant in the group should interact. The interaction signal is captured using microphones present in smartphones. As the participants may closely co-locate, the individuals' device may not capture only their

voices. Therefore, for tracking individuals' voices, we need the fixed infrastructure based unidirectional microphone, which is unrealistic in meeting group scenarios. Hence, we plan to explore different inertial sensors for identifying the active participants.

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