Contact Patterns, Group Interaction and Dynamics on Socio-Behavioral Multiplex Networks

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Abstract

The analysis of social interaction networks is essential for understanding and modeling network structures as well as the behavior of the involved actors. This paper summarizes an analysis at large scale using (sensor) data collected by RFID tags complemented by self-report data obtained using surveys. We focus on the social network of a students' freshman week, and investigate research questions concerning group behavior and structure, gender homophily, and interrelations of sensor-based (RFID) and self-report social networks. Such analyses are a first step for enhancing interactions and enabling proactive guidance.

1. Introduction

The analysis of group interaction and dynamics is an important task for providing insights into human behavior. Based on the social distributional hypothesis (Mitzlaff et al., 2014) stating that users with similar interaction characteristics tend to be semantically related, we investigate such interaction networks, and analyze the respective relations. Social media and mobile devices allow the collection of interaction data at large scale, e. g., Bluetooth-enabled mobile phone data (Atzmueller & Hilgenberg, 2013), or Radio Frequency Identification (RFID) devices (Barrat et al., 2008). However, the combination of both sources is used rather seldomly so far.

This paper summarizes an analysis of social interactions on networks of face-to-face proximity complemented by self-report data in the context of that students' freshman week presented in (Atzmueller et al., 2016b). This freshman week, the first week of freshman students at a psychology degree program, is organized as a special course (five days) before the regular courses start. We collected two types of network data: Person-to-person interaction using self-report questionnaires and active RFID (radio frequency identification) tags with proximity sensing, cf. (Barrat et al., 2008). We focus on structural and dynamic behavioral aspects as well as on properties of the participants, i. e., gender homophily. Furthermore, we investigate the relation of social interaction networks of face-to-face proximity and networks based on self-reports, extending the analysis in (Thiele et al., 2014).

Summarizing our results, we show that there are distinctive structural and behavioral patterns in the face-to-face proximity network corresponding to the activities of the freshman week. Specifically, we analyze the evolution of contacts, as well as the individual connectivity according to the phases of the event. Furthermore, we show the influence of gender homophily on the face-to-face proximity activity.

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2. Related Work

The SocioPatterns collaboration developed an infrastructure that detects close-range and face-to-face proximity (1-1.5 meters) of individuals wearing proximity tags with a temporal resolution of 20 seconds (Cattuto et al., 2010). In contrast to, e. g., bluetooth-based methods that allow the analysis based on co-location data (Atzmueller & Hilgenberg, 2013), here face-to-face proximity can be observed with a probability of over 99% using the interval of 20 seconds for a minimal contact duration. This infrastructure has been deployed in various environments for studying the dynamics of human contacts, e. g., conferences (Cattuto et al., 2010; Atzmueller et al., 2012; Macek et al., 2012), workplaces (Atzmueller et al., 2014a), or schools (Mastrandrea et al., 2015).

The analysis of interaction and groups, and their evolution, respectively, are prominent topics in social sciences, e. g., (Turner, 1981; Atzmueller et al., 2014b). The temporal evolution of contact networks and induced communities is analyzed, for example, in (Barrat & Cattuto, 2013; Kibanov et al., 2014). Also, the evolution of social groups has been investigated in a community-based analysis (Palla et al., 2007) using bibliographic and call-detail records. Furthermore, the analysis of link relations and their prediction is investigated in, e. g., (Liben-Nowell & Kleinberg, 2003; Christoph Scholz and Martin Atzmueller and Alain Barrat and Ciro Cattuto and Gerd Stumme, 2013). Overall, social interaction networks in online and offline contexts, important features, as well as methods for analysis are summarized in (Atzmueller, 2014).

In contrast to the approaches above, this paper focuses on networks of face-to-face proximity (F2F) at a students' freshman week, combining RFID-based networks of a newly composed group with networks obtained by self-reports (SRN). To the best of the authors' knowledge, this is the first time that such an analysis has been performed using real-world networks of face-to-face proximity of a newly composed group together with the corresponding questionnaire data.

3. Dataset

The dataset contains data from 77 students (60 females and 17 males) attending the freshman week. We asked each student to wear an active RFID tag while they were staying at the facility. The RFID deployment at the freshman week utilized a variant of the MyGroup (Atzmueller et al., 2014a) system for data collection. Participants volunteered to wear active RFID proximity tags, which can sense and log the close-range face-to-face proximity of individuals wearing them.

4. Results and Future Work

We analyze data of a students' freshman week and show that there are distinctive structural patterns in the F2F data corresponding to the activities of the freshman week. This concerns both the static structure as well as its dynamic evolution of contacts and the individual connectivity in the network according to the individual phases of the event. Furthermore, we show the effects of gender homophily on the contact activity. Finally, our results also indicate existing structural associations between the face-to-face proximity network and various self-report networks. In the context of introductory courses, this points out the importance of stronger ties (long conversations) between the students at the very beginning of their studies for fostering an easier start, better cooperativeness and support between the students. Our results especially show the positive effect of the freshman week for supporting the connectivity between students; the analysis also indicates the benefit of such a course of five days with respect to the interaction and contact patterns in contrast to shorter introductory courses. Such insights into contact patterns and their dynamics enable design and modeling decision support for organizing such events and for enhancing interaction of its participants, e. g., considering group organization, recommendations, notifications, and proactive guidance.

For future work, we aim to analyze structure and semantics (Mitzlaff et al., 2011; Mitzlaff et al., 2014) further, e. g., in order to investigate, if different network data can be predicted, e. g., (Scholz et al., 2012; Christoph Scholz and Martin Atzmueller and Alain Barrat and Ciro Cattuto and Gerd Stumme, 2013). For that, also multiplex networks, e. g., based on co-location proximity information (Scholz et al., 2011) can be applied. Here, subgroup discovery and exceptional model mining, e. g., (Leman et al., 2008; Atzmueller, 2015) provide interesting approaches, especially when combining compositional and structural analysis, i. e., on attributed graphs (Atzmueller et al., 2016a; Atzmueller, 2016). Furthermore, we aim to integrate our results into smart approaches, e. g., as enabled by augmenting the Ubicon platform (Atzmueller et al., 2014a) also including explanation-aware methods (Atzmueller & Roth-Berghofer, 2010). Potential goals include enhancing interactions at such events, as well as to support the organization of such events concerning group composition, and the setup of activities both at the micro- and macro-level. Developing suitable recommendation, notification, and proactive guidance systems that are triggered according to the events structure and dynamics are further directions for future work.

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