Research Statement

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Overview

My research interests can be summarized broadly as the "fusion of online and offline worlds for human behavior sense-making". In particular, I'm interested in ascertaining insights on physical phenomena such as urban events (e.g. from aggregated indoor mobility trajectories, commute patterns, call patterns, etc. from individuals) and in explaining such observations in the physical world through the fusion with non-physical sources (e.g. multimodal information from social media platforms). In doing so, several key challenges require to be addressed, including, but not limited to, (1) heterogeneity in multimodal networks, (2) dynamic, multi-timescale relationships, and (3) real-time multimodal analytics **[Misra:2014]**.

Cross-linking such online and offline worlds pave the way for richer modeling of human behavior. Real-world applications that use such models fall under varied areas such as *urban analytics, transportation planning, surveillance and peace-keeping, and recommendation systems*. The significance of the problem in the real-world can be better understood through the use of examples. The first example is taken from the surveillance scenario. With systems such as indoor localization in place it is possible to detect gathering of people at a particular location; an example of a scenario in the physical world. Although it may not be possible to collect tweets or posts from the same people, it is indeed a possibility to collect tweets or posts pertaining to that particular location, possibly from a different set of people gathered at the same location. By mining such textual data, one could infer the ambience surrounding that particular location. The combination of 1) the physical world cue that there is a large number of people gathering at a particular location, and 2) the online world cue that the particular location is exhibiting unusual amount of, say, negative or provocative sentiments can be useful in anomaly detection systems. A wide range of possibilities are open in the consumer retail industry. Recommender systems are examples where individuals can be provided with suggestions about places to go next to or activities to do next based on the individual's historic as well as dynamic physical and online footprints. Such recommender systems are also useful in city planning: in planning traffic and congestion avoidance, resource allocation and optimization, etc.

Research Topics

Within this broader theme, my current and planned research can be summarized under the following themes.

1) Understanding Physical Group Behavior

One key aspect of human behavior understanding relies in our understanding of how people act/react in the presence of social groups (e.g., friends, families, etc.) as humans spend a significant portion of their daily lives with others. This line of work focuses on discerning the differences in

the behavior of individuals, when they are alone vs. when they amongst groups. In particular, I focus on three aspects of behavior: (1) people's mobility patterns (stay times at places and next place transitions) for over 6000 students on SMU campus, (2) level of interruptability (responsiveness to calls/SMSs), and (3) app usage. The analyses revealed interesting findings that can ultimately impact design decisions of smartphone based systems and applications. For example, the individuals in larger groups tend to dwell at places for longer amounts of time, but they are also less likely to move together from place to place, when compared to individuals who are alone or are in small groups. These differences are also likely to be influenced by the semantics of the location. Information such as this is useful in applications such as context-based advertising (if the advertiser estimates that the best time to send a targeted promotion is when a person is about to transit to a particular store) and resource planning **[Jayarajah:2015a]**.

2) Urban Event Analytics

Previous work in detecting transient events at physical spaces, based on people's mobility patterns have all focused on detecting anomalous changes in the volumes of people visiting certain places. However, the volume alone can only detect high intensity events that cause drastic changes to the visitation patterns. Based on the observation that people are likely to attend events as groups (with friends/family/co-workers, etc.) as opposed to going somewhere alone, two additional classes of features for uncovering both high and low intensity events can be useful: (1) group-based features, which account for the number of people a person is currently with, and (2) social interaction based features, which takes into account the strength of relationship between any two persons based on their history of mobility. By quantifying the strength of relationship between pairs of users based on physical mobility properties such as spatial and temporal precision, spatial and temporal uniqueness, frequency and durability, at campus-scale (e.g., indoor mobility data of hundreds of students) and at city-scale (e.g., mobility data of millions of public commuters), the feasibility of detecting high and low intensity events is explored **[Jayarajah:2015b]**.

3) Multimodal Sensing for Event Understanding

Social media content (e.g., Twitter posts, Instagram pictures and Foursquare check-ins) provide significant clues into both (a) the persona and relationships among individuals and (b) the occurrence of events in the physical world. In most work to date, such social media platforms have been analyzed either in isolation or in retrospect. Motivated by this observation, the aim of this project is to leverage on the multimodal information from social media platforms to understand the spatiotemporal and semantic trajectories of events whilst addressing inherent challenges including credibility of information, localization, etc. **[Jayarajah:2015c]**.

In future, I hope to (1) fuse the physical and online world observations to answer key questions related to causality and impact and, (2) apply socio-physical sensor fusion to other domains including healthcare.

Selected Publications

[Misra:2014] Misra, A., K. Jayarajah, S. Nayak, P. K. Prasetyo and E. Lim. Socio-Physical Analytics: Challenges and Opportunities. In Proc. of the 1st Workshop on Physical Analytics colocated with ACM MobiSys, 2014.

[Jayarajah:2015a] Jayarajah, K., Y. Lee, A. Misra, R. K. Balan. Need Accurate User Behavior? Pay Attention to Groups!, ACM Ubicomp 2015.

[Jayarajah:2015b] Jayarajah, K., A. Misra, X. W. Ruan, E. P. Lim. Event Detection: Exploiting Socio-Physical Interactions in Physical Spaces, IEEE/ACM ASONAM 2015.

[Jayarajah:2015c] Jayarajah, K, S. Yao, R. Mutharaju, A. Misra, G. De Mel, J. Skipper, T. Abdelzaher, M. Kolodny. "Social Signal Processing for Real-Time Situational Understanding: A Vision and Approach, SocialSens Workshop co-located with IEEE MASS, 2015.