Tapping Wearable & Infrastructural Sensing to Improve Human Daily Lives

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With the advent of multitude of smart sensing devices, unprecedented volume of digital traces about the daily life activities of individuals and the environments can be obtained. It is therefore gradually becoming a reality to discover and take advantage of contextual information that can cater to multiple sectors such as healthcare, retail, safety, and transportation. However, many challenges exist due to unique features of the sensing devices, energy constraints, accuracy and latency that can be achieved, as well as the changing contexts. I look towards the vision of *multi-modal sensing* (using a combination of infrastructure, mobile and wearable devices) for understanding human behavior and gathering such insights for building novel pervasive systems that help improve their daily lives.

The focus of my research, thus far, has been in using smart devices and smart analytics to solve real-world problems in domains such as healthcare and retail. **Key contributions** involve: (i) developing a framework for understanding shopping behavior in physical retail stores using wearable sensing [1], (ii) design and assessment of myoelectric game-based training tool for prosthesis rehabilitation of upper limb amputees and (iii) the on-going research on understanding gym usage behavior of users to identify key reasons for their dropout and ways to improve user retention.

Deriving useful analytics about human behavior from multiple sensing modalities and presenting it back to the individual can help in improving the individual's lifestyle. For instance, using the sensors from multiple personal and pervasive sensing devices can help in uncovering deeper insights into a shopper's in-store behavior and preferences. This in turn would help in inferring a shopper's persona and using it for targeted advertisements, recommendations and reminders to the shoppers in real-time.

As with any other pervasive system, obtaining insights about human physical activity and their behavior involves a lot of challenges. Some of the **challenges** are: (i) *Accuracy* – systems monitoring various daily life activities of humans have to be accurate and the right combination of features and techniques needs to be utilized to attain a certain level of accuracy specific to individual application scenario. (ii) *Segmenting the data* – appropriate segmentation of sensor data is important to derive any useful contextual information. This also becomes more challenging when multiple sensing modalities are involved. (iii) *Latency* – applications that perform real time monitoring of activities and providing interventions based on that have strict latency requirements. For example, in the case of a prosthesis training tool, it is important to identify if the subjects are getting tired during the training and notify them to take breaks at appropriate time to avoid excessive muscle fatigue.

Shopping behavior study: We investigate the possibility of using a combination of a smartphone and a smartwatch, carried by a shopper, to get insights into the shopper's behavior inside a retail store by extensive data collection and analysis of real-life shopping data [1]. Key contribution of this work lies in appropriately decomposing an entire store visit into a series of modular and hierarchical individual interactions, such as a sequence of "in-aisle" durations (consisting of gestural interactions with products of interest), interspersed with "non-aisle" activities. Experiments with 50 real-life grocery shopping episodes, at two different grocery stores, we show that our framework can demarcate item-level interactions with an accuracy of 91%, and subsequently characterize item-and-episode level shopper behavior with accuracies of over 90%.

Games for pre-prosthesis training of upper-limb amputees: This work is motivated by the fact that existing training techniques are ineffective and users lack motivation to engage in the training process as they do not obtain any feedback on their progress. Due to lack of such appropriate pre-prosthesis training and incorporation of prostheses into daily activities, the rejection rates of prostheses among upper limb amputees remain high. To overcome these limitations, we design a training tool with engaging games that are mapped to pre-prostheses exercises that can reflect muscle activity. The training tool targets to (a) improve the user's neuromuscular control of a prosthesis, (b) quantitatively assess the performance of the users by understanding their quality of muscle contractions, detection of muscle fatigue during the game play, and (c) provide feedback on therapy progression.

My current research focuses on *understanding gym usage behavior of people*. Most of the existing works in this area have focused on problems such as automatically detecting exercise types, counting repetitions, providing workout plans and are mainly intended to help regular gym-goers. However, there is a notable set of users who go to the gym a few times and then never go back. It is worth to identify the key reasons behind the dropout of users and find solutions to retain their motivation to continue going to the gym.

References

[1] M. Radhakrishnan, S. Eswaran, A. Misra, D. Chander, and K. Dasgupta, "Iris: Tapping wearable sensing to capture in-store retail insights on shoppers," in *Proc. of PerCom'16)*.