Introduction:

Why Social Interactions are Important?

Social interaction refers to any form of mutual communication between two individuals or between an individual and a group . Such communications involve any or all forms of sensory and motor activities as deemed necessary by the participants of the interaction. Researchers working in the area of social psychology, personality studies, developmental sociology and other related areas, strongly believe that the ability of individuals to effectively control expressive behavior is essential for the social and interpersonal functioning of our society. Such social interactions are the aggregate cause of social behaviors, social actions and social contact that helps not only in effective bilateral communication, but also in forming an efficient feedback driven behavioral learning loop. It is this feedback (termed as *social feedback*) that children use towards developing good social and communicative skills.

Recent studies in behavioral psychology are furthering our understanding of the importance of social behaviors and social actions in everyday context. Researchers have revealed an unconscious need in humans to mimic and imitate the mannerisms of their interaction partners. An increasing number of experiments have highlighted this need for imitation to be very primeval and that they offer an elegant channel for building trust and confidence between individuals. From a neurological perspective, researchers have discovered mirror neurons that fire when an animal acts and when the animal observes the same action performed by another. Such neurons have been directly observed in primates, and are believed to occur in humans and other species including birds. Various studies with humans correlate such mirror neurons to understanding intentions, empathy, language development and all other forms of social learning. These mirror neurons is connected directly into the sensory stream of the humans and all forms of stimuli (visual, auditory and somatosensory) are simultaneously interlinked into the *Social Learning*.

How disability hinders Social Feedback and Social Learning?

People with disability face a challenge when it comes to both Social Feedback and Social Learning. Sensory disability (like visual and hearing impairment) prevents individuals from receiving vital information from their interaction partner as well as the environment where the interaction if taking place. While each disability will impose its own constraints on the type of social information that is hampered, the net effect is the disruption of the learning and feedback loop. For example, people who are blind and visually impaired find it very difficult to access non-verbal visual information, such as eye gaze, hand gestures etc. during social interactions. Similarly, people who are hard at hearing find it cognitively demanding to understand their partners through lip reading which forfeits them from engaging in other social exchanges that might require their attention.

From the perspective of a perceptual disability (like Prosopagnosia or Akinetopsia), where the individual’s ability to understand and process some of the sensory stimulations is deprived, subtle social signals might be missed out. For example, Prosopagnosia (or Face Blindness) is a condition wherein an individual cannot perceive faces of humans, while the rest of their visual sensory system is perfectly functional. Though the individual demonstrates complete sensory and cognitive ability, their inability to recognize people in their environment hinders their social interactions, both and a personal and professional level. Similarly, Akinetopsia refers to the inability of individuals in perceiving motion, also called Motion Blindness. Subtle movements such as the facial expressions, hand and body postures and mannerisms are not processed by the individuals in the same manner that their able counterpart would. This leads to no information or misinformation during social exchanges, thereby hindering the social learning and feedback mechanisms.

Social signals are very subtle by nature, for example, humans are very sensitive to the facial mannerisms and gestures. A subtle and rapid shift in eye gaze can be very easily perceived by a social interaction participant. The interplay of sending and receiving signals back and forth happens in a very delicate balance. While sensory and perceptive disabilities disengage the channel explicitly, cognitive disability (like autism or developmental disorder) disrupts the communication channel implicitly. Individuals cannot comprehend the stimulus or, cannot deliver appropriate social signals thereby affecting the entire interaction process. Studies have shown that some of the symptoms of cognitive disabilities can be alleviated by increasing social interactions of affected individuals.

While assistive technology specialists have considered the day-to-day problems (faced by the disabled community), like mobility, navigation, access to media, etc, access to social interaction has never been addressed before. Through social interactions do not manifest themselves as problems in the physical construct around us; they play a vital role in improving the quality of life. Any technology solutions that can enhance or enrich access to social signals for people with disability will positively impact the lives of these individuals.

How Ubiquitous Computing could play an important role in assistive technologies for social interactions?

This growth in ubiquitous computing is so pervasive that the concept of computing is no longer technology centric but human centric [REF]. Newer human centric areas of research have emerged due to this interaction between humans and technology such as Human Centered Computing (HCC) [REF], and, more recently, Human Centered Multimedia Computing (HCMC) [REF]. These areas have an overlapping goal of putting technology closer to humans and making technology adapt to human needs rather than requiring the human to adapt to the technology. Fallout of these research areas are the newer applications where the human centered technologies are being targeted at improving the quality of life of humans on an everyday basis. While not much has been done towards addressing social interaction situations for people with disabilities, ubiquitous and pervasive computing is headed towards this ultimate goal of penetrating human life at a very low level. Social interaction assistant forms an elegant convergence of computing platforms that are targeted at enriching quality of life of humans.

Parallel to the advances made in HCMC, Reality Mining [REF] and Computational Social Systems [REF] are highlighting the importance of understanding interactions between humans and their environment. From epidemic prediction to mapping of information flow, human mobility, human activity and human interactions are becoming the forefront of computational modeling. Today, most of such human interaction modeling relies upon data aggregated from social networks, GPS and GIS information of user generated data and cell phone usage data. While all these provide a coarse high level view (macro level) of the information flow, the atomic level interactions involving bilateral interactions of humans have not been addressed so far. There exists no data that captures the subtleties of interpersonal communication and data exchange. Recently work by Alex Pentland [REF] has shown the importance of technology insertion into the human-human communication channel to tap into the unconscious social signals. His work has highlighted how humans relay upon non-verbal cues in everyday interactions and is opening new insights into the modeling of human dynamics.

While Ubiquitous Computing, Pervasive Computing and other Human-Centered Computing concepts are converging towards atomic level modeling of humans, they are doing so by considering the human agent to be independently operating within his/her environment. Understanding the social interactions between humans will allow the modeling of interactions between individuals and thus model the larger envelope of human interaction dynamics.

Intellectual Merit and Broader Impact

This proposal is focused on the design and development of a social interaction assistant with the focus on understanding the human-human social interaction primitives. The intellectual contributions from the proposed research activity will directly affect three important areas

1. **Social and Behavioral Psychology:**

Non-verbal communication is an important area of research under psychology that is nascent in its understandings of social interactions on the daily lives of individuals and groups [REF]. Studies till now have worked with individuals or groups of individuals in very controlled environments [REF]. Lack of sensors and data loggers that can capture the first person perspective of social interactions has limited all analysis from a third person perspective. Further, since the observing sensors were in the environment, the possible interactions were limited to within a confined space [REF] or enacted events [REF]. The technologies developed as part of this proposal removes these barriers allowing for capture of interactions in more naturalistic scenarios with real world interaction situations. Further, simultaneous capture of information in various modalities like visual, audio and behavioral would allow data analysis that is unmatched for any social and behavioral experiments.

1. **Assistive Technology:**

There exists no assistive technology solution to cater to the social and behavioral needs of individuals who cannot engage in a synergistic social interaction due to sensory or cognitive disability [REF]. The proposed project develops a technology solution that brings social access to such a population. Providing both social rehabilitation and social assistance, it will allow for a better personal and professional outlook for these individuals. Like any other assistive technology that has grown out of the bounds of its target audience to meet the needs of an every growing productive general population, our proposed work can provide social enhancements to the lives of people in general.

1. **Computer Science:**

While the specific computational contribution of this proposal is focused on a novel machine learning methodology that incorporates human socio-behavioral dynamics into the existing , the broader contributions in the area of computer science is shown in Figure 1.

Human machine interaction, human centered computing and human centered multimedia computing are all converging on one basic need to understand the social needs of humans. This would allow technologies and solutions to be built with the capability to communicate with humans intimately with ease. The proposed Socio-Behavioral Computing paradigm, attempts to accelerate this process by providing clarity to this area of computing and identifying important research questions. One such question being the inability to label data easily in a socio-behavioral scenario, we focus our attention on one problem of auto labeling data by a novel framework for learning termed as “Simultaneous Instance and Sequence Learning” that competes with the existing Self-learning [REF] frameworks and provides an opportunity for cross sensor learning [REF] and co-training [REF].