Federated Sensing Systems that use Human Behavior to Provide Services

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(i) Participant background

Andreas Savvides is the Barton L. Weller Associate Professor of Electrical Engineering at Yale University and founder of the Embedded Networks and Applications Lab. He holds a B.S degree in Computer Engineering (1997) from the University of California, San Diego, and M.S Degree in Electrical and Computer Engineering from the University of Massachusetts, Amherst (1999) and a Ph.D. Degree from the University of California, Los Angeles (2003). Savvides joined Yale in 2003 where he leads the Embedded Networks and Applications Lab, (ENALAB). His main area of research is in networked embedded systems and wireless sensor networks with emphasis on the use of sensor systems for interpreting human behavior. To investigate these problems Dr. Savvides has been working on developing new sensing modalities for human sensing as well as composing new macro-sensors by coupling together multiple sensing modalities and exploiting their spatio-temporal properties. Examples of this work include the development of a hierarchical probabilistic grammar framework for recognizing spatio-temporal behavior patterns[1], a hybrid sensing modality for establishing correspondence between camera detected locations and wearable accelerometers[2] and a method for extracting spatio-temporal activities from GPS data[3]. In the past few years Dr. Savvides' research has been applied to elder care, security and more recently energy management applications in large buildings. His work in these areas resulted in numerous publications, software and hardware releases and actual deployments real world applications that are still in operation today. Dr. Savvides serves on the technical program committees of various conferences in the area of wireless sensor networks including ACM SenSys, Information Processing in Sensor Networks (IPSN) and the European Wireless Sensor Network Conference (EWSN). He is currently a member of the editorial board of the ACM Transactions on Sensor Networks. In 2010 he served as the General Chair for the Information Processing in Sensor Networks (IPSN).

(ii) Participant vision

My vision is to help design scalable ubiquitous computing systems that can analyze the behavior of people at multiple scales using the same underlying data to support a heterogeneous set of applications. In this realm I am particularly interested in applications that support elder health and wellness. My previous experience in the domains of elder monitoring, security and building energy management has taught me that the scalability of ubiquitous systems is hindered three main factors. First, deployments are fragmented with data access limited to the network owners and participants. Second, the process of transforming sensor data to information and knowledge has not reached a level of maturity in which multiple applications can agree on how to trust and consume the derived semantics. Third, data privacy and security controls have not matured to the level required to allow the sharing of data across multiple consumers and applications.

To address these challenges and enable ubiquitous computing at scale my vision is to develop ubiquitous sensing systems that can scale by allowing sharing of existing networks, better understanding of human behaviors from sensors and the building of trust in measurements across systems. I envision such systems to have the following properties:

i) Support of mechanisms that allow individual networks to access larger federations by providing methods for controlling access, managing resources and preserving the required levels of privacy.

ii) Methods of bridging the semantic gaps that exist in interpreted data. Disparate systems produce semantic interpretations of the data that need to be understood and consumed by other systems in the federation. For this to happen, a common ground needs to be set for semantic labels and their associated certainties.

iii) New methodologies for interpreting behavior from sensor data especially when it comes to the analysis of temporal properties of the data streams.

iv) The development of new measurement verification properties that will provide an acceptable means of confirming that the data reported by remote sensor networks operated by others is indeed accurate, properly labeled and trustworthy.

v) Explore new opportunities for macroscopic sensor composition, that is, the ability to draw data from large numbers of sensors, and combine them in a consistent ways that help detect behaviors and phenomena with large spatial and temporal footprints.

In the domain of elder monitoring and wellness, the existence of such technologies will help preserve wellness and coordinate care in ways that lower cost while preserving high quality of life.

(iii) Evidence that pursuing this vision will lead to advances in the field

One of the main acceptance barriers for sensor deployments today is the lack of effective solutions for privacy, resource management, lack of standard ways of sharing data and lack of methods for verifying that the data from foreign networks is to be trusted. This is already evident in smart phones that already feature GPS and other sensors. Despite the sensing and networking availability, people are still not willing to share their information for fear of loss of privacy, concerns about battery usage and lack of trust. A good indicator that solutions to these issues will lead to advances is the decision of the federal government and large corporations to move towards federated systems for sharing online information across agencies. The existence of a counterpart solution that cuts across cyber and physical boundaries to control access, manage resources and help with data interpretation will enable scalable ubiquitous sensing systems.

References:

[1] D. Lymberopoulos, T. Teixeira and A. Savvides, *Macroscopic Human Behavior Interpretations Using Distributed Imagers and Other Sensors*, Proceedings of IEEE October 2008

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[3] A. Bamis and A. Savvides, *Lightweight Extraction of Frequent Spatio-Temporal Activities from GPS Traces*, Proceedings of the 31st IEEE Real Time Systems Symposium (RTSS), November 30 - December 3, 2010, San Diego, CA, USA