Building a Home with Pervasive Memory

Hari Sundaram, Arizona State University; http://ame2.asu.edu/faculty/hs

1 Vision

Today, physical objects (e.g. a cup, a shirt, a hangar) have no memory. It is only by examining *physical markers*, including dents, stains, and scratches, are we at all reminded of the incident, provided it happened in our presence. Today, we cannot query physical objects about activity, with the same ease with which we can query and examine the web – we cannot "Google" a physical item to locate it.

What if every man-made physical object in the house, could remember what was done to it? Can we "ask" a shirt, when it was worn last? Or "ask" book, when I last picked it up? Or ask the desk, if I had left my keys there? Building a world, which can remember what activity took place in it, and importantly which allows for de-centralized querying (i.e. not rely on a centralized service for the answer), can have a radically transformative effect on the way we live in our physical world. In recent, NSF funded work NSF/ECCS, 0725910, we have taken some very preliminary steps towards this vision, by assuming that the environment had a set of passive RFID tags associated with each object [1]. New embedded sensors provide interesting insights - a very interesting, recent example is a contact lens, with an embedded RF sensor [2]. Notice that any embedded sensor needs to be extremely light (e.g. think of the weight of a pin, to the weight of sheets of paper to which it is attached), and not affect the utility of the object.

Building a home with pervasive memory, where we can query each object in de-centralized manner, and which can address the scale issue (houses are object dense) requires an integrative multi-disciplinary approach. In particular, it requires us to integrate these very different and complementary issues. (a) Providing power to the embedded sensor will be a challenge. It is likely to be passive or acquire power via scavenging. (b) The embedded sensors will have very limited storage (GEN 2 RFID tags have typically have 1024 bits) – efficient compression techniques would be needed. (c) We will need to be able to compute *on the embedded sensor*, if we are to any feature analysis in-situ – there are clear programmability vs. cost trade-offs (e.g. using ASICS, vs. a general-purpose computing element). (d) We will need to be able to store information reliably in the environment, possibly storing data redundantly amongst objects. Efficient redundant storage will require us to develop effective error correcting codes. (e) We need robust wireless communication between objects (e.g. to distribute data) and with the interrogator (person with device, querying the object) – the high density of objects will create significant electromagnetic interference (f) There are significant privacy issues – what if some activity data on the tag needs to be kept private with limited access? This requires an encryption scheme.

2 Proposer Background

Hari Sundaram is currently an associate professor in CSE and the School of Arts Media and Engineering (AME). He has worked extensively on problems relating to physically grounded multimedia systems [3], social network analysis, retrieval, summarization and resource constrained pattern analysis. He has received a best paper award for his work on video retrieval [4] and video summarization [5] and collaborative annotation [6]. He has led projects funded by the NSF, IBM, Microsoft, NEC, Ricoh, and Avaya. He is also an associate editor for ACM TOMCCAP and IEEE Multimedia.

Relevant NSF projects: NSF/ECCS, 0725910 (PI), "*Collaborative Research: Design of Dense RFID Systems for Indexing in the Physical World across Space, Time, and Human Experience*," (indexing physical objects via RFID), NSF/IIS, 0308268 "*Quality-Adaptive Media- Flow Architectures to Support Sensor Data Management*" (real-time multimedia architectures to support live performances), NSF/DGE, 0504647 (co-PI), "*IGERT: An Arts, Sciences, and Engineering Research and Education Initiative for Experiential Media*"

3 Research Impact

The work on pervasive memory will have a broad societal impact. Consider following scenarios (a) We can now perform decentralized search – how will this affect the home? Will people become less "organized" if everything can be easily found? This ability to search will positively influence the elderly, and the unsighted (b) we can examine clothes at home, to see when they were last worn, and with which other item, and if drycleaner treated the material with eco-friendly agents – we can understand temporal properties of physical objects. (c) At the grocery store (beyond the home), examining the embedded tags to determine food origin, and if the food had been handled safely.

4 References

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