Annual Report for Period: 08/2001 - 08/2002
Submitted on: 06/04/2002
Principal Investigator: Srivastava, Mani B.
Award ID: 0085773
Organization: U of Cal Los Angeles
Title:
ITR: Technologies for Sensor-based Wireless Networks of Toys for Smart Developmental Problem-solving Environments

Project Participants

Senior Personnel

Name: Srivastava, Mani
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Muntz, Richard
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Baker, Eva
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Alwan, Abeer
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Potkonjak, Miodrag
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Chung, Gregory
Worked for more than 160 Hours: Yes
Contribution to Project:
Greg, with his background in educational assessment techniques, is acting as the application domain expert, helping define classroom scenarios and activities for leveraging sensor instrumentation. He is also the interface between the technologists (EE, CS) and the kindergarten staff.

Post-doc

Name: Delacruz, Girlie
Worked for more than 160 Hours: Yes
Contribution to Project:
Classroom observation analysis, design of classroom procedures.

Name: de Vries, Linda
Worked for more than 160 Hours: Yes
Contribution to Project:
Classroom observation analysis, design of classroom procedures.

Graduate Student

Name: Locher, Ivo
Worked for more than 160 Hours: Yes

Contribution to Project:

Ivo is investigating techniques (hardware design, software, and algorithm) for wireless spatial sampling of acoustic/speech input within the sensor-instrumented Smart Kindergarten. He is funded through the grant as a Graduate Student Researcher.

Name: Savvides, Andreas

Worked for more than 160 Hours: No

Contribution to Project:

Andreas is investigating fine grained localization (i.e. real-time tracking location and orientation) of wirelessly netwroked objects in the sensor-instrumented Smart Kindergarten. His work spans algorithms, hardware design, and software develpment.

Name: Park, Sung

Worked for more than 160 Hours: No

Contribution to Project:

Sung is doing the hardware architecture and design of the ultra-lowpower wireless sensor badge we intend to deploy in the sensor-instrumented Smart Kindergarten. The badges will be worn by the kids, and allow us to wirelessly track their location at a fine scale, and sample physical information in theimmediate vicinity of each kid. Sung is also going to investigate low power wireless protocols in the context of these badges. He is currentl supported on a fellowship, but expenses relating to his design are supported by the grant.

Name: Mani, Murali

Worked for more than 160 Hours: Yes

Contribution to Project:

Murali is investigating middleware techniques for sensor data management, and contributing to the implementation of the MUSE software infrastructure.

Name: Cui, Xiaodong

Worked for more than 160 Hours: No

Contribution to Project:

Xiaodong is investigating algorithms relating to recognition of kid's speech.

Name: Slijepevic, Sascha

Worked for more than 160 Hours: Yes

Contribution to Project:

Sasa is investigating techniques for aggregation and information mining of sensor data. He is also contributing to interfacing of specific sensors to the software infrastructure.

Name: Wong, Jennifer

Worked for more than 160 Hours: Yes

Contribution to Project:

Jennifer is developing algorithms for profiling sensor data, and also participating in defining the SmartBoard.

Name: Chiu, Frank

Worked for more than 160 Hours: No

Contribution to Project:

Worked on design and implementation of Muse software. GUI and query optimization.

Name: You, Hong

Worked for more than 160 Hours: Yes

Contribution to Project:

End-point detection of speech signals in noise, and
worked on system integration.

Name: Al Bawab, Ziad

Worked for more than 160 Hours: Yes

Contribution to Project:

Analyzing the effects of Bluetooth protocols on ASR.

Name: Megerian, Seapahn

Worked for more than 160 Hours: Yes

Contribution to Project:

Sensor data analysis algorithms.

Name: Steurer, Philipp

Worked for more than 160 Hours: No

Contribution to Project:

Development of sensor instrumented table for classroom.

Undergraduate Student

Name: Kremenek, Ted

Worked for more than 160 Hours: Yes

Contribution to Project:

Design and implementation of Muse and of Bayesian network approach to data fusion.

Name: Martinez, Blanca

Worked for more than 160 Hours: No

Contribution to Project:

Assisting in the non-engineering aspects of the work related to arrangements with the school of education, paperwork related to human subjects.

Name: Veltri, Giacomino

Worked for more than 160 Hours: No

Contribution to Project:

Software development.

Name: Liu, Duo

Worked for more than 160 Hours: No

Contribution to Project:

Software development for iBadge.

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

University Elementary School

The Corrine A. Seeds University Elementary School (UES) serves as the laboratoy school for the UCLA Graduate School of Education and Information Sciences. In collaboration with UCLA researchers, UES teachers and administrators experiment with innovative organizational structures, decision-making processes, and instructional strategies and develop state-of-the-art curriculum based on the most recent research and using the most advanced technology.

For this projects, UES is providing its facilities to help us realize our vision of a wireless sensor-instrumented kindergarten classroom.

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

The goal of this research project is to investigate challenges in 'person to physical world' com-munications in deeply instrumented 'smart spaces' formed by unobtrusively imbedding ever cheaper, tinier, and lower power embedded processors, micro-sensors, and wireless network inter-faces in physical objects. We are exploring the challenges of these sensor-based wireless networks in the context of a 'Smart Kindergarten' that we are developing to target developmental problem-solving environments for early childhood education. This is a natural application of the ability of deeply instrumented smart spaces that allow a fusion of the cognitive and the physical realms since young children learn by exploring and interacting with physical objects such as toys in their environment and observing how they (causally) respond.

Wirelessly networked embedded sensors create a problem solving environment that can be con-tinually sensed in detail (kids, playthings, classroom 'woodwork' etc.). Our objective is to ulti-mately enable assessment of the who, what, where, when, and how of student learning by computationally relating measured physical attributes (e.g. location) of kids, teachers, and related objects in the instrumented classroom to behavioral metrics that are meaningful, credible, and in a form usable for educational assessment. The eventual system would enhance the education pro-cess by providing a childhood learning environment that is individualized to each child, adapts to the context, coordinates activities of multiple children, and allows continual unobtrusive evalua-tion of the learning process by the teacher.

Our research seeks to achieve the above objective via wirelessly-networked, sensor-enhanced toys and other classroom objects with back-end middleware services and database techniques.

The following summarizes our activities for the report period:

I. TECHNOLOGY: HARDWARE, SOFTWARE, AND ALGORITHMS

The activities in this category are broadly focused on creating techniques (algorithms, protocols) and technologies (hardware, software) that would allow dense physical sampling, capturing, management, and information mining of classroom activity via wirelessly networked sensors including student-student, student-object, student-teacher, and teacher-object interactions. Activities undertaken so far under this category were:

a. Sensor Data Management and Mining.

We have further developed the middleware for dynamically discovery and query of sensors. This middleware design and implementation has been described in several publications. Software modules for a variety of sensors have been implemented and tested. We have tested the system in a laboratory setting in preparation for deployment in the classroom in the next few months. We are continuing our research into metaprogramming techniques to support automatic adaptation to the dyamic and varied environments expected in sensor rich environments, data models and data organization suitable for streaming sensor data, and query processing techniques for probabilistic models and uncertain data. Several publications have resulted from this work. We also continue our work on the database issues in capturing, storing and retrieving multi-modal sensor data although our main goal is in the data mining issues with this complex, noisy data. Figure 1 shows a block diagram of the middleware system and its relationship to the other system elements.

b. iBadge: Wearable Sensor Badge.

We finished the design and implementation of a key component of our technology, a miniature wireless sensing module in the form of a badge to be worn by the children. Besides providing a rich suite of sensing and acoustic I/O capabilities, the iBadge uses an ultrasound based localization unit that together with a ceiling ûbased infrastructure provides a fine-grained localization capability. The badge also has support for dynamic battery-aware power management, and instrumentation of detailed monitoring of the power consumption. Due to uncontrollable delays associated with the availability of certain crucial components as well as fabrication problems associated with our use of miniature 201-size PCB components that very few fabrication houses are able to handle (part placement and soldering), the implementation of iBadge took longer than we had anticipated. However, the badge has been implemented, tested, and three of them are in operation. Unfortunately certain bugs in the design are necessitating a re-fabrication of the PCB (to avoid patch wires) before we make the badges in quantity, and we anticipate this to be done over the next 2-3 months.

We would like to mention than iBadge has been awarded the 2-nd place prize in the Student Design Contest (Operational Category) at the upcoming ACM Design Automation Conference in June 2002. Figure 2 shows a block diagram of the ibadge, while Figure 3 shows a photograph of the operational badge with relevant metrics.

c. Fine-grained Localization Service

We are nearing completion of the implementation of a fine-grained localization service using robust collaborative multilateration algorithms, the hardware on ibadge, and a ceiling-based infrastructure based on nodes called Medusa MK II. Together with the accelerometers and magnetometers, a complete x, y, z, pitch, roll, and yaw representation is calculated. Thee key element of our approach is a distributed localization approach based on Kalman filtering that limits error propagation and is robust to the presence of obstacles.

d. ChildrenÆs Speech Recognition

We are developing and evaluating two different approaches to the remote speech recognition problem. The first approach involves coding the speech signal and then transmitting the data using a standard coder (G. 722, ADPCM). In the second approach, feature extraction is first performed, then the feature vectors are compressed and transmitted to the recognizer. In both approaches, the signals are decompressed, or transformed to an appropriate feature set, and recognition is then performed. Results on the first approach showed that G.722, the speech coder to be implemented on iBadge, does not degrade ASR performance significantly. In the second approach, our efforts have focused on extending the algorithms and evaluations, that were done for isolated digit recognition tasks, to a large continuous-digit database (Aurora-2) provided by the European Language Resources Association (ELRA). We evaluated four of our front-end processing techniques with the Aurora 2 database. These techniques include three previously published algorithms: variable frame rate analysis, peak isolation, harmonic demodulation, and a new technique for peak-to-valley ratio locking. We also developed a speech-nonspeech detection algorithm to detect speech from background noise which is important and necessary in low SNR conditions. Recognition results with the Aurora 2 database show that a combination of these four techniques results in 53% in error rate reduction for the mismatched (clean training and noisy testing) case, and 12% reduction in the matched case when compared to the baseline MFCC front-end, with no significant increase in computational complexity.

Since the Smart Kindergarten Project deals with children's speech, common speech recognition acoustic models, which are typically trained by adult speech, need to be adapted. This requires speaker adaptation data read by kids according to some pre-designed adaptation text. The adaptation text should cover the basic speech units used in the recognition task in a desired manner.We developed an algorithm towards this goalthat can select N sentences as adaptation text from an M-sentence corpus (M>>N) based on the Kullback-Leibler measure under the criterion of minimum cross-entropy. By the usage of the Kullback-Leibler measure, we are able to select text material whose speech unit distribution most resembles the desired one (appears in the measure as a reference distribution.) Unfortunately, this leads to an optimization problem whose solution has prohibitively high computational complexity when M and N are large. To tackle this issue, we developed an efficient add-on procedure to reduce the computational complexity from N^M to O(NM). Experiments show satisfactory performance of this algorithm especially in the case of a limited text size.

e. Remote Speech Recognition Service

We implemented a Java-based remote speech recognition system consists of a microphone sensor module and a speech recognition engine module both of which connect to MIRA (MIRA is a remote database which is used to store in the Sylph middleware, in a systematic way, data obtained from the different sensor modules.) The microphone sensor module inputs speech signals and sends the data to MIRA. At the same time, the speech recognition engine module fetches the data from MIRA also at a fixed time interval after which feature extraction and recognition are performed. The data transfer from the microphone sensor module to MIRA and from MIRA to the speech recognition engine is realized via an ftp mechanism by two modules: Microphone Sensor Proxy and Speech Recognition Engine Proxy. The data transferred between the two modules can be coded speech signals and/or coded speech features. The microphone module used Windows APIs while the speech recognition engine is realized using Hidden Markov Models implemented on a Unix platform. As a test, a real-time speaker-independent connected digits recognition system was implemented.

f. Multimodal Sensor Information Mining

We have developed a suite of search, profiling and recommending techniques. We have developed techniques for 3D and time dependent modeling of various sensors using a ôlight compassö sensor as the driver, which uses fine-grained ambient light level sensing to draw conclusions about the spatial context.

g. Overall Testbed System

We have an operational testbed system in the lab that combines the Sylph middleware, and several different sensors (wireless camera, wireless microphones, seismic sensors, and ibadge emulators) integrated with Sylph via specialized ôsensor modulesö that plug into the Sylph core. At the current time the ibadge hardware is being integrated into this system. Another activity that we recently undertook is the development of a sensor-instrumented play table that can sense the location, orientation, and identity of ôwireless intelligent blocksö placed on the table. In conjunction with information supplied by ibadges, this would be used to create a reactive task environment for the children. Thus far we have investigated various design options, and will be fabricating such a table over the summer.

II. APPLICATION

The activities in this category are focused on application-level issues associated with ôdeploying' our technology in the classroom. Activities under this category were:

a. Development of Measures.
We developed a technical approach for examining the quality of our sensor-derived measures. We have developed a general approach, which we termed ôbehavioral calculus,ö which is an expression of how behavior-based sensor-data relates to learning and assessment measures. Our current set of measures describes collaborative group behavior, and include the following high-level and low-level variables.

High-level measures: collaborative presence (i.e., acoustic participation by at least two individuals with turn-taking observed), engagement (i.e., acoustic participation and focus of individuals that can support collaboration), group (i.e., physical arrangement of individuals). These measures collectively express a collaborative group situation.

Low-level measures: facing each other (i.e., two individuals within each otherÆs field of view), group centroid (i.e., weighted center of a polygon whose vertices are determined by individuals in a group). proximity (i.e., the distance between an individual and the group centroid) . Combinations of these measures are used to derive high-level measures.

Atomic-level measures: position (i.e., x, y, z positions in a local coordinate system), orientation (i.e., degrees relative to true north), speech on/off (i.e., speech on/off). These measures are used to derive low-level measures and are generated from the smart badges.

b. Instructional Tasks.
Our general approach will be to use existing teacher tasks to test the system. We chose this approach for several reasons. The teacher we are planning to work with uses a variety of instructional techniques, providing ample opportunity to test the system under different instructional conditions. We are planning to focus on two extreme conditions to test validate our measures: (a) inquiry-based instruction, because it is cognitively demanding, involves a complex project, requires small groups, and runs over several weeks; (b) routine small-group instruction, because it is opposite to inquiry and serves as an ideal contrast. Thus, our measures should be able to detect differences in small-group behavior across instructional conditions. We met with the classroom teacher and technology specialist at the University Elementary School (UES). The classroom teacher has identified several projects that can be used for this research. We will be examining changes in students' interaction over time (Fall vs. Winter vs. Spring) across different kinds of small group tasks: technology vs. non-technology, and cognitively complex/open-ended vs. routine tasks.

c. Literature Review.
We reviewed the literature for potential measures of physical interaction and the relationship between these measures and measures of collaboration.

d. Classroom Observations.

We videotaped six 30-minute sessions to get a sense of how children work in groups. The video data was imported into video-coding software called Vprism and analyzed for patterns of interaction, collaboration, group configurations and speech. The data revealed that when individuals interact and speak with each other, their torsos remain relatively steady with their heads moving side to side. To get the rich level of information from the sensor-badges needed to make strong inferences about interaction, it was decided to place the badges somewhere on the head. We are working on various prototypes to address this issue (attaching the badges to head bands, baseball caps, or visors).

e. Initial Test of Measures

Our goal is to be able to confidently infer cognitive operations from behavioral data. Our approach (the behavioral calculus, described earlier) is to formalize the set of relationships among sensor data, behavioral, and cognitive measures for individual and group behavior in a classroom context. Conceptually, the instantaneous behavior is dynamic-- the person could be rapidly engaging and disengaging, but integrating the behavior over time would yield an average measure of 'engaged' or 'disengaged.'

We are currently studying how accurate our sensor-based measures were in detecting: (a) individual and group (physical) locales, and (b) detecting individual and group interaction patterns. We are also examining how sensitive our sensor-based measures are in detecting changes in individual and group interaction.

Our method is to test our measures under contrived laboratory conditions (ideal conditions). The purpose of the experiments is to validate the measures under known conditions. Our general procedure has been to create short (30s) scenarios based on boundary conditions, nominal conditions, and actual video data. We use mannequins to model individuals on a coordinate grid. We enact the scenarios measuring values similar to those that will be provided by the sensor-badges (x,y,z position, orientation (degrees), and audio on/off). We are currently developing the software to derive our measures from the atomic-level data and we will examine the correspondence between the scripted scenario and the system-generated values.

f. Future Activities.

There are several activities planned for the summer. We will be conducting a controlled laboratory study of our formalizations in the summer. This will be done with individuals in the lab following a script. The performance of our measures will be evaluated and refined. A pilot study with several children will be conducted late Summer to finalize our formalizations. The field study evaluate in the classroom is scheduled to take place in the fall, when the new school year begins.

III. PRESENTATIONS

We made many conference presentations on the project that are listed in the publications section, including three at the highly selective ACM Mobicom 2001. Some of the other key conferences that we presented at were ACM Ubicomp, ICASSP, Mobihoc, and Eurospeech. We also made presentations at industrial research reviews held at UCLA so garner support for our technologies from our industrial partners. We also participated in the Student Design Contest organized by the ACM

Design Automation Conference, and won the 2nd prize (and a cash award of $2500), for the ibadge design.

Findings:

1. The first middleware infrastructure capable of handling streaming sensor data, and letting it be shared by multiple concurrent applications in a mediated fashion.

2. The first fine-grained localization system for finding location and orientation of nodes in ad hoc networks without the use of GPS and without requiring a calibrated infrastructure.

3. We have developed algorithms for incorporating belief network models into query processing. While belief networks are widely used in evidential reasoning, they are computationally expensive. Viewing data items in a database as ôevidenceö and applying this to belief network repeatedly can be very computation intensive. We have developed algorithms based on ordering of ôevidence tuplesö to maximize reuse of computation, incorporation of bounds on the probability for final outcomes which permit early termination of the computation, and other techniques to optimize the processing of queries which incorporate belief network models. Preliminary results have appeared in a SIAM conference on data mining.

4. We continue to explore database issues in the capture and query of sensor data. Our goal is to determine what benefits we may obtain from the flexibility of XML in representing richer semantics and the performance implications of the use of XML representations. Preliminary work has resulted in several conference publications.

5. Our work on dynamic reoptimization of code has resulted in several conference publications and we have demonstrated cases in which our methodology can achieve and order of magnitude improvement in execution efficiency; this is particularly important in for sensors which often operate in resource scarce environments.

6. The first wearable sensor badge design.

Training and Development:

1. The project has participation from several undergraduate students, who have been involved in software implementation relating to the sensor middleware framework, and the fine-grained localization system. The project enriched their experience in ways that go beyond the courses.

2. The project has also contributed to technical and research skills of the graduate students invlolved. For example, three of the students have participated in the design of the SensorBadge and SensorBeacons hardware, exposing them to valuable skills related to transitioning algorithms to real embedded hardware implementation.

3. Algorithms, results and experience from the research conducted under the project have significantly our graduate coursework in wireless networks (EE206A), embedded systems (EE202A, CS259), and databases (CS239).

Outreach Activities:

Journal Publications

A. Bernard, X. Liu, R. Wesel and A. Alwan, "Speech transmission using rate-compatible trellis codes and embedded source coding", IEEE Transactions on Communictions, p. 309, vol. Feb, (2002). Published

S. Megerian, F. Koushanfar, G. Qu, G. Veltri, M. Potkonjak, "Exposure In Wireless Sensor Networks: Theory And Practical Solutions", Journal of Wireless Networks, ACM Kluwer Academic Publishers, p. , vol. , (2002). Accepted

Alvin Chen, Richard Muntz, Spencer Yuen, Ivo Locher, Sung Park, Mani B. Srivastava, "A Support Infrastructure for the Smart Kindergarten: Sylph and iBadge", IEEE Pervasive Computing, p. , vol. , (2002). Accepted

V. Raghunathan, C. Schurgers, S. Park, and M. Srivastava, "Energy-aware Wireless Microsensor Networks", IEEE Signal Processing, p. 40, vol. Mar, (2002). Published

Books or Other One-time Publications

Mani Srivastava, Richard Muntz, Miodrag Potkonjak, "Smart Kindergarten: Sensor-based Wireless Networks for Smart Developmental Problem-solving Environments", (2001). Conference Proceedings, Published
Collection: Proceedings of the ACM SIGMOBILE 7th Annual International Conference on Mobile Computing and Networking, Rome, Italy, July 2001
Bibliography: pp. 132-138

Andreas Savvides, Chih-Chien Han, Mani Srivastava, "Dynamic Fine-Grained Localization in Ad-Hoc Networks of Sensors", (2001). Conference Proceedings, Published
Collection: Proceedings of the ACM SIGMOBILE 7th Annual International Conference on Mobile Computing and Networking, Rome, Italy, July 2001
Bibliography: pp. 166-179

Chatschik Bisdikian, Paul Castro, Benjamin Greenstein, Parviz Kermani, Richard Muntz, Maria Papadopouli, "Locating Application Data Across Service Discovery Domains", (2001). Conference Proceedings, Published
Collection: Proceedings of the 7th Annual International Conference on Mobile Computing and Networking
Bibliography: Rome, Italy, July 2001

Paul Castro, Richard Muntz, "An Adaptive Approach to Indexing Pervasive Data", (2001). Workshop Proceedings, Published
Collection: Proceedings of the International Workshop on Data Engineering for Wireless and Mobile Access, Santa Barbara, CA, May 2001
Bibliography: Santa Barbara, CA, May 2001

<sum> Paul Castro, Patrick Chiu, Ted Kremenek, Richard Muntz, "A Probabilistic Location Service for Wireless Network Environments", (2001). Conference Proceedings, Published
Collection: Proceedings of ACM Ubicomp 2001
Bibliography: September 2001

Gregory Chung, Mani B. Srivastava, "Fusing physical and cognitive spaces: Using wireless networked sensors to assess the who, what, where, when, and how of student learning", (2000). Conference Presentation, Published
Collection: Annual Conference of the National Center for Research on Evaluation, Standards, and Student Testing (CRESST)
Bibliography: Poster presentation.

Q.Zhu and A.Alwan, "An efficient and scalable 2D DCT-based feature coding scheme for remote speech recognition", (2001). Conference Proceedings, Published
Collection: Proc. IEEE ICASSP
Bibliography: May 2001

A.Bernard and A.Alwan, "Source and channel coding for remote speech recognition over error-prone channel", (2001). Conference Proceedings, Published
Collection: Proc. IEEE ICASSP
Bibliography: May 2001

S. Meguerdichian, S.
Slijepcevic, V. Karayan, M.
Potkonjak, "Localized Algorithms In
Wireless Ad-Hoc Networks:
Location Discovery and
Sensor Exposure
", (2001). Conference Proceedings, Published
Collection: Proceedings of ACM
MobiHOC 2001
Bibliography: pp. 106-116, October 2001

J. L. Wong, G. Qu, and M.
Potkonjak, "Power Minimization Under
QoS Constraints", (2002). Workshop Proceedings, Published
Collection: IEEE International Packet Video Workshop
Bibliography: April 2002

Z. Wang and R.R. Muntz, "Metaprogramming Metaclasses in a Java RMI Metaobject Protocol", (2002). Conference Proceedings, Accepted
Collection: Proceedings of the 6th World Conference On Integrated Design and Process Technology
Bibliography: 2002

Z. Wang and R.R. Muntz, "Reflection across Stages in Multi-Stage Programming
and Its Application to Dynamic Software Reoptimization", (2001). Technical Report, Published
Bibliography: UCLA CSD Technical Report TR010044

Z. Wang and R.R. Muntz, "Object Type Transformation and Stackable Meta-Stubs
Architecture for Distributed Object Programming", (2001). Technical Report, Published
Bibliography: UCLA CSD Technical Report TR010014

Z. Wang and R.R. Muntz, "Managing Dynamic Changes in Multi-Stage Program Generation System", (2002). Conference Proceedings, Accepted
Collection: Proceedings of the 1st ACM SIGPLAN/SIGSOFT Conference on Generative Programming and Component Engineering
Bibliography: 2002

Cheng-Jia Lai, Richard Muntz, "GIN: Generic Identifier Network in Pervasive Computing", (2002). Technical Report, Published
Bibliography: UCLA CSD Technical Report TR020014

Yi Xia, Wei Wang, Jiong Yang, Philip Yu and Richard Muntz, "Efficient filtering of large data sets --- a user-centric paradigm", (2002). Conference Proceedings, Published
Collection: Proceedings of the 2nd SIAM International Conference on Data

Mining (SDM)
Bibliography: April 2002

M. Murata, D. Lee and M. Mani, "Taxonomy of XML Schema Languages using Formal Language Theory", (2001). Conference Proceedings, Published
Collection: Proceedings of Extreme Markup Languages
Bibliography: August 2001

M. Mani, D. Lee and R. Muntz, "Semantic Data Modeling using XML Schemas"", (2001). Conference Proceedings, Published
Collection: Proceedings of Intl Conference of Conceptual
Modeling (ER 2001)
Bibliography: November 2001

D. Lee, M. Mani, F. Chiu and W. Chu, "NeT and CoT: Inferring XML Schemas from Relational World", (2002). Confrence Poster, Published
Collection: Proceedings of ICDE 2002
Bibliography: February 2002

. Lee, M. Mani, and W. Chu, "Efficient Schema
Conversions between XML
and Relational Models", (2002). Workshop Proceedings, Accepted
Collection: Workshop on Knowledge
Transformations for the
Semantic Web
Bibliography: Invited Paper

Paul Castro, Alvin Chen, Ted Kremenek, Richard Muntz, "Evaluating Query Processing Systems for Ubiquitous Computing", (2001). Workshop Talk, Published
Collection: UbiComp Workshop on Evaluation Methodologies for Ubiquitous Computing
Bibliography: September 2001

Richard Muntz, "Capture, Management and Reconstruction of Complex Spatio-Temporal Events", (2001). Talk, Published
Bibliography: IBM Academy

M. Hasegawa-Johnson, A. Alwan, "Speech Coding: Fundamentals and Applications
", (2002). Book Chapter, Accepted
Collection: Encyclopedia of Telecommunications
Bibliography: December 2002

A. Bernard and A. Alwan, "Channel decoding - Viterbi
recognition
for wireless application", (2001). Conference Proceedings, Published
Collection: Proceedings of
EUROSPEECH 2001
Bibliography: Vol. 4, pp. 2703-2706

Q. Zhu, X. Cui, M. Iseli and
A. Alwan, "Noise Robust Feature
Extraction for ASR using
the Aurora 2 Database", (2001). Conference Proceedings, Published
Collection: Proceedings of
EUROSPEECH 2001
Bibliography: Vol. 1, pp. 185-188

X. Cui and A. Alwan, "Efficient Adaptation Text
Design Based On The

Kullback-Leibler Measure
", (2002). Conference Proceedings, Published
Collection: Proceedings of IEEE
ICASSP 2002
Bibliography: Vol. 1, pp. 163-166

Web/Internet Site

URL(s):

http://nesl.ee.ucla.edu/projects/smartkg/

Description:

This web site is for external dissemination of information related the project.

Other Specific Products

Product Type: Software (or netware)

Product Description:

SYLPH & MUSE, a sensor middleware software infrastructure, has been developed in a shared effort with another project. Besides providing the usual service discovery and proxy mechanisms, SYLPH provides ability to deal with quality of information issues, and composing higher order virtual sensor services from underlying noisy, uncertain, and failure-prone sensors.

Sharing Information:

We make the software available to interested researchers who approach us.

Product Type: Hardware design of wireless sensor nodes

Product Description:

We have developed hardware designs of two types of wireless sensors nodes: a wireless sensor badge (iBadge) to be worn on person, and a wireless sensor beacon node (Meduasa MK II) that has multiple ultrasound transceivers to function as a beacon node for localization. The ibadge is oeprational while the medusa MK II is still in design phase.

Sharing Information:

We make our designs available as file in Protel (a widely used pCB design tool) format for selected groups that ask us. Eventually (once we have tested our design) we will put the design files on the project website along with associated firmware/software. We have shared our designs with several groups at other Universities.

Product Type: Software (or netware)

Product Description:

A Java-based remote ASR system that works with the SYLPH sensor middleware.

Sharing Information:

The software will eventually be available on the project website. At the present time it is not mature enough. However, it is available to other researchers upon request.

Product Type: Data or databases
Product Description:
Data collection of children's speech, and associated protocols.
Sharing Information:
Available upon request.

Product Type: Software (or netware)
Product Description:
Code for the ITU-G.722 speech coder .
Sharing Information:
Disseminated via the web.

Product Type: Data or databases
Product Description:
Light data for several days on identical and different positions.
Sharing Information:
Available upon request.

Product Type: Software (or netware)
Product Description:
Multimodal Data Sensor Statistical Software
Sharing Information:
Available upon request.

Product Type: Software (or netware)
Product Description:
Light Modeling Software
Sharing Information:
Available upon request.

Product Type: Software (or netware)
Product Description:
Network-Flow suite of Optimization Algorithms for Sensor Networks
Sharing Information:
Available upon request.

Product Type: Software (or netware)
Product Description:
AhLos: Software for fine-grained localization via distributed collaborative and iterative multilateration
Sharing Information:
Available upon request as C-code and MATLAB files. Shall be web accessible soon.

Contributions

Contributions within Discipline:
The focus of the project thus far has been on the development of the hardware, software, and algorithms needed to realize our technological vision. In adiditon we have conducted preliminary classroom observations and deployments to refine our

procedures. As a result, the contrinutions thus far are dominantly technological. Going forward, in the final year, as we deploy our technology, we anticipate our contributions to shift towards an udnerstanding of the impact of wireless sensing technology in education.

- Middleware infrastructure capable of handling streaming sensor data, and letting it be shared by multiple concurrent applications in a mediated fashion.

- Fine-grained localization system for finding location and orientation of nodes in ad hoc networks without the use of GPS and without requiring a calibrated infrastructure.

- Range of hardware devices (ibadge, medusa) needed to create a sensor instrumented space

- Algorithms for analsysis and mining of multimodal sensor data

- Robustremote speech recognition over wireless

- Data sets from observations of children and their interactions with each other and with classroom objects while engaged in routine classroom activities

Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Unobligated funds: less than 20 percent of current funds
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Activities and Findings: Any Outreach Activities
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering

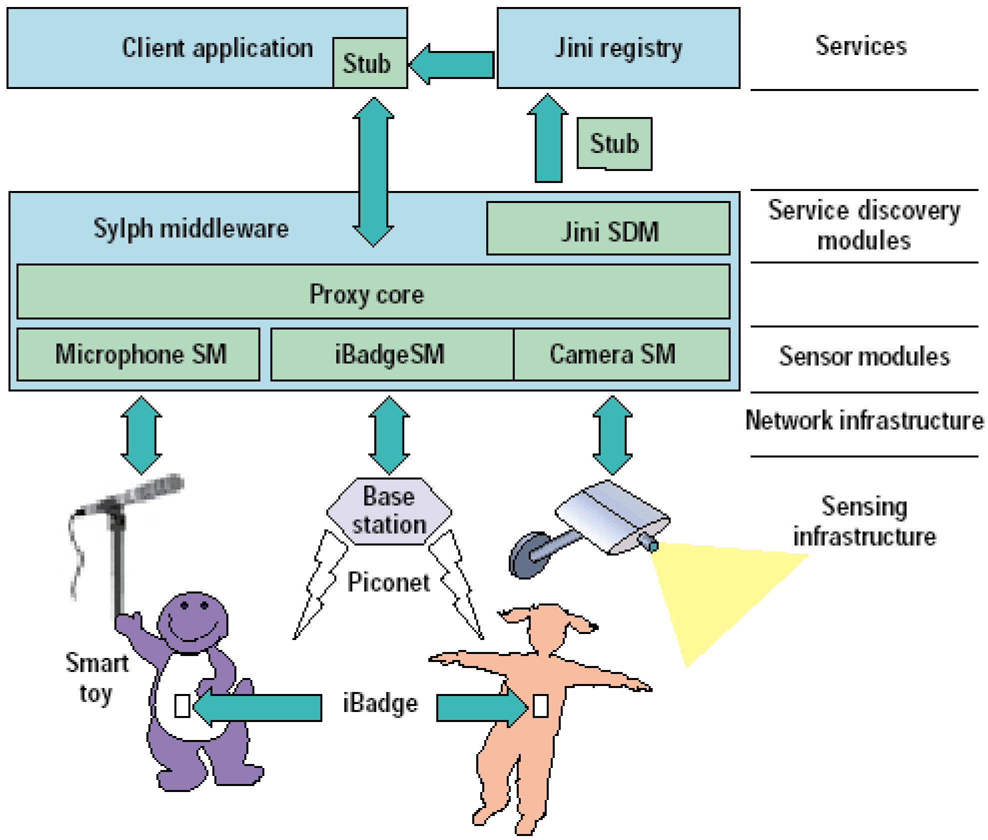

Figure 1: Smart Kindergarten Middleware Architecture

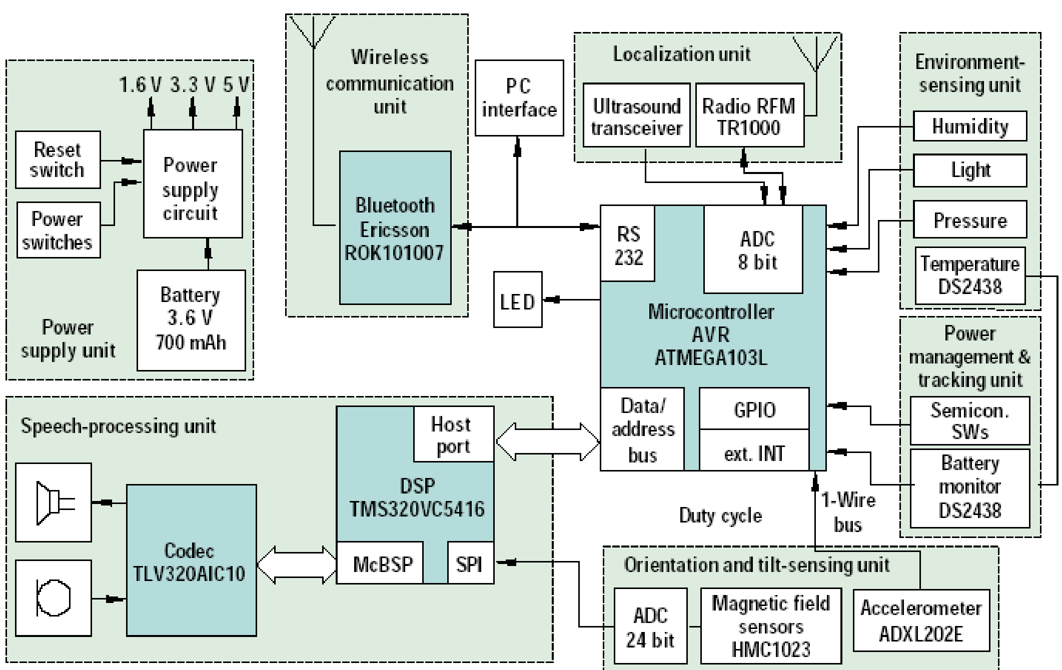

Figure 2: iBadge Architecture

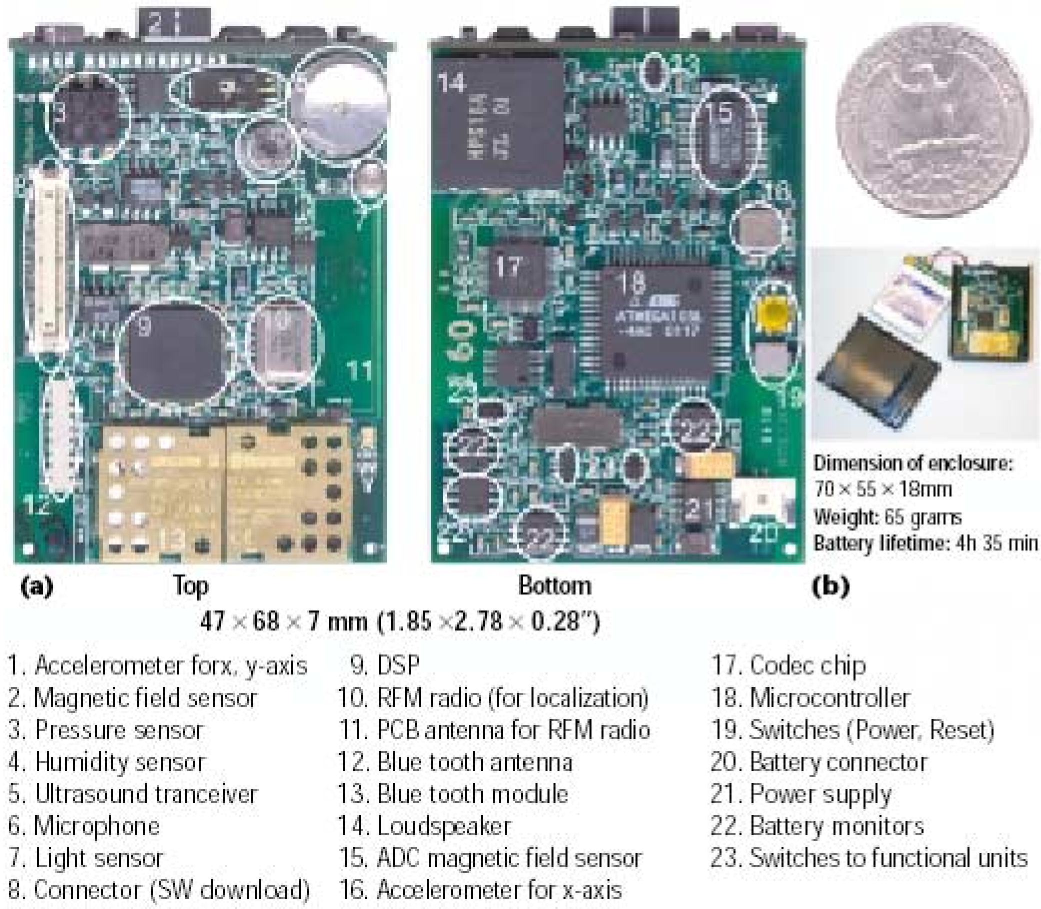

Figure 3: (a) iBadge Printed Circuit Board, and (b) iBadge Enclosure and Battery