

# Living Laboratories: The Future Computing Environments Group at the Georgia Institute of Technology

Gregory D. Abowd, Christopher G. Atkeson, Aaron F. Bobick, Irfan A. Essa,  
Blair MacIntyre, Elizabeth D. Mynatt and Thad E. Starner  
College of Computing & GVU Center  
Georgia Institute of Technology, Atlanta, GA 30332-0280 USA  
{abowd,cga,afb,irfan,blair,mynatt,thad}@cc.gatech.edu  
<http://www.gvu.gatech.edu/fce>

## ABSTRACT

The Future Computing Environments (FCE) Group at Georgia Tech is a collection of faculty and students that share a desire to understand the partnership between humans and technology that arises as computation and sensing become ubiquitous. With expertise covering the breadth of Computer Science, but focusing on HCI, Computational Perception, and Machine Learning, the individual research agendas of the FCE faculty are grounded in a number of shared *living laboratories* where their research is applied to everyday life in the classroom (Classroom 2000), the home (Aware Home), the office (Augmented Offices), and on one's person (Wearable Computing).

## Keywords

organizational overview, ubiquitous computing, context aware computing, computational perception, HCI

## INTRODUCTION

The Future Computing Environments (FCE) Group mission is to invent and better understand what constitutes an effective, everyday partnership between humans and emerging computing technology. A critical component of our approach is building and extensively experimenting with prototype environments, which we refer to as *living laboratories*. Largely due to initial successes with these living laboratories, the FCE Group is recognized as a leading research group in ubiquitous computing (ubicomp). Our reputation has resulted in growth in associated faculty and research breadth and depth.

We are in an excellent position to pursue a research agenda in which we not only create ubiquitous computation and ubiquitous sensing technologies (both embedded in the environment and worn by the inhabitants), but also uncover the essential HCI principles that will allow these technologies to be smoothly and appropriately incorporated into the ebb and flow of everyday activity. Our view of the major application themes for HCI research in ubicomp (capture, context, natural interfaces and everyday computing), as well as additional challenges to understanding the impact of ubicomp on our everyday lives, are discussed in [2].

© Copyright on this material is held by the author(s).

## THE GROUP: HISTORY AND EXPERTISE

There are now seven full-time College of Computing faculty actively involved in the FCE Group, with over 20 Ph.D. students and numerous masters and undergraduates. We have ongoing interactions with faculty and students in other units on campus, such as Electrical and Computer Engineering (e.g., the Broadband Institute) and the Center for Signal and Image Processing), Architecture, Psychology, the Center for Rehabilitation Technologies, and the School of Literature, Communication and Culture.

Both the students and faculty members have diverse backgrounds and interests covering a wide range of Computer Science, and are well balanced between areas important to the group's research agenda: HCI (Abowd, MacIntyre, Mynatt), Computational Perception and Computer Vision (Bobick, Essa, Starner), Machine Learning and Pattern Recognition (Atkeson, Bobick, Essa), and other areas of Computer Science such as Computer Graphics (Essa, MacIntyre), Assistive Technology (Mynatt), Software Engineering (Abowd) and Distributed Systems (MacIntyre).

A common interest in ubicomp led Gregory Abowd and Chris Atkeson to co-found the FCE Group in 1995 as a way of combining their diverse expertise; Dr. Abowd's research interests lie in the intersection between Software Engineering and Human-Computer Interaction, while Dr. Atkeson focuses on Machine Learning. Since then, Dr. Abowd has been looking at the research issues involved in building and evaluating ubicomp applications that impact our everyday lives, and Dr. Atkeson uses ubiquitous computing as one domain in which to explore the behavior of machine learning algorithms.

Irfan Essa joined the FCE group the following year, adding his expertise in Computational Perception to the set of diverse research areas that continue to define the group's activities. His focus is on representation, recognition, and modeling of people, their activities and behaviors. In addition, he also works on understanding the different modes of communication (speech, gesture, expressions, and touch). He is working towards applying these capabilities to build systems that are aware of people and can interact with them naturally.

Because of its growing reputation, the group doubled in size in the 1998/1999 academic year, adding new faculty members Blair MacIntyre, Elizabeth Mynatt and Thad Starner. Dr. MacIntyre brings his experience building

distributed augmented reality applications, and research interests in Distributed Systems and HCI, to the group. His research focuses on blending an assortment of “new” interaction paradigms (e.g., augmented reality, tangible media, ambient displays, wearable computing, and ubicomp) into cohesive Augmented Environments.

After spending three years exploring the HCI implications of ubiquitous computing at Xerox PARC, Dr. Mynatt brings her HCI experience with user-centered design to Georgia Tech and the FCE group. In her research, she continues to combine computer science with psychology and sociology to explore the HCI implications of ubicomp. She is particularly interested in how continuous access to computation can be integrated into everyday life.

A long-time advocate of wearable computing, Thad Starner adds a new dimension to the FCE group’s vision of ubicomp through his conviction that sensing and computation are often more appropriately located on the person rather than in the environment. With a strong foundation in computational perception, his research focuses on the use of computational agents for everyday-use wearable computer systems.

The newest member of the FCE Group is Aaron Bobick, who was on the faculty of the MIT Media Lab prior to joining the Georgia Tech College of Computing in the fall of 1999. Dr. Bobick brings to the FCE group his considerable experience with the machine perception of movement, activity and action, and with the integration of HCI and Computational Perception.

#### LIVING LABORATORIES

The cornerstone of the FCE Group is a common belief in the value of creating *living laboratories* where we can experience, analyze and improve the very technologies we are inventing. In these laboratories, we are investigating and building futuristic computing applications that apply ubiquitous computing technology to everyday life, such as in the classroom, the office, and the home. FCE members have created several living laboratories (Classroom 2000, the Wearable Computing Project, and Kidsroom [3]) and are in the process of creating two more (the Aware Home and the Augmented Office).

#### Classroom 2000

Classroom 2000 is an attempt to study the impact of ubicomp on education. The prototype classroom environment seamlessly captures much of the rich interaction that occurs in a typical university lecture. By capturing the different streams of activity in the classroom and presenting an easily accessible interface that integrates those streams together, we reduce the need for verbatim note-taking, allowing the student to engage in, and better understand, the classroom discussion. Our ultimate goal is to revolutionize the classroom experience through the evolutionary introduction of a natural and useful capture, integration and access service. Classroom 2000 has been an ongoing research effort for over 4 years with over 100 classes taught by more than 24 instructors [1].

#### Wearable Computing

As a strong advocate of continuous-access systems, and co-founder of the MIT Wearable Computing Project, Dr. Starner has worn a custom wearable computer since 1993. By living with these technologies, Dr. Starner and other members of the FCE Group are uncovering new issues and opportunities in areas of augmented memory, augmented reality, intellectual collectives, and wearable sensing.

#### Aware Home

We have initiated a research agenda centered around computing in the home. Because we feel that any significant research in this area must be conducted in an authentic yet experimental setting, much of this research will take place in the Broadband Institute Residential Laboratory, a research house that will be completed early in the year 2000. This house will serve as the living laboratory for ubiquitous computing in home life. We refer to our collected efforts as the Aware Home project, signifying our intent to produce an environment that is capable of knowing information about itself and the whereabouts and activities of its inhabitants. We have initiated parallel technology- and human-centered research programs to study the technologies (such as smart floors) as well as specific applications (such as support for elderly occupants) [4].

#### Augmented Offices

We are currently instrumenting a number of office spaces in and around Georgia Tech to help us study how ubiquitous computing can be used more effectively in the office environment. We are interested in exploring how we can perceive the activities of the inhabitants, and apply that information to more effectively support office workers who may be using a diverse set of technologies (such as wall sized or head-worn displays).

#### EDUCATION

To push our research themes into the classroom, we teach graduate and undergraduate courses in Ubiquitous Computing and run an ongoing research seminar. The undergraduate class, co-taught by all FCE faculty, gives the students hands-on experience with ubiquitous computing technologies. We also integrate ubiquitous computing issues into our graduate and undergraduate classes on computational perception, machine learning, embedded systems, HCI software and evaluation methods for HCI.

#### REFERENCES

1. Abowd, G. D. Classroom 2000: An Experiment with the Instrumentation of a Living Educational Environment. *IBM Systems Journal* 38(4): 508–530. Special issue on Pervasive computing, October 1999.
2. Abowd, G. D. and Mynatt, E. D. Future directions for Ubiquitous Computing. *ACM Transactions on Computer-Human Interaction*, special issue on HCI research in the 21st century. Provisional acceptance to appear in 2000.
3. Bobick, A. F., Intille, S. S., Davis, J. W., Baird, F., Pinhanez, C. S., Campbell, L. W., Ivanov, Y. A., Schutte, A., and Wilson, A. The Kids-Room: A Perceptually-Based Interactive and Immersive Story Environment. *Presence* 8(4): 369–393, August 1999
4. Kidd, C. D., Orr, R., Abowd, G. D., Atkeson, C. G., Essa, I. A., MacIntyre, B., Mynatt, E. D., Starner, T. E., and Newstetter, W. The Aware Home: A Living Laboratory for Ubiquitous Computing Research. *Proceedings of CoBuild’99*, pages 191–198, October 1999.