THE PLACELAB: A LIVE-IN LABORATORY FOR PERVASIVE COMPUTING RESEARCH (VIDEO)

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Video: http://www.mit.edu/~intille/Pervasive05.html

Abstract

In this video, we introduce the PlaceLab, a live-in laboratory for the study of ubiquitous computing technologies in the home. The PlaceLab is a real home where the routine activities and interactions of everyday home life can be observed, recorded for later analysis, and experimentally manipulated. Volunteer research participants individually live in the PlaceLab for days or weeks at a time, treating it as a temporary home. Meanwhile, sensing devices integrated into the fabric of the architecture record a detailed description of their activities. The facility generates sensor and observational datasets on typical domestic activity that can be used for research in pervasive computing, preventive healthcare, user interface design, and other fields where domestic contexts impact behavior.

1. Goals

Mobile and ubiquitous computing devices are transforming the way that people interact with digital information. Ideally, emerging human-computer interfaces will be able to automatically detect context and present and gather information without unduly disrupting the complex activity inherent to any real and dynamic environment such as the home. Studying behavior in naturalistic living environments allows researchers to better understand how to create such technologies that respond to and respect the complexity of life.

As a complement to existing tools and methodologies for gathering data on behavior and use of technology in home settings (e.g., laboratory user studies, surveys, interviews, ethnographic observation) we have developed a live-in, apartment-scale research facility called the PlaceLab[2], which opened in July of 2004 [1]. The PlaceLab is located in Cambridge, Massachusetts in an urban neighborhood just a few blocks from the MIT campus.

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A key motivation for the creation of the PlaceLab arose from our prior work developing context-detection algorithms in traditional laboratory settings. Controlled laboratory studies allowed dense sensor installation useful for the study of behavior and development of new context-aware algo-

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[2] The PlaceLab is an MIT House_n and TIAX, LLC collaborative initiative.

rithms, but simulated rooms or short stays severely constrained behavior variability. As an alternative approach, we have also installed portable sensors in real homes, but practical limitations dictated that only a subset of a laboratory system could be deployed at once.

A living laboratory [2] such as the PlaceLab is a compromise option that can be used to help migrate work from the laboratory setting to the home. Although asking a person to move into any environment other than his or her own home will alter some behavior, a live-in lab may allow for more natural behavioral observation and data collection on everyday activities such as cooking, socializing, sleeping, cleaning, working from home, and relaxing than can be obtained from short laboratory visits.

In designing a living laboratory for home-based technologies, we sought to complement existing methodologies and address unmet research needs. The PlaceLab was designed with 7 goals in mind: The PlaceLab (1) enables the researcher to study the intersection of physical space, technology, and people, (2) provides a natural setting that accommodates a variety of lifestyles and supports "free living," (3) provides the setting and resources to permit observation of the same participants over an extended period of time and in multiple related contexts, (4) facilitates generation of rich qualitative descriptions of user activities of interest, (5) produces comprehensive quantitative datasets that can be searched efficiently for specific events, (6) offers an agile, flexible facility to support the addition of new technologies, and (7) provides infrastructure that enables context-aware interactive applications.

2. Infrastructure

This video includes a tour of the PlaceLab and the sensor infrastructure as of January 2005. The environment has been designed so that the sensors blend into the architecture. Fifteen prefabricated and reconfigurable cabinetry components form the interior of the PlaceLab. Each contains a micro controller, an addressable speaker system, and a network of 25 to 30 sensors. New sensors can be easily added to this network as required. Existing sensors record a complete audio-visual record of activity. All sensing devices are discreetly integrated into the cabinetry, appliances, furnishings, and fixtures.

Eighty small, wired switches detect on-off and open-closed events, such as the opening of the refrigerator, the shutting of the linen closet, or the lighting of a stovetop burner. Interior conditions of the apartment are captured using distributed temperature (34), humidity (10), light (5), and barometric pressure (1) sensors. The PlaceLab also features electrical current sensors (37), water flow (11) and gas flow (2) sensors. MIT environmental sensors (MITes) are small wireless sensors that detect movement and can be easily taped onto any movable objects or worn by the participant with wristbands or ankle bands [4]. Nine infrared cameras, nine color cameras, and 18 microphones are distributed throughout the apartment in cabinet components and above working surfaces, such as the office desk and kitchen counters. Twenty computers use image-processing algorithms to select the 4 video streams and 1 audio stream that may best capture an occupant's behavior, based on motion and the camera layout in the environment. These data streams are synchronized with all other sensor data and saved to a single portable disk drive. Unlike other living laboratories (e.g. [2, 3]), the multi-modal sensing infrastructure is not only truly ubiquitous throughout the home, but also provides a single, unified, synchronized dataset for the researcher.

Example PlaceLab data streams are shown in the video.[3] They are being used to develop and test new context-detection algorithms and to prototype context-aware computing applications for desktop and mobile devices.

3. Examples of Captured Behaviors

Since opening, participants for three pilot PlaceLab stays of 10 days each were recruited via electronic mailing lists, posters, and word-of-mouth. One man and two women volunteers in their 50s who were not members of the research team or affiliates of MIT were compensated $250 for participation. Each was directed to conduct his or her life as normally as possible for the study period. The participants indicated that the primary reason they were participating was a belief that this research could yield long-term social and scientific benefits.

From these first three sessions, we have captured synchronized, multi-modal sensor records of behavior that would be unlikely to occur in settings where participants do not feel a sense of control over the environment or cannot maintain their normal routines. Participants combined computer work with music or television and spent long periods in relatively sedentary behavior, interrupted by bursts of activity, including taking breaks, making snacks, and attending to cleaning tasks. Searching behavior, for example, was on display on at least two occasions, when a participant misplaced items and searched across rooms to find them.

We also have captured multiple occurrences of problem-solving behavior in response to difficult, but commonplace technological interfaces in the home (e.g., laptop computer, television system, appliances). We observed an instance of contradictory behavior, when a participant spent a significant amount of time and effort preparing materials for recycling, while the refrigerator door was left wide open, apparently unnoticed. We have seen how participants must respond to unplanned events, such as when one participant used a hand mixer to whip pudding, splattering it all over the kitchen, prompting 15 minutes of clean-up time. In short, we see examples of typical, but complex, behaviors that comprise everyday life and that pervasive computing researchers must respond to when developing enabling technologies and applications.

These examples of complex, unscripted behaviors with synchronized sensor data can be used to develop and test emerging pervasive computing applications. Such datasets would not be easily obtained using other current in-lab or in-home observational and ethnographic methodologies and highlight an important service that living labs can fulfill. The compilation of a library of video, audio, and sensor data on common activities in the home setting may, in itself, justify the efforts that are required to build and run a living lab. Even a few concrete examples of real activity observation may provide greater value than lengthy hypothetical discussions about how users might behave in a given situation. Moreover, the collection of unusual and unplanned behaviors captured by a live-in research home can challenge designers to break out of stereotypical assumptions, ultimately leading to more creative solutions.

Among pervasive computing and health projects, the PlaceLab may be best suited for research projects such as the following: generating example datasets to evaluate context-detection and activity detection algorithms; validating existing and new ethnographic instruments, such as surveys or portable sensing tools, to improve large-scale data collection efforts; determining which of hundreds of sensors are best suited for various pervasive computing projects; qualitatively measuring responses

[3] Examples in the video show a member of our research team in order to protect the privacy of the actual volunteers.

to innovative context-aware pervasive computing applications; and creating a library of example activities for use by pervasive computing designers to ground discussions during the creative process about what people in homes may or may not do.

For example, health researchers interested in diabetes and obesity want to understand eating and cooking behavior. Experts in these fields will often readily admit that they have a fairly poor understanding of behavior and how the context of everyday life impacts people's activity and decision-making in the home – because they don't have the appropriate research tools. Video and sensor data such as that shown here can be used to validate existing and new tools for gathering information on the impact of context on behavior.

Researchers who may be interested in using the PlaceLab or PlaceLab datasets are encouraged to contact the authors.

Acknowledgements

This work was supported, in part, by National Science Foundation ITR grant #0313065 and the House_n Consortium. In addition, we thank TIAX, LLC and our initial volunteers.

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