Augmenting Memory for Student Learning: Designing a Context-Aware Capture System for Biology Education

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ABSTRACT
The Memex Metadata for Student Portfolios (M^2) project is using mobile technology to augment student memory and improve student learning. We have constructed a student-targeted Context Awareness Framework (CAF) and we are developing a metadata scheme that integrates the CAF with a variety of mobile technologies. In particular, we are exploring the use of Microsoft SenseCams, which capture images and sensory data approximately every 90 seconds and can extend student memory, enabling for an enriched learning experience for undergraduate biology students. We are exploring the use of SenseCams along with other mobile devices (e.g., a GIS and Tablet PC) for biology students conducting scientific field work such as specimen identification. The development of our CAF and metadata scheme also support the development of e-portfolios that can extend student memory and maintain useful records of educational activities. This paper presents research and development activities underlying the $\mathbf{M^2}$ project, including research methods, evaluation activities, and next steps.

Keywords
Personal Information Management, Metadata, Ontology, Educational Technology, Memory

1. INTRODUCTION
Digital memories surpass biological memories by enabling people to directly see and interact with captured information. This powerful capability can help people manage their personal information. But personal collections become harder to manage as they grow in scope and complexity [3, 4]. This tradeoff is especially salient in education. Students and instructors commonly rely on mobile technologies (laptops, cell phones, PDA's) to capture, organize and use information. This approach falls far short of the ideal—a unified and useful e-Portfolio.

In this paper, we describe an alternative approach that can both *reduce complexity* and *improve retrieval* of captured digital educational information. We are designing a context-aware capture system for undergraduate biology students. This system will enable students to automatically capture virtually all of their personal educational information—such as lecture notes, slides, videos, lesson plans, and assigned readings, as well as paper drafts, assignments, brainstorming on whiteboards, or images and artifacts from field trips.

In this paper, we present the M^2 project's work, including research methods, evaluation activities, and future work.

2. PERSONAL INFORMATION MANAGEMENT (PIM) AND STUDENT PORTFOLIOS
Higher education is one domain where contextual retrieval is particularly promising. Wide use of portable computing devices, along with increased use of electronic course management software such as Blackboard and WebCT provide new opportunities for students to synthesize information and to assemble personal portfolios for evaluation. Personal, digital educational portfolios allow students to assemble notes, slides, videos, lesson plans, readings, and other digital artifacts as well as their own work products [1, 2, 6]. PIM research suggests that people tend to apply only rudimentary classification schemes to personal information; therefore, much PIM development has focused on search tools [3, 4].

The M^2 project extends this focus on search, by adding contextual metadata to automatically-captured educational information, enabling improved information organization, enhanced recall and recognition, and potentially improved learning.

3. RESEARCH OBJECTIVES

The objectives of our work include:

- Building and testing a Context Awareness Framework (CAF).
- Designing a Metadata Scheme to support effective contextual retrieval.
- Integrating the capture system, CAF, and metadata scheme.
- Evaluating the prototype system with students.

4. METHODS AND RESULTS

4.1 Context Awareness Framework (CAF)

A foundation component of our work is the Context Aware Framework (CAF), which embodies knowledge of user context [see Figure 1]. The CAF integrates a series of ontologies constructed using the W3C's Web Ontology Language (OWL) [http://www.w3.org/TR/owl-features]. The CAF records context information such as location, preferences, social network, current role, or schedule. We have developed intelligent software agents to leverage context awareness to provide advanced services for users. For example, when combined with GPS or RFID location information, the CAF can detect that a student has entered a classroom for a specific class and load necessary software or content for the designated class session.

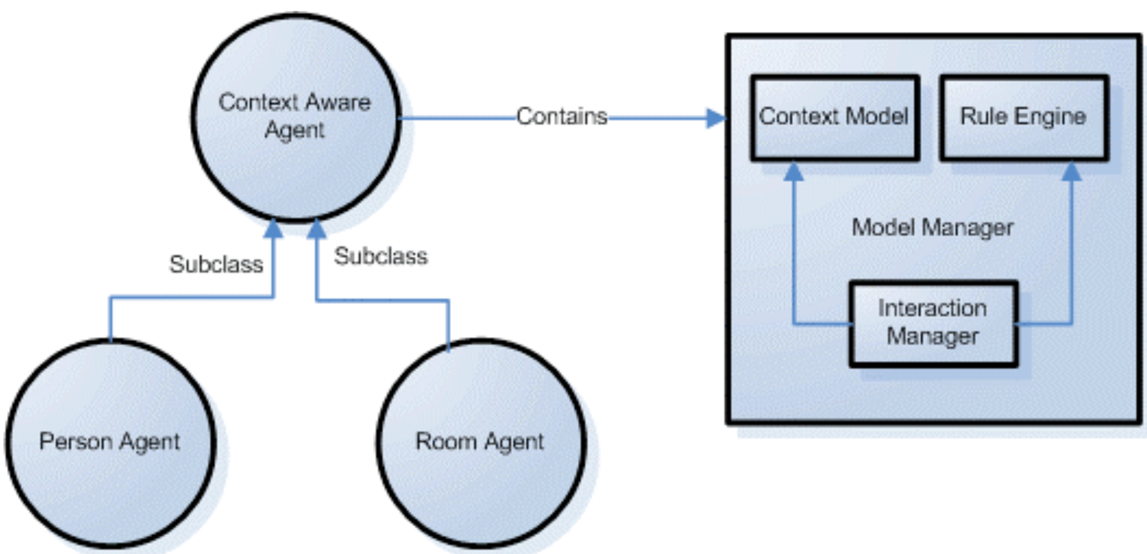

Figure 1. Context Awareness Framework architecture.

The CAF software agents are implemented in Java using the Java Agent Development Environment (JADE) toolkit. JADE is an implementation of the Foundation for Intelligent Physical Agents (FIPA) intelligent agent standards. Each context-aware agent provides a model manager that contains its internal context model. The model manager uses ontologies and rule sets to understand context and make inferences about information that comes in from the environment.

4.1 M^2 Metadata

The CAF is being enhanced by the development of a metadata scheme that will record object content, structure, and context. Metadata schemes generally focus on specific functions, or a series of functions, such as resource discovery, preservation, or structure [5]. The M^2 scheme integrates and extends common metadata-supported functions to facilitate context awareness. Our scheme includes automatically captured metadata (e.g., *date* and *time* of an event, *location*, *student id*—all of which are generated from mobile technologies or automatically derived from pre-programmed data. This automatically captured metadata is integrated with manually generated metadata (e.g. *subject annotation*).

Scheme development is based on a metadata model that considers sequential activities (e.g., description of event 1, followed by description of event 2, and so forth). A fundamental question we are exploring is "When, during an activity, is the best time to automatically capture or provide an interface for manually creating metadata?"

4.3 Evaluation
Based on interviews with biology instructors, and a review of syllabi and relevant class assignments, we have developed a user study to evaluate the prototype system. The user study will address whether students can effectively learn to use the system, and whether it supports their educational needs.

In the study, participants will explore the flora of a local arboretum while wearing a SenseCam and a GPS unit, and working with a tablet PC. The SenseCam will capture pictures of the environment which will be annotated with their location from the GPS. The SenseCam can record 2,000 images per day, or over 700,000 per year. Dealing with this volume of data—answering the question "How does one find a particular image among 700,000?"—is also fundamental to our work.

Participants will use the retrieval interface to work with the captured data, and use it to complete a plant identification assignment, create a log of plants found, and map their observation route. Instructors will evaluate these assignments, and students will be interviewed to assess their experiences with the capture system.

5. FUTURE WORK
We have been studying information use in biology classes. We are pilot testing biology students' use of the SenseCam and Tablet PC's (with GPS units) in the field. We are testing the usability of MLB in supporting retrieval of Web-based biology information and class notes and materials, as well as MLB's organization and annotation capabilities. This work will help us to understand in more depth students' use of automatic capture and retrieval tools. These insights will enable us to improve the retrieval interface, and work with biology instructors to develop new class activities that leverage the capture system.

6. ACKNOWLEDGMENTS
We would like to acknowledge Microsoft Research and UNC's Information Technology Services for their support.

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