Beyond Human Memory:
SenseCam Use in Veterinary College and as Assistive Technology

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1. Problem Statement

We propose a research, development, and education program at Virginia Tech that will help lead to a world in which SenseCam-type devices are widely used. We will leverage our work on the 5S (Societies, Scenarios, Spaces, Structures, and Streams) framework [10] so that our efforts have a sound theoretical foundation. We will demonstrate the power of our approach, using it to guide our exploration in two very different application areas, and showing that the tools and techniques we discover have broad applicability. In area one, we will study how students in the Virginia-Maryland Regional College of Veterinary Medicine (VMRCVM) integrate their personal information to assist them in their day-to-day study and practice. In particular, we will focus on the use of SenseCams by pairs of collaborating students in labs, and will explore how data from multiple SenseCams can be integrated. In application area number two, we will explore how students with motor disabilities can benefit, and will use a SenseCam to track location throughout the day. The information collected by the SenseCam will be used by a care-giver to help identify locations on campus where handicap access is problematic. The focus on this second area is to provide a record of daily activities for a student with disabilities and to enhance student/care-giver interaction to better provide services.

In the next two sections, we present scenarios to provide context in which our work will be developed. We follow each scenario with a brief highlight of the issues to be studied in the project.

Virginia-Maryland Regional College of Veterinary Medicine: The students in Veterinary Medicine are being inundated with massive amount of data from their lectures, meetings, discussions, and laboratory sessions with live and dead animals (anatomy). They have electronic access to the published literature as well as their personal information, such as email messages, instant message transcripts, and information from various web sites. In addition, there is significant involvement in mentoring; senior students participate in the medical treatments under the supervision of the doctors at the Veterinary Teaching Hospital on campus. The following scenario helps characterize a day in the life of a Veterinary Medicine student, we have included here the role that a SenseCam can play in the student's activities.

> Kara is a second year student in the veterinary school. Before leaving her room in the morning, she turns on her SenseCam, which hangs around her neck. Her morning classes begin at 8 am so she hurries down Duck Pond Drive to the lecture hall. In the lecture hall, while her SenseCam records audio and video data, she highlights and adds comments on the lecture notes she received from the professor. After taking three classes straight, sitting in the same seat, she feels a little drowsy, but remains confident of the value of her program since she knows all the lectures are being recorded in her SenseCam for later review.
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> During the lunch break, she has a review session with her clinical-techniques group in the dining hall about yesterday's physical exam procedures on a dog, a cat, and a horse. The clinical-techniques class requires thorough re-

views because different physical examination procedures are required for different animals. Everyone studies from their notes in their Tablet-PCs, and tries to remember the procedures they observed. The afternoon is busy with yet - another lab session with a live animal. Kara records information on paper but the clear images of complex clinical tests are forgotten gradually. To refresh her memory of the anatomy sessions for the final exam, she often comes back to the lab with other students, where they struggle to recall the procedures based on their notes and their text-book.

When Kara goes home she places her SenseCam on the dock to recharge and to download the recorded data into her laptop. In the evening, she begins to study pharmacology in a cafe. Kara opens up her laptop and connects to the course web site. It shows the typical network of interconnected information including lecture notes, audio and video data, etc. All this data is interconnected by relations and include not only data the professor has made available to the students, but also notes that Kara has taken as well as notes and information some of her peers have tagged as public. Some of the data here comes from her own SenseCam, as well as from other student's SenseCam. Kara studies the video and audio file of the lecture, glancing at her annotations on the right side of the screen.

We will study the problems of memory recall and heterogeneous data storage/retrieval/sharing using the SenseCam and MyLifeBits in the context of student life at the Vet School. The goal of this is to improve the memory recall of clinical procedures studied in lab sessions and to promote learning through sharing of information among students. Integration of audio/photos from multiple SenseCams, video from the professor, and live notes taken by several students should improve memory retention and recall of clinical procedures.

We will use the MyLifeBits architecture to share some of the information captured. Students will have the option of providing access to particular pieces of information by particular users. This information will be uploaded automatically to a web server where it will be available to other students for download into their MyLifeBits data store.

Students with Disabilities: Students with disabilities struggle in their day-to-day activities on most university campuses. Their struggle, however, is not only with the academic coursework. At times it involves finding a ramp into a building, reaching an elevator button that is too high, or maneuvering around a corner in a hallway that is too narrow. A SenseCam used by a student with disabilities could provide direct benefits to them by helping them avoid more than a single instance of such problems, and also could help each student's care-giver and university staff in analyzing how to better serve the needs of this campus population. Consider this scenario.

John has muscular dystrophy and is unable to move from one place to another without the help of a motorized wheelchair. His arms are weak and fragile and any intense workout could exhaust his whole body. Still, he tries to do everything himself without the help of others. He sees himself as any other student on campus. However, there are times when architectural barriers cause him to surrender. His care-giver, Ben, would be happy to follow John to class to see if he can help mitigate some of the barriers. However, John believes he should be self-sufficient, and has told Ben that he can handle everything himself.

On a normal day, John rides the elevators to his class on the third floor. Before going into the class he takes a restroom break. He notices that the door handle is situated in a way that hinders a smooth entrance into the restroom. After pulling and maneuvering his chair to access the restroom, he finally gets in. Tired and almost out of breath he goes into the accessible station. Upon his exit he goes through the same difficulties when he tried getting in.

With the help of the SenseCam, John's daily activities have been recorded. John uses the audio and pictures from the SenseCam to analyze the day's activity and help him remember key events. Furthermore, he shares with Ben some of the SenseCam data from his SenseCam. Ben uses the SenseCam to study barriers and problems John faced. He can identify problems that John has faced (even if John was not consciously aware). Ben also sees a navigational

map of the routes John takes to get to and from class; he uses this data to help the Assistive Technologies Staff identify locations used by students with disabilities. He classifies sites, noting those which might need further improvement or re-design. The SenseCam keeps track of GPS locations when outside. A small handheld device equipped with 802.11, coupled with the SenseCam, keeps locations while inside buildings. Thus, Ben is able to assist John in making student life much easier.

We are interested in exploring how a SenseCam can help students with disabilities in their day-to-day activities on campus. In particular, we are interested in using location tracking and some form of simple tagging of the audio or video data to help students with prospective remembering. We also are interested in allowing students with motor disabilities to share data with their care-giver and/or with the Staff of the Assistive Technologies office. We have the capability of tracking locations indoors through the use of an 802.11 device [13].

2. Why is it important?

In both scenarios above, our focus is on helping students in their daily life. The similarities end there, however. In the case of Vet School students, the key problem is information overload. Students take up to 4 courses, struggling to remember clinical procedures after having observed a demonstration just once. The level of collaboration is high with students in this setting, so a SenseCam can become a source of data to be shared with others. The challenge is to determine how the students want to designate what to share, and how to integrate the information from multiple sources (including from different students).

In the case of the student with disabilities, information overload is not as serious a problem. The SenseCam, however, can be a leveling agent, allowing them to have an audio recording of class and record of the day's activities. Location tracking coupled with Rapid Serial Visual Presentation [9], can help care-givers and other personnel to assist the students in their movement around campus.

3. What is the potential contribution to the field of the project if successful?

This project involves the study of the use of a SenseCam by non-technical users. In both cases described above, sharing and collaboration takes place; we will explore how such a SenseCam can assist in this collaboration. The two user populations explored will have very different social needs for collaboration, personal gains from the collaborations and different motivation for engaging in collaborative data sharing. The potential impact of the use of the SenseCam in these two scenarios is tremendous. All should benefit by having data integrated into an organized web of information that includes not just class notes, but also personal video/audio of experiences in hands-on applications, in lab, class, and around the campus and town.

4. Previous Work

MyLifeBits [8, 9] is both an application and a framework to manage a personal lifetime of memories. It emphasizes organizing multimedia files, with results accessible according to a timeline or a cluster. It's a system for storing and retrieving all of one's digital media, including documents, images, sounds, videos, web pages visited, emails, etc. A time property cov-

ers the time range to which a content refers allowing time-based browsing. The framework also supports named links that support automatic or manual relationships to be built. The relationships can be semantically meaningful, helping in the retrieval of information. MyLifeBits stores its data in an SQL server and thus can be extended by accessing the SQL server directly. MyLifeBits allows developers to build new visualizations of data that can be integrated into is shell. Our work will use MyLifeBits in two ways. First, we will use it as the central repository of information for our users. We will extend its functionality to include new data elements (802.11 location inside of buildings), and new visualizations (route mapping both outside and inside building). The second extension involves functionality for sharing data over a web site for the students in the Veterinary School. We will explore both publishing personal data as well as importing other's data.

Stuff I've Seen (SIS) [7], developed at Microsoft, is another system that helps users gain access to personal information without the need of strict organization of the information. The key features in this system are: cross information index and using contextual information in its search interface. SIS transforms the problem of personal information management from data organization to searching. It builds an index for all relevant information, no matter its source. It uses multiple clues such as time, author, and thumbnails to assist the user in building a query.

Ringel [12] explored the value of extending timeline views by incorporating both public and personal landmarks. Psychological research suggests that memory is organized into episodes and that people use anchors when trying to reconstruct memories of the past. Ringel et al.'s research treats landmarks as anchors for episodic recall. Public landmarks include holidays and news events. Personal landmarks include calendar appointments and digital photographs. The Remembrance Agent [11], a weareable computer, also used automatically captured context to aid information retrieval. Our work will explore the impact of public events, such as scheduled talks in the Veterinary School, in the recall of information for students.

Semex [1, 6] is another system that uses a flexible desktop feature. In general, the area of desktop searching desktop is very topical these days. Apple, Microsoft, and Google all have entries into this domain [2].

Vemuri et al. [14] developed a wearable "memory prosthesis." They recorded audio in a pocket PC and transcribed it to text using IBM's ViaVoice. Users were able to browse by date and time, and to search for keywords. The tool helped mitigate memory problems associated with transience, blocking, and misattribution; it serves as a model for audio based memory prostheses. This approach might help disabled students to access information recorded from personal conversations for prospective recall.

Of particular note is the method used by Vemuri et al. [14] for evaluating their system. We plan to use a similar protocol in our evaluation of memory aids in the Vet School studies. We will ask two students of Veterinary Medicine to wear a SenseCam for a week at a time. A few weeks later, we will ask questions related to material presented in lab lectures and related to other Vet School activities. We will administer this questionnaire to the students who had the SenseCam as well as their

peers that were present in the lab but did not have the SenseCam. In short, Vemuri et al.'s work will be a model for us when developing the procedures to test and evaluate SenseCam impact on memory recall. The goal is to identify: memory improvements (better recall), issues of privacy (how did other students feel about being recorded), and how the information might be shared. We will repeat this study in the second semester, having improved the software infrastructure, in particular the capability for data sharing between students.

5. Schedule and Procedure

Term	Veterinary School	Students with Disabilities
Spring 2006	Early-semester - 2 students use SenseCam for week at a time Mid-semester - administer memory test; design and prototype data sharing functionality Late-semester - focus group, interview students	Early-semester – identify students that will participate, consider privacy and legal issues Mid-semester – allow student to use SenseCam for a period of time. Design and prototype indoor route visualization. Late-semester – analyze effectiveness of SenseCam for students with disabilities
Summer 2006	Implementation of new functionality into MyLifeBits schema. Write papers with early results, participate in workshops	
Fall 2006	Repeat memory study using new functionality. Consider collaboration and sharing of data more explicitly.	Recruit new participants Deploy system with participants and care-givers Evaluate effectiveness.
	Publish results, participate in workshops	

6. Use of Funds

Category	Amount
GRAs Step 13, plus fringe benefits. This includes 1 GRA for 12 months (Jan 06-Dec 06) and another GRA for just the spring semester.	$28,604.00
Tuition for GRAs for three semesters	$9,990.00
Travel to present work at conferences, participate in workshops	$4,000.00
Equipment - laptops for the GRAs so they can do their work/capture data, 802.11 equipment	$4,800.00
Materials and supplies ($1000) and payment for study participants ($1500)	$2,500.00
Period of performance: January 1, 2006 till December 31, 2006, **Total Requested Amount**	$49,894.00

7. Expected Outcomes

The expected outcomes of this work include: 1) a better understanding and a characterization (using the 5S framework) of how this technology (digital memory, SenseCam) can improve the lives of non-technical users; 2) identification of problems with technology for these populations, along with suitable solutions; 3) design and implementation of a framework for sharing SenseCam data; and 4) extension of the MyLifeBits architecture to include new sources of data (e.g. another student's notes) and new visualizations.

8. Number of SenseCams Requested: We are requesting two (2) SenseCams**.**

9. Dissemination and Evaluation

We plan to publish results at some of the following conferences: JCDL/ECDL, SIGIR, SIGMOD, and Ubicomp. Also, Pérez-Quiñones is coordinating a workshop on information-reuse to be held in 2006. We will include the area being studied in this proposal (digital memories) as part of that planned workshop.

10. Other Support

The following list includes personnel at Virginia Tech that has agreed to collaborate on this project.

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11. Qualifications of PIs

Dr. Pérez-Quiñones is an assistant professor in Computer Science at Virginia Tech. His areas of interest include human-computer interaction, information refinding [2], mobile devices [3, 4], personal information management [5], and educational uses of computers. He has served on several conference program committees, and serves in the Editorial Board for JERIC. He was an NSF Career Award recipient. He completed his PhD at George Washington University in 1996 under the supervision of Dr. John Sibert.

Dr. Edward Fox is a full professor in Computer Science at Virginia Tech. He is chair of the IEEE Technical Committee on Digital Libraries, Executive Director of the Networked Digital Library of Theses and Dissertations, and runs VT's Digital Library Research Laboratory. He is involved in the organization of ECDL, JCDL, and ICADL – the leading digital library conferences around the world, as well as many editorial boards. He completed his BS at MIT in 1972 working with Licklider and Kessler; his PhD was completed in 1983, supervised by Salton at Cornell.

References

1. Y. Cai, X.L. Dong, A. Halevy, J. M. Liu and J. Madhavan (2005) *Personal Information Management with Semex*. SIGMOD 2005.
2. R.G. Capra and M.A. Pérez-Quiñones (2005) *Using Web Search Engines to Find and Refind Information*. to appear in IEEE Computer, Oct 2005

3. R.G. Capra and M.A. Pérez-Quiñones (2005) *Mobile Refinding of Web Information Using a Voice Interface: An Exploratory Study*. To appear in Proceedings of 2nd Latin American Conference on Human-Computer Interaction, Oct 2005, Cuernavaca, MX
4. C. Chhatpar and M.A. Pérez-Quiñones (2003) *Dialogue Mobility Across Devices*. In Proceedings of the ACM Southeast Conference (ACMSE 2003), pp. 62-63. Savannah GA.
5. M. Czerwinski, D. Gage, J. Gemmell, T. Catarci, C.C. Marshall, M.A. Pérez-Quiñones, M.M. Skeels (2006) *Digital Memories in an Era of Ubiquitous Computing and Abundant Storage*. To appear in CACM January 2006 Special issue on Personal Information Management.
6. X.L. Dong, A. Halevy and J. Madhavan (2005) *Reference reconciliation in complex information space*. In Proceedings of the 2005 ACM SIGMOD International Conference on Management of Data, ACM Press: Baltimore, MD. Pp. 85-96.
7. S. Dumais, E. Cutrell, J.J. Cadiz, G. Jancke, R. Sarin and D. C. Robbins (2003) *Stuff I've seen: A system for Personal Information Retrieval and Re-use*. SIGIR, 2003.
8. J. Gemmell, G. Bell, R. Lueder, S. Drucker and C. Wong (2002) *MyLifeBits: fulfilling the Memex Vision*, in Proceedings of the tenth ACM international conference on Multimedia, ACM Press: Juan-les-Pins, France. p. 235-238.
9. J. Gemmell, L. Williams, K. Wood, R. Lueder, and G. Bell (2004) *Passive Capture and Ensuing Issues for a Personal Lifetime Store*. In Proceedings of CARPE '04, pp. 48-55.
10. M.A. Goncalves, E.A. Fox, L.T. Watson, N.A. Kipp (2004) *Streams, structures, spaces, scenarios, societies (5s): A formal model for digital libraries*. ACM Trans. Inf. Syst., 2004. 22(2): p. 270-312.
11. B. J. Rhodes (1997) *The wearable remembrance agent: a system for augmented memory*. In Proceedings of the 1st IEEE International Symposium on Wearable Computer. IEEE Computer Society.
12. M. Ringel, E. Cutrell, S. Dumais, E. Horvitz. *Milestones in Time: The Value of Landmarks in Retrieving Information from Personal Stores*. Proceedings of Interact 2003, p. 184-191.
13. M. Sampat, A. Kumar, A. Prakash, and D. Scott McCrickard (2005) *Increasing Understanding of a New Environment using Location-Based Notification Systems*. Poster paper in Proceedings of 11th International Conference on Human-Computer Interaction (HCII '05) , Las Vegas NV, July 2005.
14. S. Vemuri, C. Schmandt, W. Bender, S. Tellex, and B. Lassey (2004) *An audio-based personal memory aid*. In Proceedings of Ubicomp 2004: Ubiquitous Computing. September 7-10, 2004. Nottingham, UK. pp. 400-417.