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Health Training with SAVOIR and the RSM

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Abstract—SAVOIR, a middleware system, provides services that coordinate usage of a wide variety of collaborative and advanced applications, devices and services, and coordinates them for multiple simultaneous participants. Collaboration among participants is captured and recorded to bridge the knowledge gathered in past collaborations, making it available for future sessions. The Resource Space Model can effectively manage the references to the heterogeneous rich media in the stored sessions, and forms the basis for a flexible query mechanism. This paper presents the design of a healthcare training system based on SAVOIR and RSM, and is a specific instance an EventWeb.

I. INTRODUCTION

SAVOIR (Service-Oriented Architecture for a Virtual Organization's Infrastructure and Resources) is a collaborative system which is being used to train health care professionals in clinical settings. It can support people from different organizations to work cooperatively via different types of devices which are accessed via Web services. Participants include tutors, students and observers. The system allows these users to share access to rich multimedia devices for health care training; such collaborations are called SAVOIR sessions. Moreover, SAVOIR captures and records training sessions and can access previously recorded sessions and deliver them to new sessions

For each session, the system records the locations of the collaborators, their activities, their requests for data files, their conversation over text-chat and audio, what subjects they were discussing, their expertise, the goals of the session, etc.

This captured data and metadata as well as the audio/video signal and timing information are stored in a file system. References to them, which allow query-based searches are stored also. How to manage the recordings of these heterogeneous sessions effectively is an interesting research issue. Current database systems based on the relational data model are specialized in managing rather simple data [1]. The data cube is mainly for online data analysis and supporting read-only operations [2].

The Resource Space Model RSM is specialized in managing contents through multi-dimensional classification [3, 4, 5]. It is a semantic data model for specifying, storing, managing, and locating contents of various resources by appropriate classification.

II. DISTINGUISHING FEATURES OF SAVOIR

SAVOIR provides a middleware for integrating a variety of interactive devices, services and resources to provide a rich collaboration experience for several participants. It manages the interactions through several management services: the user manager, the session manager, the resource manager and the workflow manager. We use the term *edge* service to refer to

any of the interactive devices, services and resources that are not part of the core of SAVOIR. These devices are wrapped as web services and thus made available to SAVOIR. SAVOIR also provides a bus which allows the edge services and users to share information. Recently we have added a threshold manager, which consists of a rule engine loaded with rules specific to a given situation. When the state of one of the resources or users changes in a way that signals an important event, like a patient's condition worsening, then other events are triggered to provide an appropriate response. Besides coordination, SAVOIR also records the information captured during the session. For the visual tools, it captures and audio-video file and marks it up with the usage information that is available at the time: who is using the tool, what data files are being accessed, etc.

In Fig 1, several health-related edge services are attached to SAVOIR.

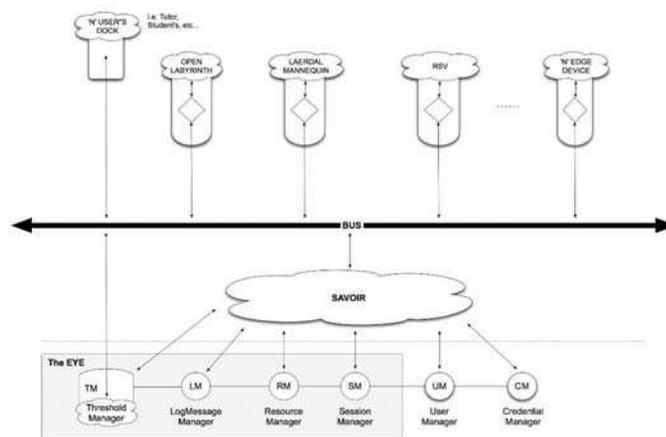


Fig 1. SAVOIR and resources for the health training

Some tools communicate vital signs like blood pressures, respiration rate, pulse, etc. The Hypovolemic Shock Model is a mathematical model for health and medical monitoring of the blood vitals of a simulated Virtual Patient. Other tools include the human-like mannequin from Laerdal which allows students to practice performing procedures such as intubation, cardiopulmonary resuscitation, injections, etc.

Remote Stereo Viewer (RSV) [6] is an immersive 2D and/or 3D experience which enables a student, instructor, doctor or other medical staff/researcher to view anatomical models of specific parts of the human anatomy, from all angles using intuitive navigation. VolSeg [7], or the Voluminous Segmentation Viewer, performs volumetric rendering of the Visible Male dataset [8], and allows participants to analyze the tissue layers of a cadaver, enabling insight into tissue structure, symptoms of disease and causes

of death, as well as overall anatomy. It simulates interactive dissection by allowing the user to choose where and what to cut away and reveals the tissues beneath.

For these tools, SAVOIR records the specific information on the subject of interest. All such information is recorded with a time stamp so that an event can be replayed and the various parts can be resynchronized.

III. DESIGN OF RESOURCE SPACES

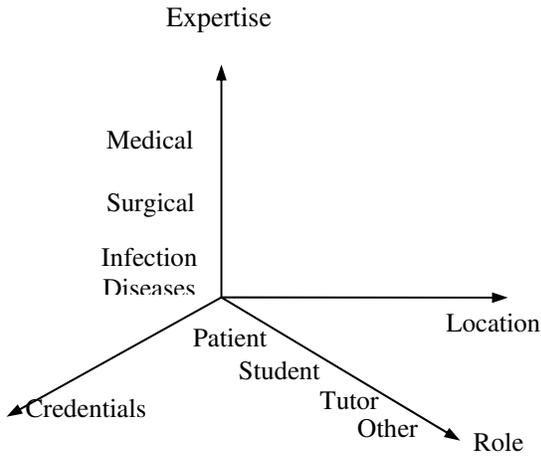


Fig. 2. The resource space for managing persons who involve in the application.

An n -dimensional resource space represents n kinds of classification method. Selecting one coordinate at every dimension can locate a set of resources of the same category. Since a resource space focuses on contents, resources in a point can take any form. Dimensions in a resource space are discrete and every coordinate can be a coordinate tree, where the low-level coordinates finely classify their parent coordinate. A resource space can be normalized to ensure the correctness of managing resources by setting constraints on axis and between axes. The normal forms of the RSM are to realize this type of normalization. Fig 2 and Fig 3 shows the design of two resource spaces for managing health care training resources.

A session may consist of several segments, which could involve any form of media. As a resource space only manages the index of resources. So segments of a session can be managed by a resource space, as shown in Fig 4. A point in the space represents the category of a segment.

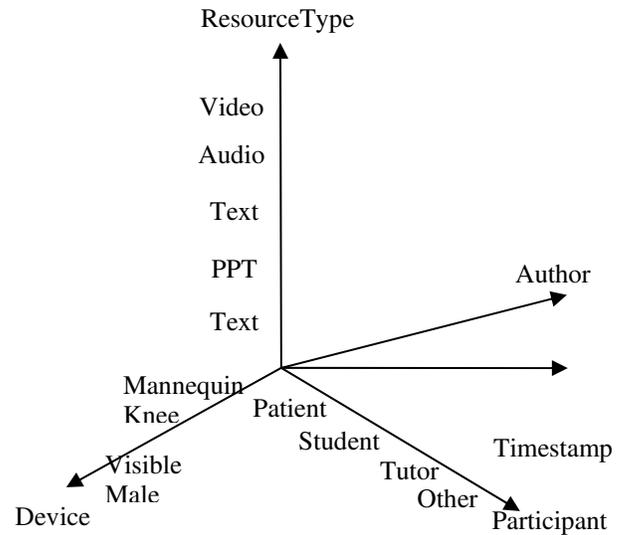


Fig. 3. The Resource Space for managing resources.

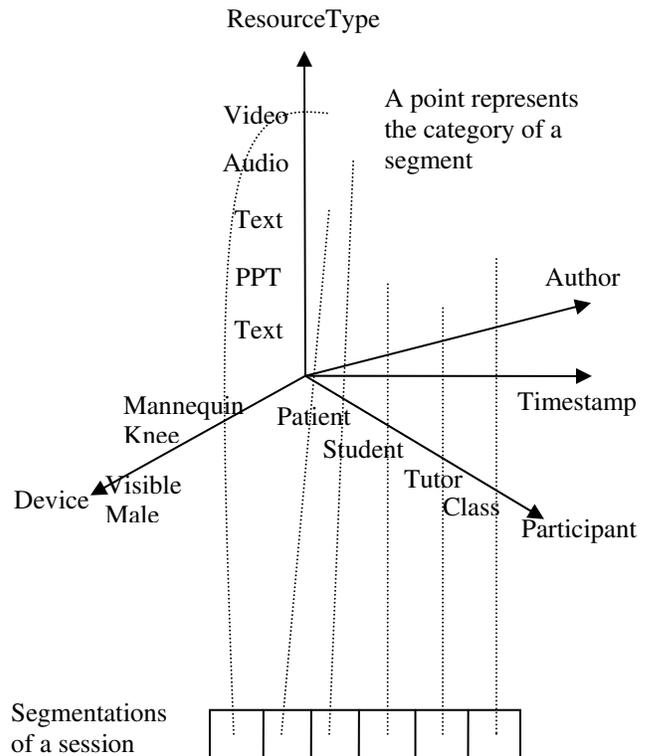


Fig. 4. A resource space can manage segmentations of a session.

IV. COOPERATIVE MECHANISM

A. Sessions

A SAVOIR session, which integrates a number of resources, devices and applications, can often be divided by time into several segments. Each segment may have its a distinct set of users who are making use of several devices. Fig. 5, 6, and 7 show three segments focused on 3D visualization with RSV, interactive camera, and virtual surgery respectively.

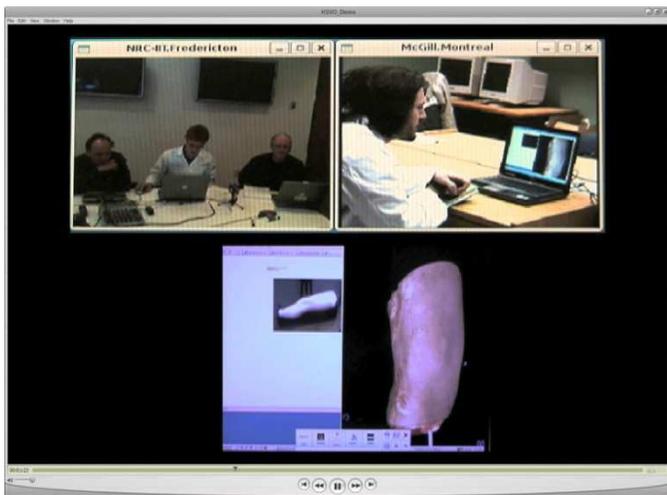


Fig.5. A segment showing collaboration on 3D visualization of the knee.



Fig.6. A segment showing collaboration via an interactive camera.

We show an example session with three segments. In the first segment, in Fig 5, we see two teams of people, one in Fredericton consisting of three students, and one in Montreal, consisting of several students and one instructor. Both of the teams of students are studying the knee; they are using RSV to look at a stereo image of the knee. There is also a knee model in Montreal and the students in Fredericton have access to a interactive camera array that provides four video feeds on the

knee model. In Fig 6, the students in Fredericton have selected any one of the feeds to be the one that is sent from Montreal to Fredericton. In case one of the camera's view of the knee is obstructed, for instance by the instructor's hand in Montreal, the Fredericton students can select a different view.

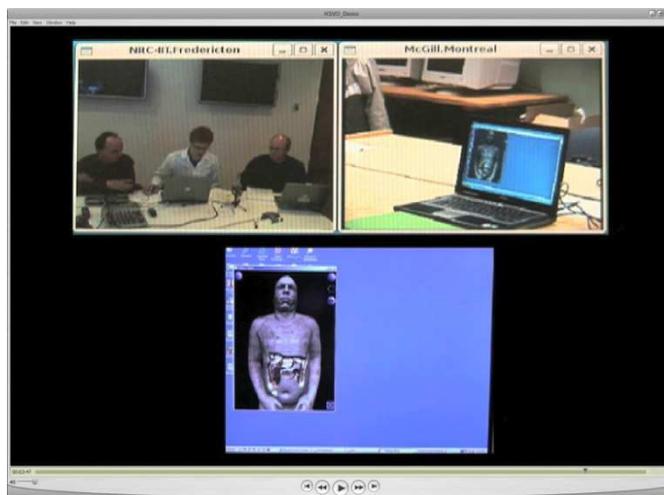


Fig. 7. A segment showing collaboration on a 3D visualization of surgery.

In Fig 7, the students have moved on to a surgical simulation with the VolSeg which performs volumetric rendering of the Visible Male data set. The instructor asks the students in Fredericton to illustrate how the tools works and the students in Montreal can follow along, thus illustrating how it is the collaboration and communication between participants that creates the rich experience for each user.

B. Creation of Rich Repositories

Besides value created by SAVOIR collaboration, data files which capture SAVOIR session also provide value. Richly annotated, segmented media files are a valuable resource for off-line reviewing of teaching sessions like the one just presented, and for bringing information in those previously recorded sessions into the current session. Imagine that following this session on the knee, a group of students no longer has access to the physical model of the knees, but needs to locate the point on the skin surface where pain originating in a ligament would be expressed. This was pointed out by the instructor in Montreal. This particular session was marked up with the subject ligament pain. This markup could in the future be found with audio processing. At present the annotations for this session include the identities of the participants, their locations, the devices and applications used – and the session is also addressable by it three distinct segments with timestamps. There are two a/v files: captured in Montreal and Fredericton. The annotations are in the RSM model (Fig 4.)

C. Queries

With a fully populated RSM, we could run the following queries:

- (1) Show me all the sessions where a surgeon whose expertise is orthopaedics is treating a paediatric patient.
- (2) Which data files relevant to the knee joint have been accessed in sessions in this month?
- (3) Show me all the segments where a surgeon talked about arthritis.
- (4) Who else has accessed this session?
- (5) Set up a session for me to videoconference with him where this previous session is included as a resource.

V. USAGE THEMES

A. Creation of Authentic Content

The growing repository of content from training and practice sessions using these tools will become a main source of information for health care professional so increasing the effectiveness of their skills. It can be used by individuals or groups, synchronously or asynchronously or a combination of the two. It will also become a repository for evaluation data for measuring a trainee's ability to perform procedures. This will measure performance of high level, cognitive skills. Given a tutorial from a clinical situation, such as a patient bleeding after an automobile accident, were you able to assess the situation quickly and make use of the data sources available to you, applying clinical practice guidelines (another of our edge devices) to determine the cause of the problem and return the patient to health. This is currently the type of scenario presented by Open Labyrinth, but with SAVOIR, the scenario can be studied in conjunction with a Laerdahl mannequin on which some of the examination procedures can actually be performed, so that examination and diagnostic skills can be practiced in one event. The captured session becomes a subject of study in itself, for the trainee being evaluated and for others wanting to learn from his/her experience. The collection of all such captured experiences becomes a repository of experiences. The Resource Space Model provides the basic storage and retrieval for this repository.

B. Rule-based Coordination of Edge Devices

While earlier versions of SAVOIR have mostly been coordinators of control data for edge devices, recently integration of edge devices at the content level has been incorporated into SAVOIR. Since the edge devices are accessed by web services, these functions are exposed to SAVOIR and can be invoked on demand. This is used for many tasks: (1) In the case of the visualization tools (VolSeg and RSV), specific data files can be loaded and displayed to specific users. (2) For the simulation tools (Laerdahl Mannequin, OpenLabyrinth, Hypovolemic Shock Model) a description of the situation being simulated, a so-called scenario file, can be loaded by SAVOIR. They often contain a description of the basic situation of the patient, the initial vital signs, etc. (3) At runtime, the coordination is performed by a rule engine loaded with a set of rules that react to messages that are exchanged between edge devices. For instance if the hypovolemic shock model predicts that the patient's blood

volume will be below a certain threshold, a rule can express that this situation should trigger a response. The mannequin can be given this information and exhibit that response, perhaps an arrhythmia, so that the trainee can become vividly aware of it. We are investigating the use of Rule Responder [9] and other rule engines.

C. An Instance of the EventWeb

Jian [10] presents a vision of a web of event. Fundamentally different from document-centric hypertext of the current Web, it consists of captured multimodal rich data, focusing on audio and video and immersive telepresence, which can be stored, organized and replayed synchronously, providing an environment for people to re-experience the event. The data can be reorganized on demand to provide different viewpoints. The system described in this paper, consisting of SAVOIR and RSM, provides an instance of the EventWeb. Many of the properties of the EventWeb are part of the system described in this paper: access to previous events, synergy between past events and current ones, deriving insight from this synergy, the use of powerful and efficient indexing for accessing events, capturing and combining events.

There is still a tremendous amount of work to do to realize a complete EventWeb. This is a start.

VI. CONCLUSION

SAVOIR is an existing software system for coordinating the collaboration among participants of healthcare training sessions. The Resource Space Model is an effective system for managing various resources along multiple criteria. The combination creates a resource for healthcare training and supporting advanced functions by allowing efficient access to data captured from segmented sessions and different types of resources.

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