Semantic Annotation in Ubiquitous Healthcare Skills-based Learning Environments

Mark J. Weal[1], Danius T. Michaelides[1], David De Roure[1], Mary Gobbi[2], Ellie Monger[2], and J. W. McDonald[3]

[1] Pervasive Systems Centre, University of Southampton, UK
{mjw,dtm,dder}@ecs.soton.ac.uk
[2] School of Nursing and Midwifery, University of Southampton, UK
{m.o.gobbi,em}@soton.ac.uk
[3] Southampton Statistical Sciences Research Institute, UK
J.W.McDonald@soton.ac.uk

Abstract. This paper describes initial work on developing a semantic annotation system for the augmentation of skills-based learning for Healthcare. Scenario driven skills-based learning takes place in an augmented hospital ward simulation involving a patient simulator known as SimMan. The semantic annotation software enables real-time annotations of these simulations for debriefing of the students, student self study and better analysis of the learning approaches of mentors. A description of the developed system is provided with initial findings and future directions for the work.

1 Introduction

Skills-based learning is an essential part of delivering healthcare. The UK Government's agenda to ensure that there is a competent workforce which is "fit for practice" requires not only an increase in the number of Healthcare workers but significant changes in their roles, competence levels and working practices[2]. The ability to enable students and qualified staff to acquire professional competence safely and quickly within the context of increasingly complex, changing and technical working environments, without detriment to users of the health services, is challenging. One response to this is to more fully exploit and evaluate technologies which can be used to provide these learning experiences. The opportunity to enhance practice learning has never been greater, with interactive media for students via the Web in both academic and workplace environments now a reality.

In this paper we look at a case study in using semantic annotation to enhance skills-based learning for healthcare. The Semantic Web approach is particularly compelling in this context because the learning environment is very much about information reuse, and sits in the context of the broader clinical information system; for example, the patient journey though the health care system could now be tracked, anonymised and used in providing training scenarios. Our case study provides a rich environment for semantic annotation, in which annotations are

created or authored by multiple parties and are consumed in different ways and for different purposes. Our approach builds on previous work in using Semantic Web to support meeting capture and replay [10].

The study is based around scenario-driven skills-based learning in hospital ward simulations located within teaching facilities [5]. The simulations allow for the acquisition of practical skills and decision-making, team working, communication and problem-solving etc[4], and are incorporated into assessment of student performance [11]. To use these facilities for assessment and feedback purposes, they need to be sound, valid, reliable, feasible, educational, and acceptable to practitioners[6].

The annotations therefore need to be able to cope with these forms of activity and provide opportunities for meaningful, timely feedback to student, teacher and researcher. The aim is to identify what observable characteristics and features of the students' performance could form valid and reliable criteria for formative and/or summative assessment purposes. This is in a field where little or no benchmarking of 'natural' performance capability for students or practitioners exists. To some extent this is because current technologies have not been developed to handle the vast volume of data generated by a single student.

The student training sessions are recorded and this material is then used as a resource during the exercise and post-exercise by multiple parties for a wide range of purposes. Video annotation systems for other domains exist, for example news production [9] where the focus is on more explicit description of content or for collaborative annotation of video [3]. Here, the authoring process occurs both in real-time and post-exercise and it is envisioned that annotations will be reused throughout this process. For example, coarse annotations made during the exercise may be used as a basis for more detailed annotations about specific activities and events.

Annotations are made about physical things, but for replay and reuse these annotations have to be overlaid on the recorded video. These annotations, although possibly using medical terminology, are more naturalistic observations, and the ontologies developed are not intended as a mechanism for sharing clinical knowledge as is supported by other systems[8][7].

This paper describes the scenario and then goes onto describe the annotation system that is being developed. The different stages at which annotations are authored and reused are discussed.

2   The skills-based learning environment

As part of the teaching process in the School of Nursing and Midwifery (SONAM), Southampton, students take part in skills-based learning scenarios in ward simulations located within the teaching facilities. Each teaching ward contains a nurse's station with six fully equipped beds viewable from a central control room via six audio-equipped cameras. The cameras are controllable from the central control room with 360° viewing angle. This allows multiple cameras to be trained on a single bed in the case of single patient simulation exercise.

There are a range of adult/paediatric mannequins including four adult computerised and interactive SimMan[4] mannequins[1]. The SimMan mannequins provide numerous multi-sensory physical outputs (e.g. blood pressure, heart rate, and voice/respiratory sounds) as well as event logging.

Although 'Virtual', the student experiences are exactly as they would experience in the workplace in real time. Hence, when the students and mentors are 'immersed' in the simulation and behave 'as in real practice' the video captured data provides important information about their performance. The ward experience can involve a variety of continuous or simultaneous activities embedded within a structured clinical scenario. These might include interacting with the patient (SimMan), phone conversations with mentors, personal interruptions and structured role plays/simulations involving 'clients, relatives and other members of the multidisciplinary team.' The scenarios carried out in the skills laboratory are videoed from the control room (see Figure 1).

Fig. 1. The video stream of the learning scenario.

Students participate in simulator-based scenarios in groups of three or four, typically with a second group observing the activity from a distance. During the course of the scenario, the patient will typically develop a range of symptoms with the nursing students dealing with the situations that arise as they would in a hospital environment. Mentors are present playing the various roles such

[4] http://www.laerdal.com/SimMan

as doctors or on-call consultants and the scenarios are moved forward through their actions and the programmed scenario followed by the SimMan mannequin.

Each scenario session is followed by a debriefing session involving the participating students, the observers, and the mentors who facilitated the session.

The aims of this project were to take this existing setup and through the use of semantic annotation augment the learning process to provide more focussed debriefing, better personal reflection by the students of the process they have been through, and a rich source of information to inform the teaching practices of the mentors involved.

3   The Annotation System

For annotation to be successful it is important to design cues/prompts that are easily recognisable and familiar to the users. There appear to be at least two ways of achieving this:

– Through naturalistic time sequenced observation.
– Through the use of established observational schedules.

In this case we used naturalistic time sequenced observation, followed by clustering of themes according to discipline specific relationships, for example 'taking a pulse' was clustered under a heading of 'taking and recording vital signs'. The individual activity of the pulse then breaks down into further components.

Observation	Observation commments
pulses	Looking at watch, feeling pulse, one can actually see whether they are holding the patient's arm properly and in the correct place

Through a series of workshops, observational sessions and discussion groups, four different types of annotation were identified which fall into two categories: annotations made in realtime during the exercise, and annotations made post-exercise.

3.1   Real-time annotations

Annotations can be derived directly from the SimMan control system which logs all activity concerning the mannequin. These will include events initiated by the programmed scenario, for example entering the 'deterioration' phase of the scenario, as well as interactions with the mannequin itself (it can detect when an oxygen mask is placed over the mouth). The log files that are created, and the scenario files driving the activities, can both be parsed and synchronised with the annotations created manually.

During our discussions, other useful annotations that could be made automatically were identified. These included annotations based on direct analysis

of the video, perhaps indicating positioning around the bed. Other possibilities might include the augmentation of equipment within the ward with sensors to record specific interactions such as the students using the taps, holding the charts etc. These types of annotation were considered beyond the scope of this project, as they require further pieces of technology to be developed; however, we recognise that handling automatic annotation by pieces of software is a key feature of the annotation system that we are developing.

3.2   Post activity annotations

Post-exercise annotations can be made either by observers of the exercise or by the students involved. Annotations could be more detailed than the ones made in realtime and might utilise specific annotations for focussed analysis. Whilst time is less pressing when creating post-exercise annotations, it is still an issue when faced with a large number of sessions to annotate. We believe that annotation speed can be improved by an annotation system that can adapt to the current context. Our use of hierarchies and categorisations of types of annotation allows us to establish rules about the sequence in which they can occur. Our annotation interface will then adapt by, for example, only showing possible annotations for the current context.

3.3   Phases of annotation use

Having identified types of annotation, we have constructed an ontology representing the range of annotations applicable in the scenarios. The ontology provides the basis for the annotation interfaces developed. We have identified four phases during which annotations are created or used: live recording, immediate feedback, post annotation and reflective study.

Live annotation During live recording, video is being captured and SimMan logs its own internal events. Realtime annotations are authored by teaching staff in the control room using the annotation interface pictured in Figure 2. The interface is kept simple, with double clicking on the annotation name creating a new time stamped annotation. This allows the lecturer to spend the maximum time watching the video monitor and the minimum time interacting with the interface. Keyboard shortcuts could improve this but the range of annotations available makes this problematic. Often, real-time annotations become placeholders for more elaborate annotation post-exercise where time constraints are less of an issue. Due to the cognitive load of annotating in real-time, simple scoping is provided to narrow the range of annotation types to speed up selection. As the system can potentially have detailed knowledge about the scenario in advance, this could also be used to restrict the list of appropriate annotations. A proposed extension to the system is to use knowledge from the ontology as to sequentially related annotations, to enable the interface to provide prompts for likely subsequent annotations. If an annotation has been made referring to the
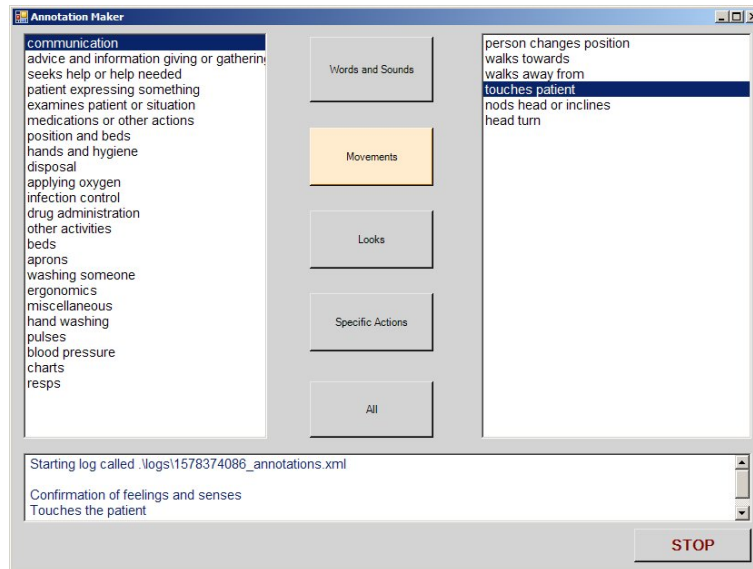
Fig. 2. The simple real-time annotation interface.

blood pressure cuff being put on the patient, subsequent common actions such as inflating the cuff and removing the cuff can be suggested as likely to occur.

Figure 3 contains a snippet of an XML log file generated as part of a real-time annotation session.

Student debriefing Immediately after the exercise, the students receive feedback from the mentors. The current mechanism for this is purely verbal, as although the session is videoed, use of the video is problematic as attempting to find specific points of interest would require going forward or backwards through the video and visually identifying points of interest. The annotations captured real-time give an index into this video and enable the quick identification of points of interest based based on the events captured. It is hoped that through the use of the augmented feedback more specific aspects of the scenario can be focussed on and reflection can be made through viewing back events deemed of specific interest by the mentor running the debriefing session. An interface to the playback of the video overlaid with authored annotations can be seen in Figure 4.

Post session annotation For the purposes of providing training material or producing more detailed data analysis further annotations may be made on the recorded video. This process may involve multiple authors making multiple passes over the material. The annotations may also be produced around the specific expertise of researchers and academics, for example if a particular re-

```
<annotationfile date="2007-06-20 12:46:09Z" timestamp="12707973">
<videofile name="Sessions_20-6-07.avi"  startindex="3804"/>
<annotation id="annotation_12717707" type="look" timestamp="10">
<name>at paperwork charts</name>
<description>Looking at paperwork charts</description>
</annotation>
<annotation id="annotation_12722564" type="none" timestamp="15"
peleton="annotation_12717707">
<name>advice and information giving or gathering</name>
<description>Advice and information giving or
gathering</description>
</annotation>
<annotation id="annotation_8723513" type="words" timestamp="407"
communication="true"
involves_others="true">
<name>solicited information</name>
<description>Solicited information</description>
</annotation>
```

Fig. 3. A fragment of annotation file in XML form.

searcher has expertise in issues surrounding hygiene and infection control. The annotation interface, as before, can be scoped to reflect the annotations that are most pertinent to the areas of interest of the annotator. Those annotations made during real-time annotating that were serving as placeholders or aide memoires can be given more detail. For example, in the live session a simple annotation of "taking blood pressure" was recorded. In a second pass post activity, this can be used as a cue to prompt for more detailed annotations such as "put cuff on", "inflate cuff", "remove cuff", etc. which would have been difficult to annotate live but provide a much richer source of data for analysis. It may be that the time taken to perform the taking of a blood pressure might be an interesting metric.

Student personal study The final identified phase of annotation use involves students using the video and annotations as a resource for self-study and reflection. During the exercise the students are immersed in the activities and often, due to the strenuous nature of the activities may struggle to assimilate all of the information from the debriefing session. By making the videos and annotations available to them afterwards they can review the scenarios with appropriate commentary of the unfolding events from the attached annotations. Over time, these sessions can also provide an index library of exemplar activities where should the student wish to see examples of how their learning has improved over a number of sessions they will be able to do so.

Fig. 4. Playback of the annotations overlaid on the video.

4 Conclusions

Semantic Web technologies offer potential to enhance skills-based learning by facilitating information reuse. In this paper we have detailed the current state of a system for annotating a live learning experience. The system must cater for the authoring of annotations at different states of the scenario and provide facilities for reusing these annotations for multiple purposes.

In contrast to many Semantic Web applications, this study involves working in realtime. As with all rich multimedia recordings, special attention needs to be paid to synchronisation. There is also an overhead in authoring annotations, however, because of the high level of reuse, the investment is justified.

Our initial experiments have highlighted the necessity for the nursing staff to create their own ontology for their annotations. This is especially important for accurate and efficient realtime annotation where familiarity with the annotation hierarchy is vital. It also allows them to include events pertinent to their own specialisms.

The development of the system will continue, with more longitudinal studies to better understand the activity. This will also build up an effective resource for use in the teaching activity as well as for those studying the teaching methods and processes. We are also interested in linking the annotations back to

the "storyboard" of the scenario and in generating scenarios from real clinical experiences.

One avenue of further work would be a hand-held version of the annotation client to allow observing students and mentors to make their own annotations. Such an interface benefits from using the annotation ontology to make best use of the limited form factor of hand-held devices.

The system could also be used by students in the longer term by allowing the students to make annotations of their activities during their placements. The reuse of the ontology would provide a link between their placement and the knowledge acquired in the university learning environment.

Acknowledgements

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