

Grid-enabled data collection and analysis – semantic annotation in skills-based learning

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Abstract. This paper describes how Semantic Grid technologies can be used to generate enhanced tools for data collection that provide enabling technologies for interdisciplinary work, thereby enhancing the capacity to address substantive social science research. A feasibility study is presented in which semantic annotation (i.e. machine-processable annotation using Semantic Web technologies) is used to capture and work with the digital record, in support of subsequent qualitative and quantitative analysis. This case study provides a proof of concept, helping to develop the agenda for future work in this area.

Introduction

This case study focuses on the research and practice of skills-based learning in the context of health care education. 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 (Dept. of Health, 2002). Simulation is being used increasingly within the field of healthcare to help students develop their clinical skills with regulators valuing and supporting its appropriate use (Nursing and Midwifery Council, 2007). The School of Nursing and Midwifery at the University of Southampton has developed ‘Virtual Interactive Practice’ (VIP) to augment student placement capacity and provide new opportunities to address the quality, nature and type of student learning experiences. VIP is a designated period of assigned practice where web-based and/or simulation-based clinical scenarios are integrated to provide coherent learning experiences with which students can interact. These scenarios are constructed with real patient data so as to mimic real practice contexts and responses.

The School has two skills laboratories resembling hospital wards separated by a central control room. Each ward is viewable from the central control room via 6 audio-equipped ceiling mounted cameras, each controllable with a 360 degree viewing angle. Each ward is equipped with computerised and interactive SimMan® mannequins, which are used to simulate interactions with real patients. Our work utilises this significant skills-based learning facility as a powerful testbed for the study, including extensive data collection and replay capabilities. Student nurses carry out simulation activities which are video recorded, with post

activity feedback given by the facilitating practice based mentors and academics. These activities build on the students' previous use of on-line learning resources developed by the School. This provides a social science research context in which to investigate the new techniques. The simulations in the skills-based learning lab allow for the acquisition of practical skills including decision-making, team working, communication and problem-solving (Gobbi et al., 2004). To use these facilities for assessment and feedback purposes, they need to be sound, valid, reliable, feasible, educational, and acceptable to practitioners (Ram et al., 1999). The video annotations therefore need to cope with these forms of activity and provide opportunities for meaningful, timely feedback to student, teacher and 'real time' or 'post hoc' researchers.

In addition to any technical difficulties and economic costs, research and education activity involving video analysis is known to have significant challenges associated with systematic viewing; creating a notational system with appropriate mechanisms and categories suitable for data processing and analysis (Loizos, 2000). This case study demonstrated that the process of developing an ontology can create an iterative synergy between 'marking', categorising and analyzing video captured data. It is also labour saving and facilitates inter rater reliability.

Ethical and governance issues

The use of video recording itself is not without ethical challenges as the capture, storage and future use of such recordings have to be carefully considered and protection of participants given priority. This was achieved prior to the start of this study by the development of the Programme of Research and Education/ Ethics into Virtual Interactive Practice (PREVIP) Protocol. The protocol addresses and manages legal, ethical and indemnity issues associated with video recording for the collection, storage and use of real patient images and data for the generation of web-based scenarios, and for research use in the simulated scenarios involving students and facilitators. The protocol addresses consent, access to data, data storage, retrieval, reuse, removal, dissemination and destruction. A system of data guardianship has been introduced to manage the data in the best interests of persons about whom data has been collected. Note that informed consent for the collection, storage and use and analysis of video, weblogs and other student data was obtained using written consent forms, following the approval of the University of Southampton School of Nursing and Midwifery Ethics Committee.

Video annotation

The approach taken was to use naturalistic time sequenced observation, followed by clustering of themes according to discipline specific relationships, for example 'taking a pulse' was situated under a heading of 'taking and recording vital signs'. Through a series of workshops, observational sessions and discussion groups, different types of annotations were identified including those made real-time during the exercise and annotations made post-exercise. The annotation ontology was constructed through a co-design exercise allowing the vocabulary to be controlled by the domain experts and aligned with the vocabulary used within the on-line resources. A goal of future work might be to integrate existing disciplinary classification systems and notation schemes into the ontologies (for example the International Classification Nursing Practice® system).

Figure 1 shows the annotation tool used by the experts during the trials. Whilst watching a monitor in the control room showing the activities of the students in the simulated ward, the experts could select and add annotations from the lists available which are then recorded with timestamps to enable later video replay. The pane on the left contains the top level annotations with the pane on the right displaying the sub annotations for the currently selected

top level annotation. The large buttons in the centre allow quick filtering by type. The interface was kept deliberately simple to reduce the time spent by the experts looking away from the video monitor during the session.

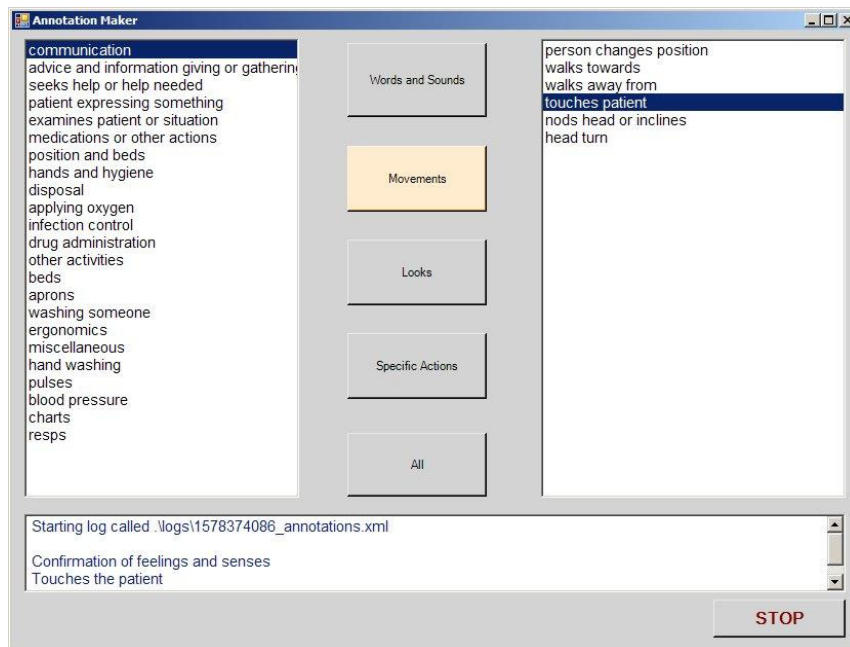


Figure 1. The annotation software.

Immediately after the exercises, the students receive feedback from the mentors. The standard mechanism for this is purely verbal, as although the session is videoed, video use is problematic as attempting to find specific points of interest would require going forward or backward through the video and visually identifying the relevant points. Annotations captured real-time can index this video and enable the quick identification of points of interest based on the events captured. Our approach builds on previous work in using Semantic Web technologies in the capture and replay of meetings (Page et al., 2005). Through the use of the captured annotations more specific aspects of the scenario can be scrutinised and post-hoc reflection in, and upon action, can be facilitated through viewing back events marked as important by the mentor running the debriefing session. A more detail description of the video annotation system can be found in Weal et al., (2007).

These annotations, although possibly using medical terminology, are more naturalistic observations, and the Semantic Web ontologies developed are not intended as a mechanism for sharing clinical knowledge as is supported by other systems (Gustafsson et al., 2006; Kashyap et al., 2005). The co-design process allowed an ontology to be constructed that was easily recognizable to the users of the system. Clustering by discipline specific relationships allows thematic groupings to be made, as in the previous example, 'taking and recording vital signs' including the more specific annotation of 'taking a pulse'. This hierarchy allowed the annotators to make more general annotations real-time which could then be further refined in a post-annotation session where the video could be paused and replayed allowing more time for detail to be added. The ontology was created based on the outputs of a series of workshops, observational sessions and discussion groups involving students, mentors and academics.

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. The ability to annotate quickly was most noticeable in a simulated emergency situation where several students acted simultaneously. The ability to annotate after the activity allows the video archive to be constantly augmented with experts from specific fields adding to the teaching resource with specialist annotation. For this reason, the ontology is designed to be extensible in order to readily include such specialisms.



Figure 2. Replay of the annotations overlaid on the video.

Figure 2 shows the annotation replay tool where the real-time annotation are overlaid onto the video during playback. In addition to providing a tool for post session debriefing, such a replay tool would allow the students to reflect back on their own session at a later date with accompanying expert annotation helping them see what areas they might need to revisit or focus on in more detail. Post session study by the students could incorporate personal as well as teacher-led video annotations as an index into relevant on-line material that share the common vocabulary of the annotations. Video annotation systems for other domains exist, for example news production (Nack and Putz, 2001) where the focus is on more explicit description of content or for collaborative annotation of video (Fraser et al., 2006).

Web log analysis

The analysis of the students interacting with the on-line Web resources can provide insights into their learning strategies and achievements. By processing the logs created by the Web server we can potentially answer questions such as: did the students cover the material adequately, how deeply did the students engage with the material and what do the paths students took through the material suggest about the content and its organisation?

The web-based resources were available via computer labs with dedicated headphones at the university/hospital or elsewhere, e.g. home if the student used a VPN connection. To use these resources, students had to login with their username and password. The session web access log files, weblogs for short, were saved for analysis. We transform the logs into a

sequence of timed-events representing each student's session. As a secure HTTP connection was used, the username was recorded in the weblogs and, therefore, it is possible to track students who access these resources on separate occasions and to link their multiple session weblogs.

We explored the potential of computer-assisted data collection for the study of the interaction of users with the VIP scenario-based learning package. Sequences of timed-events were used to create visualisations that helped the researchers to understand the weblog data. For visualisation, we use directed mathematical graphs and event history charts available within a grid-enabled R service, based on the open source R package for statistical analysis. Directed mathematical graphs showed the popular pages and routes that students take through the material, whilst event history charts plotted the sessions in the time domain and represented durations of page viewing and total session time. These visualisations promote exploratory analysis but require some manipulation of the data.

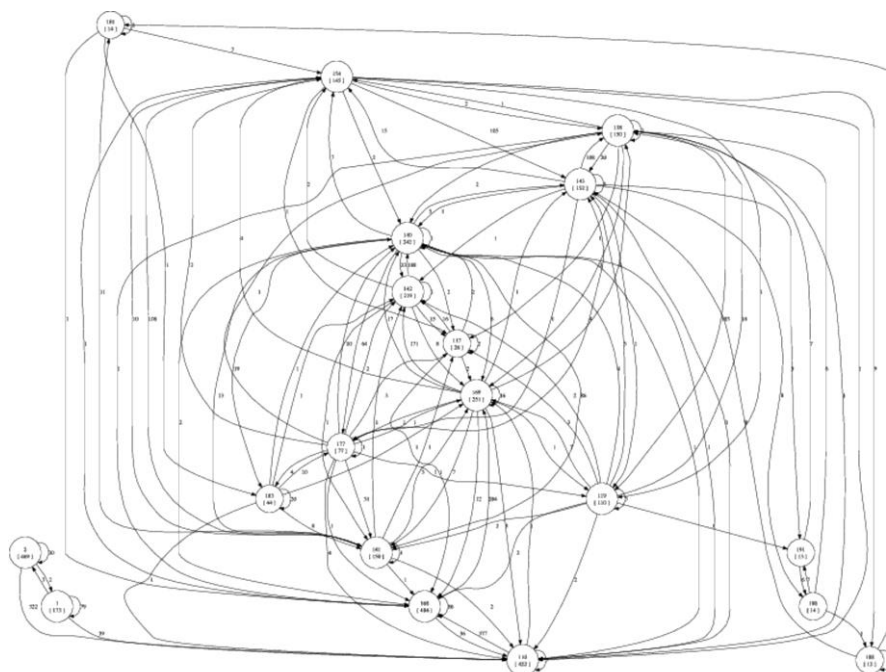


Figure 3. Directed mathematical graph of URL visits.

We illustrate the weblog analysis by considering one day's weblogs of first year students, where 45 students accessed the VIP package 64 times, 34 students used the package once, 7 students used it twice and 2 students used it 3 times. We will focus on the Hygiene area in the Techniques for Nursing Care section which is a resource that addresses basic nursing skills. The weblog analysis starts with visualization of the visits to each URL using directed mathematical graphs. The number of visits and revisits can be visualized using Rgraphviz, which interfaces R with the AT&T GraphViz library for drawing mathematical graphs. Figure 3 presents a directed graph representation of the weblogs for one day of sessions using Rgraphviz. The nodes (circles) represent URLs of learning resources. The first number is the URL code and the second number in square brackets is the number of visits to the node. The directed edges (arrows) represent the number of movements from one node to another, with the arrowhead showing the direction. Note that it is possible for an arrow to start at a given node and end at the same node. This may occur with a page refresh in the browser or by clicking on the link to the current page. On the bottom left of Figure 3, the codes 1 and 2

refer to URLs ‘\../clinical_skills’ corresponding to the Clinical Skills home page (the second with an ending forward slash). Code 110 corresponds to ‘\../clinical_skills/tnc.asp’, the first visit to the Techniques for Nursing Care information page. Code 168 corresponds to ‘\../clinical_skills/tnc.asp?section=0’, the start page for Techniques for Nursing Care. One problem with using directed mathematical graphs for visualisation is it is hard to ‘see the forest for the trees’ if there are a large number of nodes and many directed arrows. The full graph including all possible nodes typically looks like a ‘plate of spaghetti (edges) with meatballs (nodes)’ and is not easily interpreted.

For ease of interpretation we focus on a subgraph. Figure 4 presents a subgraph consisting of only seven nodes. The subgraph focuses on the ‘Hygiene Student Nurses’ Responsibilities’ page and related nodes. The codes are: 169 - first visits to ‘Hygiene Student Nurses’ Responsibilities’ page, 117 - revisits to ‘Hygiene Student Nurses’ Responsibilities’ page, 142 - Privacy & Dignity page, 140 - Principles of Bed Bath page, 177 - Do the crossword: Things you need for a bed bath, 183 - Play video ‘bedbath2’ and 141 - Principles of Baby Bathing. Note that the size of the circles representing the nodes is related to the number of visits in order to help the analyst see which nodes were accessed most frequently. The minimum node size is set to 1 (node 183 had only 9 visits) and maximum node size set to 2 (node 169 had 64 visits). The size of the node is given by the formula: $1 + (n / \max n)$, where n is the number of visits to the node and $\max n$ is the number of visits to the node with the largest number of visits, here 64. Hence, the node sizes vary from 1 to 2. We can immediately see that the bedbath video was accessed only 9 times by an external media player and the crossword was accessed only 28 times. One conclusion is that fewer than two-thirds of the 45 students accessed the crossword, so either the students were not fully engaging with the online material or they decided to access these learning resources another day. Note that even for students who accessed the URLs corresponding to the crossword and media player to watch the video, the directed subgraph cannot tell us if they completed the crossword or completely watched the video. For more details see McDonald et al., (2008).

Event history charts/graphs can be used to display the relative timing of different types of events (Goldman, 1992; Lee et al., 2000). The horizontal axis represents the elapsed time since a given time origin (e.g. the occurrence of a given event). The timing and the occurrence of events of interest are presented for each student session, with one horizontal line for each session. Different plotting symbols are used to represent the different events. Figure 5 is an event chart which focuses on nodes: 140 - Principles of Bed Bath page (solid circle), 183 - Play video ‘bedbath2’ (solid triangle) and 177 - Do the crossword: Things you need for a bed bath (upside down triangle). The rest of the nodes are represented by unfilled circles.

The time origin in Figure 5 starts with a visit to node 140 - Principles of Bed Bath page. Note that this visit can be the last node of the session e.g. as in the case of sessions 1-3. Session 14 consists of visiting node 140 for approximately 12 seconds then exiting to a node other than nodes 183 or 177. Session 4 is a very short session with the overplotting of a solid circle with an unfilled circle. In 4 sessions the student requested access to the external media player (solid triangles) and these failed every time (http error code not found according to the weblogs), possibly due to the media player not being installed on a home computer. The total time it takes the video ‘bedbath2’ to play is 22 minutes and 21 seconds or 1,341 seconds. Only 10 of the event chart lines are long enough for the student to have watched the entire video, so one conclusion is that either few of the students fully engaged with the video or they decided to access these learning resources another day or they already had these clinical skills.

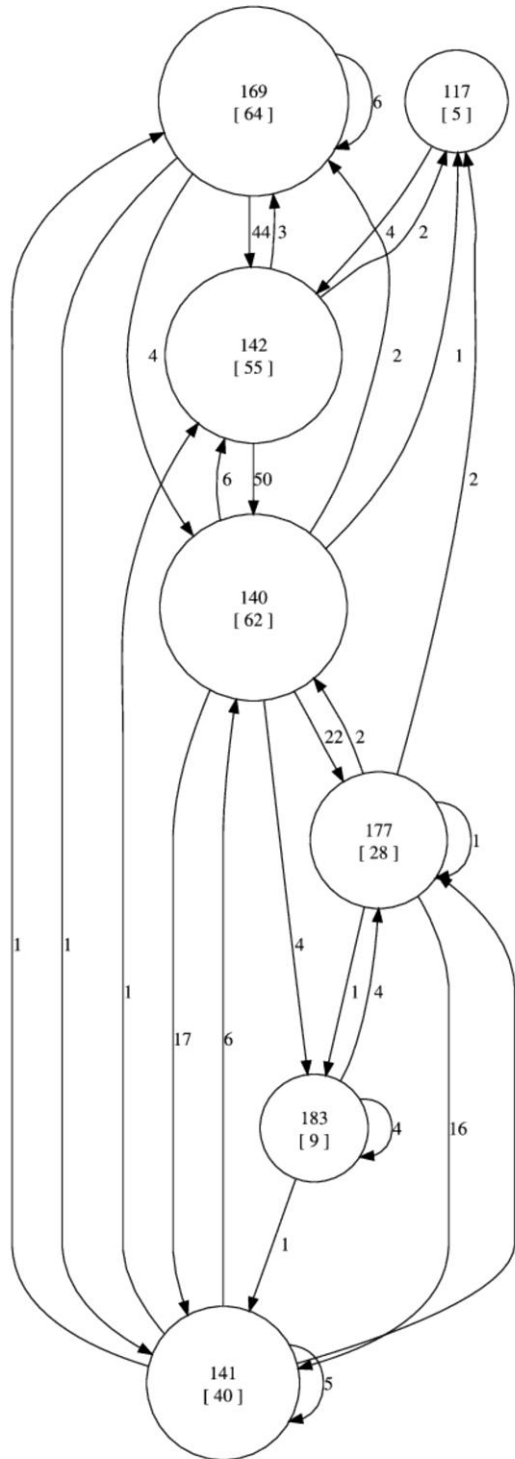


Figure 4. Directed mathematical graph of selected URL visits.

The mathematical graphs and event history charts promote exploratory analysis of the weblogs, but require repeated manipulation of the data and inputting different parameters to the R software for producing the mathematical graphs and event history charts. To help facilitate this exploratory analysis we provide workflows (Gil et al., 2007) encapsulating this processing, which allows the analysts to select and refine the views they require easily.

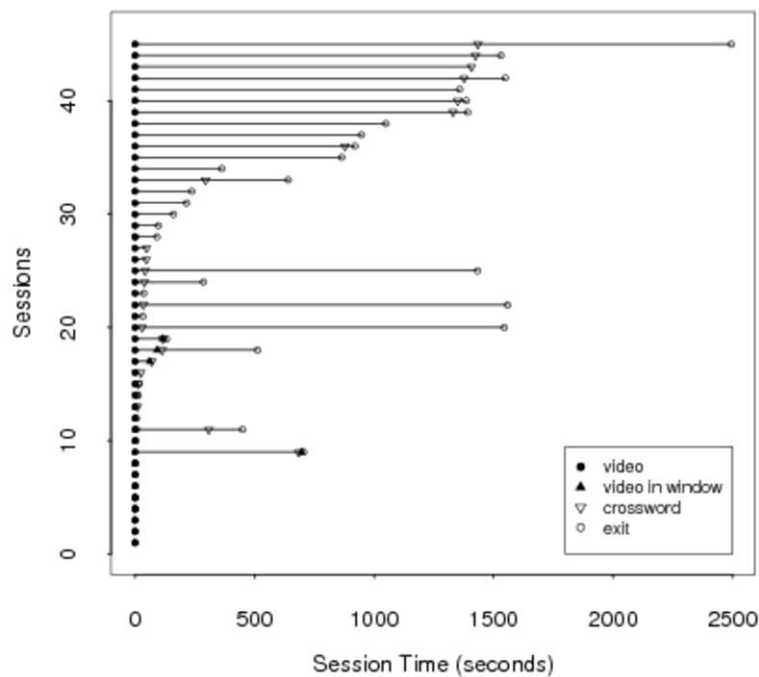


Figure 5. Event chart for 45 student sessions where the time origin starts with a visit to node 140 – ‘Principles of the Bed Bath’ page.

The high-level workflow language also allows the authoring of new visualisations by allowing components of the analysis to use different parameters and also be composed in different arrangements. These workflows are launched from a tool directly on their personal computer but may interact with remote databases and services.

Conclusions and future work

Similar to the ability to search and mark video for student feedback purposes, the researcher can use this facility to guide the direction of any subsequent transcriptions required for analysis. This raises questions and options for the future direction of the traditional ‘transcriber’ role in qualitative research. For example, the researcher can annotate and bookmark in real-time or later before it is given to the transcriber. This can provide technical commentary, guides, instructions or explanations to the transcriber. Second, it may be possible to use or train domain specific transcribers so that they can do ‘real time’ work for research or other purposes. Third, it is worth considering whether parallel annotation of the researcher and transcriber might have a role in the first or second stage of video analysis. Fourth, the potential to use these technologies to guide therapeutic interventions in interpersonal therapies has yet to be explored, particularly in fields involving behavioural analysis. Finally, the future development of these techniques is of interest to those using video ethnography or other visual and textual media who need to capture, categorize, analyse and retrieve visual and textual media.

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 real-time

annotation where familiarity with the annotation hierarchy is vital. It also allows them to include events pertinent to their own specialisms and to integrate more fully with the on-line teaching resources. 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. Parallel work that considered the potential of video analysis in the assessment of student performance indicates that an annotation facility could help realize effective formative and assessment strategies (Gobbi and Monger, 2008).

Through the use of a Semantic infrastructure, we are better able to link the activities across disciplines allowing the statistical analysis of the Web logs to feedback into the teaching activity both in the modification of the on-line Web resources and providing a more comprehensive overview of the student learning process for the educators in nursing. More complex analysis of the Web logs will require more complex visualization tools that allow greater interactivity and exploration from the macro (common paths through the material) through to the micro (an individual student's experience). The analysis of the Web logs will also feed into the design of future learning materials both to improve their benefits as teaching resources but also to guide their construction to more easily facilitate these new types of analysis. This has wider applicability beyond the domain of this case study. This case study involved a small number of videos and Web logs as a proof of concept. To scale this up to cohorts of five or six hundred students a year would present new challenges.

The capturing of detailed annotation of student activities during skills-based sessions is also allowing researchers in nursing to look it more detail at the teaching process itself, and providing a record of what nursing educators 'see' when they watch students carry out the scenarios. Analysis of this record may provide some insight into deeper research questions around the assessment and education of students in such sessions.

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