Using Location Information in an Undergraduate Computing Science Laboratory Support System

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Location is important to both students and tutors in teaching laboratories – in particular, it influences how they interact during help-giving. We have developed the Lab Support System (LSS) to support tutor-student interaction in teaching laboratories that utilises mobile wireless-enabled computers. In this paper we discuss the ways that we represented and used locational information in this system and our observations of the role of location during a field trial of the LSS. We also consider how additional location information might be exploited in future system developments.

Introduction

Location is important to both students and tutors in university teaching laboratories – in particular, it influences how they interact during help-giving. We have developed a system to support tutor-student interaction in laboratories and, in the course of developing and using the system, we have had to confront a variety of issues related to the role of location and location information in the activity and in our system design. This paper reports on our experience and some of what we have learned from it.

The Lab Support System (LSS) is a web-based application, deployed on static workstations and wireless-enabled palmtop computers, that supports student-tutor interaction in computer laboratories, particularly the process of students asking for help and tutors delivering it. In developing the LSS our primary focus has been the tutorial process, especially as it exists in teaching labs in Computing Science at our university; issues related to location and mobility were very much secondary and emergent and not a initial central concern. Exploiting location information was not a prime factor in our design nor did we set out to change the locational aspects of the activity (e.g., reduce tutor movement). Nevertheless, our system did take location into account and we found some interesting interactions between location and system use, as will be reported below.

In this paper we describe the LSS, discuss the way it handles locational information both in the current system and in possible future versions of the system, and report our observations of the role of location and location information during a field trial of the system. Section 2 provides an overview of the way tutors serviced student help requests prior to the introduction of the LSS. Section 3 gives an overview of the LSS and section 4 discusses the features of the system that relate to location information. Section 5 presents some observations on how location and location information influenced system use during a four week field trial. Finally, in section 6 we offer some conclusions and consider possible location-oriented enhancements of the system.

Locational Information in Teaching Labs

The LSS has been developed in the context of the GRUMPS project, investigating support for large-scale distributed experiments based on computer usage data [Atkinson et al, 2000]. The LSS was one part of a larger initial testbed for capturing data generated by student lab performance, both at the keystroke level and at an application level. Our development was originally focussed on student-tutor interaction in a 1st year teaching lab in the Computing Science Department at the University of Glasgow (GUCSD) [Draper 2001]. Although our longer-term aims are more general, the work reported here refers to the system we developed for this 1st year lab.

The GUCSD 1st year laboratory consists of a single room with 60 student workstations deployed on benches. First year students carry out practical work in tutorial groups of around 20 students and a staff tutor. Groups remain fixed for a semester's work. Each tutorial group attends one two-hour laboratory each week during the year, working on practical exercises. Each tutorial group has assigned to it a cluster of workstations (a set of contiguous workstations in one area of the lab) intended to be used by the group during the lab session. Machines in the lab are divided into four clusters, each with a different colour represented by a coloured sticker on the machine's monitor

In GUCSD 1st year lab sessions, physical location influences help requests and help-giving in several ways. Students are static in the sense that, for most of a lab session, they remain at one workstation, although they may use different workstations during different sessions. Tutors have no fixed location but move freely around their tutorial group as well as occasionally visiting students from other groups and consulting with other tutors and demonstrators.

There is a relationship, albeit fuzzy, between physical location and group membership. Although a student may use different workstations on different occasions, they are supposed to choose from the machines belonging to their group's cluster, although this is not strictly enforced. Also, currently unoccupied machines in a cluster may be used by students not belonging to the group scheduled to use that cluster.

Tutor help is largely demand-driven. Students catch the attention of a tutor (usually the one belonging to their group) and the tutor must work out a strategy for handling the current set of requests. The help itself, of course, is given when the tutor is near the student (standing behind, looking a the display, or sitting next to them). Occasionally, the tutor might make an announcement to the entire group or call a small group away for a mini-tutorial.

We can consider location and location information from both the students' and tutors' points of view. For a tutor servicing help requests is largely influenced by estimation of need. However, physical location plays a part. For example, some tutors take requests from a nearby student first, if they think it will not be long. Other tutors work their way systematically along a lab bench, using the physical layout to structure the help servicing. In general, tutors find it difficult to walk past a student in need of help to service the request of another student further away.

Finding a student who has requested help in a busy lab is not always easy. As mentioned, presence of a student in the assigned cluster is not a good indicator of group membership. Also, the shape of clusters makes a difference. For example, one cluster in the lab studied is T-shaped. Students at the end and head of the T were rarely seen.

From a student's point of view, getting the attention of a tutor is the most important part of requesting help. This clearly depends on where the tutor is relative to the student and what they are doing. The most popular methods of obtaining help before the introduction of the LSS were hand-raising (36% of students questioned stated that they used this method every lab. 52.8% used it in some labs) and attracting attention when tutor is passing by (12.4% of students questioned stated that they used this method every lab. 53.9% used it in some labs). On rare occasions, a student would get out of their seat and approach the tutor directly (thus maximising their locational advantage). Some students appear to have consciously chosen to sit out of their cluster, as far away as possible so that they could work unimpeded by unsolicited tutor attention.

System Description

The LSS was implemented in Cold Fusion™ using SQL Server™ as the persistent data store. Cold Fusion™ was chosen because it required a minimal specification on the client machines and allowed the system to be run across different platforms. It also allowed the rapid prototyping and development of the system. The system proved to be very reliable; it failed only once, due to a failure of the web server (unrelated to the use of the LSS). Students ran the system on low-specification Windows NT4™ workstations (the standard lab machines they used for their practical work) and the tutors used Compaq iPAQ™ handhelds running WinCE 3.0™. In both cases, the system was run using Internet Explorer™ browsers. In this section the functionality of the two versions of the system – for students and tutors – is described.

The Student System

The primary aim of the student system was to allow students to request help from their tutor with a minimum of disruption. It was also hoped to prompt the students to think about their problem by requiring them to type in some keywords summarising their problem. The LSS also enabled a student to see who else in their group was requiring help and, if the student requiring help wished it, the keywords describing the problem. This would allow students, who perhaps had been stuck with a similar problem, to help each other. A secondary aim of the LSS was to allow students to record personal memos. These memos, which only the student can view, can be used to record anything but were primarily aimed at allowing students to record problems outside supported lab times to act as a reminder to raise the problem at the next scheduled lab. The interface to the student system can be seen in figure 1.

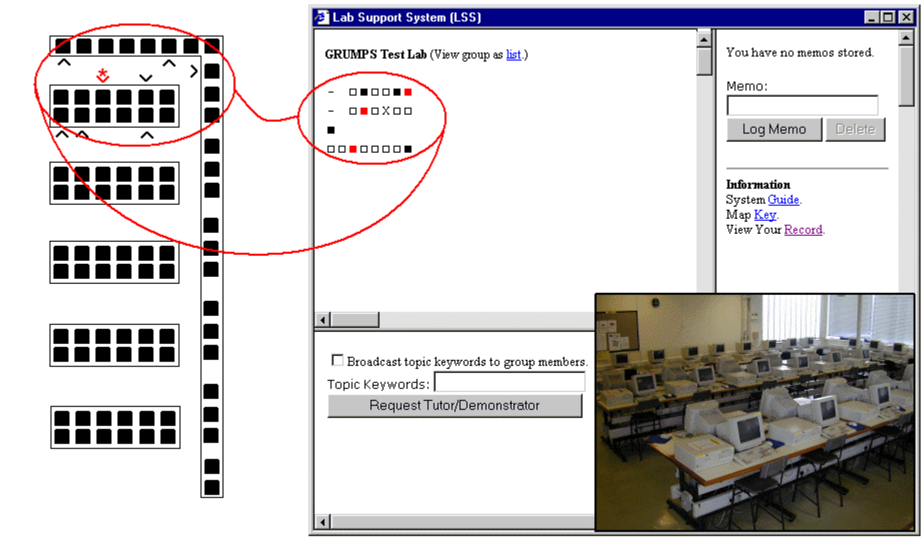

Fig. 1. Student interface to the LSS (on the right) showing the three main areas of functionality: view group (in this instance as a map); request help (in the lower window); and create/delete memo. Correspondence between map and the actual workstation cluster in the lab is shown to the left. Note that map orientation is rotated 180^{o} from the student interface since the student using this interface would be facing the camera. The student is represented by 'X' on interface and is marked with '*' on map. The direction a student is facing in the map is given by the point of the arrow. A photo of the lab is inset at bottom right.

The top left hand area of the interface presents the current the state of a lab group. In this case, the group is represented in a map. The student is represented on the map as a black 'X'. Other members of the group who are using the system are represented as a black '■'. Computers not in the student's colour cluster are represented as '-' and unoccupied[1] computers in the student's cluster are represented as '□'. If a student requests help then their representation on the map turns red. It can be seen, therefore, that in Figure 1 the computer cluster the student is sitting at is approximately rectangular (there are two computers from an adjacent cluster at the left represented by '-') and there are eight students logged in including the student whose interface is shown. Three students are asking for help. They are shown in red on the interface and are located two computers to the left of the student, at the end of the row facing the stu-

[1] In this context unoccupied means not being used by a student who is the lab group and is using LSS. Future versions of LSS will more accurately represent the presence of a student at a machine regardless of lab group and use of LSS.

dent and to the left and behind the student. It is also possible for the student to view the state of their group as a list. In this case all members of the group are shown regardless of their location in the lab or login status. If they are logged into the system, the name of the machine they are using is given. If they have asked for help this is indicated and, if they have permitted, the topic keywords for the help request will be given also.

The area at the bottom of the screen allows the students to request help. The students must type in some keywords describing their problem before they are allowed to submit a request. If they check the 'Broadcast topic keywords to group members' box the keywords they enter will be shown to other group members. The area at the top right of the screen allows students to record and delete memos. These memos are only visible to the student. The student is also able to view their record. This allows the student to see the information that is provided to the tutor, such as previous help requests and when they have been seen by a tutor. There are also some links to web pages providing help in operating the LSS.

The Tutor System

As well as allowing tutors to service student requests for assistance, the tutor system also provided tutors with background information on students, thus enabling them to provide more meaningful help to individual students. Furthermore, by providing a high-level view of the entire group, it was hoped that tutors might be able to recognise problems common across their group and, for example, convene a mini-tutorial. It was not our intention, however, to impose any particular strategy for the handling of help requests. We wanted to give tutors more information during labs, but leave it to them to decide how to use that information.

The tutor interface is shown in figure 2. The tutor has three separate windows, only one of which can be viewed at a time. In the options window, the tutor can select the lab group they are going to work with, how that group will be represented, either as a map or a list, and, if represented as a map, how the map is rendered: the orientation of the map and whether the whole lab is viewed or just the area with the group's students. Figure 2 shows the group view rendered as a map. The tutor view is similar to the student view, but students requesting help are allocated a number, based on the order they asked for help. In this case, there are three students asking for help. A tutor can see a student's record by clicking on their representation on the map or their name in the list view. This brings up the information window which is shown on the right in figure 2. In this window, the tutor can see a photograph of the student, the student's help request, if any, as well as details of previous help requests and when the student has been seen by a member of the teaching team.

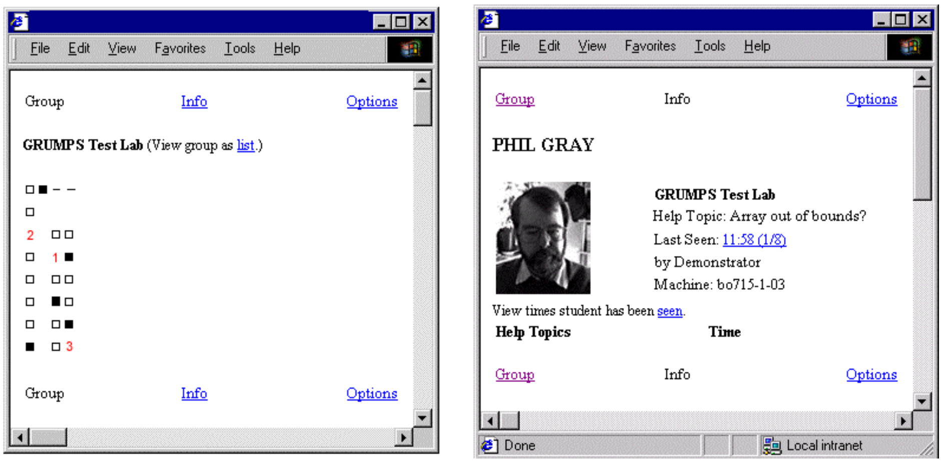

Fig. 2. Tutor interface to the LSS. The map view on the left is shown giving the tutor a high level view of the state of his/her group. The right-hand image displays the detail associated with the student logged in at workstation represented by '1'.

Locational Information in the LSS

Several forms of locational information are used in LSS. The entire system is based on data held in an SQL Server™ database. This database stores information describing the layout of a computing science teaching laboratory. As well as containing information about the x,y co-ordinate location of individual machines, the database stores higher-level locational information such as the orientation of the machine and the cluster the machine belongs to (the machines in the lab are divided into four clusters, each with a different colour represented by a coloured sticker on the machine's monitor). This information is used to generate maps for both the student and tutor interfaces.

In the student interface, the orientation of the map depends upon the computer the student is using. The orientation of the map is always such that what is in front of the student in the lab is above the student's location on the map. This is achieved by using the orientation information associated with the workstation as stored in the database. Fixed orientation is not possible with the tutor's interface, since it is used on a hand-held device. Therefore, map orientation is configurable via a menu, including options presented in terms of four landmarks in the room (windows, printers, tutorial room, fire exit).

The students are not able to specify the area of the lab visible to them. If the student is sitting in the correct cluster for their lab group then they can only see that cluster. If they are sitting at the incorrect cluster for their lab group they can see the cluster they are sitting at, the cluster they should be sitting at and any clusters located between them and the cluster they should be at. Furthermore, to reinforce the fact that they are sitting at the wrong cluster, the student's representation on the map changes from 'X' to '*'. By minimising the amount of the map shown to students it is possible to minimise the screen space used taken up by the LSS interface on the student machines. Tutors are able to choose either a view of the entire lab or just the area where their students are sitting. In the latter case, if one or more students are sitting outside the appropriate cluster for the tutorial group, the map view is resized accordingly to include their machines in the view. Although the tutors are using a handheld device with a limited screen-size, because LSS is the only application running and the full screen is being used (as opposed to the student situation where LSS is run as a background application) the full map of the lab can be displayed on the screen without the need for scrolling.

Different lab groups have different cluster(s) associated with them. This can be a single cluster or a list of clusters, perhaps covering the whole lab. Thus, the system is able to cover different perceptions of the importance of location. If students are to sit in an appropriate cluster for a lab their group has a specific cluster associated with it. If students are to sit anywhere (i.e. location is unimportant) the lab group would have all the clusters associated with it.

Observations on the LSS in Use

Both the LSS and its related keystroke level system were deployed in a 1st year computing lab from 24 April to 18 May 2001. A total of 27 tutors and 283 students used the LSS system during 87 two-hour lab sessions. During this trial, we collected data via the Grumps tools themselves, as well as via: direct observation during lab sessions; discussion groups (i.e., focus groups); questionnaires; diaries and interviews.

The non-computer-based data collection was intended to identify critical incidents and to explore behaviours and attitudes that couldn't be captured automatically. The comments that follow are based on this data.

Introducing our system tends to reduce the power of location to control the order in which help requests are serviced. We noticed that tutors sometimes felt compelled to use the numbering system even when they may have wanted to use some other servicing strategy. Direct observations of LSS and non-LSS lab sessions suggest that tutors find it uncomfortable to walk past students who were further down in the queue of requests. 81% of tutors who commented on their LSS servicing strategy employed a combination of help request order and systematic circulation of the lab group.

During the trial, the use of the LSS changed the role of tutor location on student requests and on student perception of the response. When making a request for help, students located the tutor in the room and were more likely to use the LSS to summon help if the tutor was located at a distance or out of sight of the student; when asked to explain how they used the LSS, 26.3% of students who responded reported using this strategy. Similarly, students reported that tutors' strategies for responding to help requests were noticeably different when the LSS was in use. Students reported that tutors would respond to help requests as they appeared in the queue, rather than servicing student help request based on the students' proximity. That is, students were aware of the change in tutor strategy that we also recorded. A number of students commented on the fairness of the first-come, first-served strategy.

Tutors tended to keep map orientation fixed, setting it up at the start of a session. Occasionally, they were observed turning the machine to orient it to the room rather than changing the map orientation.

For students we anticipated that the map would give them information about the state of their group – who was there and where. We expected that some might use this to find nearby students with similar problems. We have little evidence that this information was actually used explicitly in this way. With respect to orientation, students would often get a different orientation each time they logged in. We found no evidence that this caused any problems. Observation of students in the lab suggested that they could locate other members of their group in the map.

As stated above, we anticipated that the map, if used in combination with publicly broadcast topic keywords, might encourage peer-to-peer help amongst the students, the pedagogical benefits of which have been described in other studies [Greer et al, 1998]. There is no firm evidence that the LSS stimulated this kind of behaviour. The post-study student questionnaire suggests that users experienced difficulty expressing their problem in keywords, and the recorded archive of keywords used also supports this.

Probably because of the relationship between tutors and students, we observed no explicit negotiation to establish the ways that the new technology would be used, unlike the process reported in other studies on the introduction of mobile location-aware technology [Weilenmann 2001].

Conclusions

Perhaps the main finding resulting from our dealings with location in developing and using the LSS is the richness of issues in this application that are related to location. Even without introducing sophisticated location awareness, introducing mobility to some of the technology had a significant impact on how people performed their tasks. We benefitted from what we found out during early investigations of the domains and we were also fortunate that unexpected and unanticipated effects of introducing a mobile information source didn't cause the LSS to fail. It appears that the details of location matter and can have significant influence on the success and appropriateness of information presentation and interaction techniques.

We intend to develop the LSS further, although the means of doing so is currently under discussion. There are a number of ways in which such an LSS enhancement might benefit from location, including:

- Proximity awareness of a tutor

  In the current system, a student must explicity complete the help session by pressing one of a set of help completion buttons on their interface (the buttons correspond to different types of help completion, e.g., tutor provided help, I solved the problem myself, etc.) and they cannot make another help request until this is done. Students often didn't bother to complete this, until they needed help again. Proximity sensing could be used to provide automatic closure on a help request. That is, if a tutor is detected physically close to the student, their subsequent departure (after a suitable interval) could be interpreted as completion of the help session or could trigger a modal dialogue (like using the taking of a card in an ATM to trigger dispensing of money).

- Location awareness of student
  We currently determine student location by login to the LSS. This is problematic because a student might be sitting in the lab, not yet logged in, or logged into the workstation, but not the LSS.
- Detecting locational features of help requests
  Another location-oriented issue is identifying sets of help requests that are spatially nearby and presenting this information to the tutor, allowing the tutor to create ad hoc tutorial groups. The map provides some support for this, but still requires cognitive effort to identify potential groups.

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