The candidate confirms that the work submitted is their own and the appropriate credit has been given where reference has been made to the work of others.

I understand that failure to attribute material which is obtained from another source may be considered as plagiarism.

(Signature of student) __________________________

Social Navigation of Scientific References

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MSc project 2001/2002
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Abstract

Social navigation helps people make their decisions through observing the behaviours and actions of other people who are put under similar circumstances. Although social navigation is quite normal in people’s every day life, it is only “slowly being adopted in software systems” (Dieberger, Dourish, et al, 2000). Social navigation systems do provide information more readily, but being informative versus being compact is a problem that needs some careful thinking.

The objective of this project is to design, implement, and evaluate a Web-based system that supports social navigation of the references of scientific publications. This system starts with a list of academic papers and books. Different researchers within a research group can each add more publications to the list and annotate the references, and as a research community they can share the information about the references as they find out about the papers and books. The system thus facilitates the whole research community to navigate through a large number of references. It is in this sense that it is called a social navigation system for scientific references. The navigation information that helps the research community as a whole may include data items such as the visitor, the visited entry (i.e. the reference), the visiting frequency of an entry, the latest date/time of visit, and trails of navigation in the reference space.

Based on a review of related literature and systems, the project has achieved design, implementation, and evaluation of such a Web-based scientific references system. The system stores basic data of references and participating members. It also accumulates social navigation history data including the visitor (who visited the system), the visited entry (what reference was visited), and the time of the visit. Furthermore, the system provides a ‘also visit’ list for each reference, based on the history data. The system has a two-level feedback and rating mechanism which record users’ comments and ratings about the references, and reviews and confidence ratings about the comments. The aim of the first level feedback and rating is to balance the ‘snow ball’ effect of visit count, and the second level feedback and rating is to advise on the reputation of the first level rating.

The results of the system evaluation produced some useful suggestions about the usability of social navigation in the context of scientific references. The system limitations and potential improvements are discussed in relation to system design and evaluation results.

Keywords: Social Navigation, Scientific References System, PHP, MySQL, HCI, Web-based application
Acknowledgments

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Thanks must also go to Mr. Eric Atwell for his insightful advice. His comments on potential future applications of this system have encouraged me. I have also benefited from his helpful lecture about the MSc Project report.

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Chapter 1. Introduction

The primary information source for academic researchers is journal and conference papers. Most academics keep a record of papers they have read, and some maintain this in the form of a database. Within research groups, different researchers need to share information about papers they have each read, but currently this only occurs on an ad hoc basis (e.g., in response to a specific request).

The goal of this project is to design, implement and evaluate a Web-based system that allows social navigation of scientific references. Much research about social navigation has been performed in a wide range of situations, but would a social navigation system be helpful in the context of scientific references? If it is, which social navigation information is particularly helpful? And in what way could they be helpful? This project aims to study these questions, if not to answer all of them.

1.1 Background, and concept of social navigation

Regarding the concept of social navigation, it is useful to draw some parallel examples from daily life. When a visitor first arrives at a beautiful little town, he or she naturally wants to find out where the most interesting place is to visit. The visitor may either consult a tourist information officer, or stand by the central square to see where most tourists go and just follow them. A second example is when an adolescent student has to decide which style of clothes he or she should buy. In this case, following the up-to-date college fashion might be a popular choice. As a further example, when a student enters the university library, having a quick look at those newly returned books may not be a bad idea since those books are what others have just read. These are all the examples of how we use social information every day to help make a decision, and benefit from the interaction with others in a community.

As learning from social information is so familiar in our daily life as human beings, there is little doubt that similar situations will occur with our new communication means, in electronic space. Discussion made by Dieberger, Dourish, et al (2000) indicates that in 1939 Vannevar Bush already proposed the idea that “people might share the ‘trails’ they create through information space”. As the growing of online information, Dourish and Chalmers (1994) introduced the first concept of social navigation as “moving towards a cluster of other people, or selecting objects because others have been examining them.” After that, research in this area became vibrant, and the concept of social navigation has been broadened widely, ranging from web browser’s bookmark to newsgroup and daily email. To emphasize the role of social navigation in providing advice, Svensson, Höök, et al (2001) gave a slightly modified version of the definition: “Social navigation is navigation that is conceptually understood as driven by the actions from one or more advice providers.” Of course these advice providers are not only the direct ones like the message author in a newsgroup but also some indirect ones like aggregated purchase count from previous record (e.g. Amazon online store, top sellers).

1.2 Classification framework of social navigation

The type of social systems used for interpersonal communication may be classified more clearly by Riedl’s (2001) framework of social navigation. According to Riedl, the electronic space social systems could be evaluated on two axes: synchronicity, and directness.
The first axis, synchronicity, indicates “whether social interaction occurs synchronously or asynchronously” (Riedl, 2001). Like the occurrence in Microsoft NetMeeting, and web-based chatrooms, synchronous systems enable real-time communications to happen between each user without any obvious delay. In these systems, users could put forward any new problems and get reply with the lowest time-costs due to the delay in reception. In contrast, those asynchronous systems such as email and newsgroups usually need users to consume much more time waiting for the answers. However, the users of the later systems could always expect some higher quality response than those in former systems, since more time, therefore more careful thought, could have been employed by respondents.

The second axis in Riedl’s classification framework for electronic space social systems is directness. The definition of directness is introduced by Svensson (cited by Riedl, 2001) as: “the capacity for mutual communication.” Direct social systems provide users with the ability to reply to the initially received message. In other words, users could contact one another directly (Dieberger, Dourish, et al, 2001). Social systems like email, newsgroups, and MUDs (multi-users dialogs) are all the examples of direct system. Compared with this phenomenon, there are no reciprocation mechanism occurring between users of recommender systems (Resnick and Varian, 1997). These systems help people make selections based on other people’s behaviours, but there are no one-to-one solutions. Therefore this kind of systems could be classified as indirect social systems. Compared with indirect ones, direct social systems have the apparent advantage of having very low equivocality and uncertainty costs because reciprocation can be used to refine and clarify the message (Riedl, 2001), but their response is more subjective. In contrast, recommendations from indirect social systems could be more objective due to accumulation of many people’s behaviours, but the obvious drawback is its strong affect in terms of equivocality and uncertainty costs.

Quoted from Riedl (2001), Figure 1 illustrates how different electronic space social systems map the classification framework.

![Figure 1](image-url)  
**Figure 1**: Examples of electronic space social interaction plotted against synchronicity and directness. Quoted from Riedl (2001).

### 1.3 Key properties of social navigation

To distinguish social navigation from general navigation, two properties are emphasized to describe the phenomena: **personalization** and **dynamism**. Two examples borrowed from Svensson (2001) demonstrate the importance of these ideas:

1. Walking down a path in a forest is social navigation, but walking down a road in a city is not.
2. Talking to a person at the airport help desk that explains how to find the baggage claim is social navigation, but reading a sign with (more or less) the exact same message is not.
The first example illuminates the dynamic property of social navigation. Compared with the intrinsic attribute of a city road, the state of a path in a forest could change from time to time. Without any traveler walking through it, the path will disappear gradually after a period of time.

In the second example the personalization of the navigational advice is underlined. The personalized navigational advice is delivered to each particular customer. Each time the same message might differ on different terms, different presentation, or even different language depending on the various customers.

To indicate these two properties in the context of electronic space social systems, we could imagine the employment of recommender systems. For different users, recommendations provided by the system might differ due to users’ various personal interests. On the other hand, for a certain user, the system might deliver different recommendations at different times because of the dynamic accumulation of social navigation data.

1.4 MSc project planning

Recall the goal of this project: design, implement and evaluate a Web-based system that allows social navigation of scientific references. To carry out the design, sufficient survey of related literature and systems is essential. To implement the design, learning an appropriate computer language and database is necessary. To execute evaluation, suitable user tasks should be established.

To make sure the work could proceed smoothly, an initial planning was made at the beginning of the MSc project. Table 1 demonstrates a brief project schedule. This has been broadly followed throughout the whole project. The exceptions were (i) some write-up was done as the project proceeded, and (ii) some system implementation persisted till the middle of August.

<table>
<thead>
<tr>
<th>Date</th>
<th>Stage</th>
<th>Planning Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/05/2002</td>
<td>Planning</td>
<td>1. To be clear on the project objectives at the outset.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Produce an outline plan for the achievement of the objectives, to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>provide a framework for the other activities later and to act as a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>starting point for the planning process throughout the project.</td>
</tr>
<tr>
<td>10/06/2002-21/06/2002</td>
<td>Literature survey</td>
<td>1. Understand the background in which the project is to be undertaken –</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Social Navigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Understand the problems likely to be encountered – Related systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>survey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Understand of the initial feasibility of the objectives set for the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>project – Classify the characteristics of social navigation information used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>in the related systems, begin to think about design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Produce a better definition of the problem and provide the project with</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a clearer sense of direction – Begin to think about the evaluation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tasks</td>
</tr>
<tr>
<td>29/06/2002-05/07/2002</td>
<td>Solution Designing</td>
<td>1. Produce a systems architecture design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Produce a database design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Produce and improve interface design while implementing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Implementing the design</td>
</tr>
<tr>
<td>03/08/2002-30/08/2002</td>
<td>Evaluation &amp; Conclusions &amp; Write up</td>
<td>1. Processing evaluation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Summarise conclusions about following two aspects: achievement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>against the project objective, and project experience</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Writing up final report</td>
</tr>
</tbody>
</table>
Chapter 2. Review of Indirect Social Navigation Systems

Although there are several classes of social navigation, this project only focuses on indirect social navigation systems like recommender systems (Resnick and Varian, 1997). This class of social systems has much more social information than direct social systems, thus it would be more valuable because “most problem-solving tasks are collaborative in nature” (Wexelblat and Maes, 1999).

2.1 Existing Systems

To analyze the characteristics of indirect social navigation information, a number of existing social systems have been investigated. Table 2 shows the investigation results of non-scientific references systems. Most of these systems were commercial Websites. Some of them were used in research settings. The investigation results of scientific references systems are shown in Table 3.

<table>
<thead>
<tr>
<th>Systems</th>
<th>Non-Social Navigation</th>
<th>Social Navigation (Indirect)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Search Engine</td>
<td>Categorization</td>
<td>Action count</td>
</tr>
<tr>
<td>Jungle online Store</td>
<td>V</td>
<td>V</td>
<td>Topsellers</td>
</tr>
<tr>
<td>Gobazaar online Store</td>
<td>V</td>
<td>V</td>
<td>Topsellers</td>
</tr>
<tr>
<td>Warner online Cinema</td>
<td>V</td>
<td></td>
<td>UK Top ten movies</td>
</tr>
<tr>
<td>Blackstar online Store</td>
<td>V</td>
<td>V</td>
<td>Topsellers</td>
</tr>
<tr>
<td>EFOL (Svensson, 2001)</td>
<td>V</td>
<td></td>
<td>Ranked recipe list</td>
</tr>
<tr>
<td>WHSmith online Store</td>
<td>V</td>
<td>V</td>
<td>Bestsellers</td>
</tr>
<tr>
<td>Empire online Store</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amazon online Store</td>
<td>V</td>
<td>V</td>
<td>Top/Hot sellers; Chance encounters (Also bought count)</td>
</tr>
<tr>
<td>HMV online Store</td>
<td>V</td>
<td>V</td>
<td>Chance encounters (Also purchased count)</td>
</tr>
<tr>
<td>Dooyoo customer reviews online system</td>
<td>V</td>
<td>V</td>
<td>Top products based on customer rating, Opinion &amp; rating on product</td>
</tr>
<tr>
<td>Epinion online Store</td>
<td>V</td>
<td>V</td>
<td>Bestsellers</td>
</tr>
<tr>
<td>CoWeb</td>
<td></td>
<td></td>
<td>Time-related visit count</td>
</tr>
</tbody>
</table>

Table 2. Social Navigation Systems for Non-Scientific References Context
2.2 Recommendations and reputations

As introduced by Resnick and Varian (1997), recommender systems help people make selections based on other people’s behaviours. In this sense, all the systems shown in Tables 2 and 3 could be called recommender systems since they all provide users with some information about others’ action and help users make their decisions with this information.

As for the ways to present this social information, action count can be seen as integrated social information. It comes from a number of people’s behaviours and no individual behaviour could be seen from it. Action count tells users what most other people have done here. One famous example here is how Amazon online store recommends books, with information: “others who bought this book also bought…” A user can trust the recommendations coming from this integrated information if he or she can be sure that most other people’s decisions as a whole should be right. However sometimes this belief might be a risk. A case of this risk is the problem called “snowball” effect “where more and more users follow each other down the wrong path” (Svensson, Höök, et al, 2001).

To balance the “snowball” effect, social systems should provide a feedback mechanism which store the information about what happened after the action (purchase, and view). With this mechanism users can come back to the systems after their action, leave their individual reviews and rating about whether the items they bought, read, or visited really met their needs and whether they enjoyed them (Dieberger, Dourish, et al, 2000). This policy could help later users assess the quality of the items.

However, “reviews can vary widely in quality” (Dieberger, Dourish, et al, 2000). Therefore one more feedback level is needed here to ensure the reputation of the first level feedback. One successful example of this two level feedback principle is Epinion online store. Users of Epinion can either leave their reviews and ratings on products, or make their comments and ratings on reviews.

Compared with Table 2, Table 3 illustrates that the methods used for scientific references. It can be seen that the systems adopted for scientific references are quite different from the non-scientific references systems. In spite of customer review and rating in those store-based systems, all four scientific reference examples such as ACM digital library and Web of Science (WoS) used citation to indicate the quality of the references. This appears to be the most popular way in the scientific references context. This is because within the existing scientific reference systems a large quantity of citation data is already available, and it is an accepted indicator of the quality of the papers. As
the citation-based systems are already widely available, it would be interesting for this project to test the two-level feedback mechanisms from those store-based systems. For a research community, it may seem to be an interesting experiment to try an alternative system that has been in use elsewhere.

2.3 Navigation information to be captured

There are quite a large variety of social navigation information that can be captured. A good approach for this problem is Wexelblat and Maes (1999)’s category of social information: what, who, why, and how.

All the actions like visiting WebPages, or reviewing products, or rating reviews, can be seen as what was done. In implementation, usually it is only the object of action that is recorded, that is to say, the captured information here usually is which object. And the information of who has done something normally used for “establishing authority and authenticity” (Wexelblat and Maes, 1999).

Some other possible categories are “place” information and “path” information. All the action objects could be “place” within an information space, while “path” might be an item that links several users, or a person who links several items.

Table 4 shows a analysis of social information captured in the existing systems.

2.4 Discussion

Without the support of social navigation, a product/service provider can only tell the user what the product is. While with the help of social navigation, the system can answer the question of who, choose what when, and why they do that, thus it gives more useful information to help the user make informed decisions on product purchase or scientific references retrieval. In other word, the decisions taken are based on the statistics of a wealth of social activity information.

Without the support of social navigation, a user of a scientific reference database will only see the references as they are listed in the database. He/she will not be able to know how others have used the database, who the other users are, or at what points of time the other users made use of the references, or the reasons why certain references are regarded more highly than others. With the help of existing social navigation, a user is able to obtain some information as part of the use of the database, primarily through indicators of citations. For a research community that share some common interests in the topics of research, it may be interesting to test a system that provides further information on social navigation, in a similar way to what has already been done with the web-based commercial systems.

However, social navigation supporting technology does not replace navigation technologies that appeared before it, such as the keyword search, categorization, and Boolean calculations of similarity, etc. In fact, social navigation is built on top of such techniques. All these techniques work together and as an integrated system they achieve better information retrieval in cyberspace.
Table 4. Classified social information retrieved from existing systems

<table>
<thead>
<tr>
<th>social navigation techniques</th>
<th>Navigation history information classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action count</strong></td>
<td></td>
</tr>
</tbody>
</table>
| “Top ten” / “Bestsellers” (“Mean” user data) | a. Item purchased / read *(where)*  
c. Frequency / number of action – purchase / reading – within a period of time (calculated, how many, used to rank “top ten” / “bestsellers”, *(why)*) |
| “Chance encounters” – “Also bought” / “Also read” (“Mean” user data) | a. Actions subject *(who)*, the link of all actions  
b. Action object – Item purchased / read *(where)*  
c. Time of action – purchase / reading *(when)*  
d. Action objects statistics (calculated, how many, used to rank “also bought…/ read…”, *(why)*) |
| **Two level feedback mechanism** |                                               |
| “Customer’s reviews”  
a. One level *(Individual)* user data  
b. Two levels / Expert - customer review (“Mean” user data) | a. Actions subject *(who)*, one link of the actions  
b. Action object – Item assessed *(where)*, another link of the actions  
c. Time of action – review *(when)*  
d. Review and rate of the object – level one (quality of object, *(why)*)  
e. Comment and rate of the review – level two (quality of assessment, *(why)*)  
f. Action statistics of a object (calculated, how many, used to show the quality of the object, *(why)*)  
g. Action statistics of a subject (used to show the authority of the assessor, *(why)* *(who)*) |
| “Cited by …”  
a. Each document *(Individual)* user data  
b. Citing number (“Mean” user data) | a. Action object – Document assessed *(where)*, link of the actions  
b. Actions subject *(who)*, another link of the actions  
c. Time of action – cited *(when)*  
d. Assessment – link of citing document written by action subject *(why)*  
e. Action statistics of a object (calculated, how many citing, used to show the quality of the object – document, *(why)*)  
f. Action statistics of a subject (used to show the authority of the assessor, *(why)* *(who)*)  
Note: the link to the citing document could show the quality of the assessment – using the same way shown above (Level two assessment) |
Chapter 3. System Design

According to the discussion of Dieberger and Dourish [et al?] (2000), there are some important challenges that face the recommendation systems. The main challenge is the “early rater” problem which system’s early users could hardly benefit from the system before huge social navigation data been accumulated. This early rater problem is avoided here in this project. This project is to design a social navigation system of scientific references as a history-rich recommendation system. The system supports indirect social navigation, and provides two level feedback and rating mechanism. The first level feedback is used to balance the ‘snow ball’ effect, and the second level feedback indicates advice provider’s reputation (Dieberger and Höök, 2001).

3.1 Navigation data capture and presentation

Basically, information of each member and of each reference is to be recorded in the system. Keywords will be stored separately as navigation data, since members will determine each reference’s keywords. Each time when information of a new reference is uploaded into the database, a relationship between the reference and its keywords will be recorded. Based on such data, each time when a visit action happens, three pieces of navigation data will be captured by the system. The captured data is who visits which reference at what time. Data of visiting action is saved separately. In the current version of the system, only first two pieces of data are used for presentation. Display of the third data item could be implemented as one of the future improvements. Using the second data item - reference, the object of the visit action, as the first link, the system can find out all the previous members who have visited the same reference. Then, using each member, the subject of the visit action, as the second link, system can detect all other references visited by these members. By cumulate such data, the system can then present a related reference list for the initial reference as the form of “People who visited this reference also visited…”

When the first navigation data item is recorded, the degree of popularity of a reference will be displayed by the system through a “visit count”. The reference with the highest visit count is the most popular reference on a particular research topic, which suggests that it might be worth reading first. However, “visit count” presentation is accompanied by the “snowball” problem (Svensson, 2001). Consequently, the system provides a feedback/rating mechanism to balance the “snowball” effect of reference’s visit count.

Feedback/rating mechanism of the system is a two level feedback/rating mechanism. The first level of the mechanism, comments and rating about the reference, is applied to compensate the effect of visit count. The rating used here does not provide a strictly objective academic standard like the citation count, nevertheless the average rating of a reference will assist users to have some information about the reference’s quality. Furthermore, the second level of the feedback/rating mechanism, the review and rating about a certain comment, will answer the question about advice provider’s reputation (Dieberger and Höök, 2001).

Each time when a member adds a comment (first level feedback) or reviews (second level feedback), the system will record four kinds of data: who (member) did what (rating), when (date and time), where (reference or comment), and why (comment or review). Both first and second level feedback will be stored respectively.
In summary, we could imagine the information storage structure of the social system as a big building with many rooms. The whole building symbolizes the whole scientific references database, and rooms symbolize certain references. Within each room there are some desks and a guest book, each desk has several drawers. The guest book will store the information about the visitors, the desks will represent comments about the reference, and the drawers will represent reviews about a comment. The difference between these two models is that within a physical building, the number of rooms, desks, and drawers are all fixed. In contrast, in an electronic space, the number of references, comments, and reviews are all dynamic, and the capacity could be much bigger than the buildings found in the real world.

### 3.2 Database design

One key assumption has been made for the system structure is that no common reference will belong to different members at the same time, a certain member could only upload and maintain the reference information in his/her individual list. This presumption will simplify the system structure by preventing overlapped uploading. However, this hypothesis will make the system functionality a little too simple and may bring users some inconvenience. The system structure should be improved in the future so that different users could possess some of the same references in their individual space as well as precluding overlapped maintenance.

Based on the former system analysis, the system structure could be demonstrated in Figure 2 as an entity-relationship (ER) diagram. In Figure 2, there are in total seven entity types and nine one-to-many (1:M) binary relationship types between those entity types.

![Figure 2. ER-diagram of the system](image)

Illuminated by Connolly and Begg (2002), the definition of entity type is “a group of objects with the same properties, which are identified by the enterprise as having an independent existence.” An entity type can be objects with a physical (or ‘real’) existence like ‘Member’ and ‘Paper’ entity types, it can also be objects with a conceptual (or ‘abstract’) existence such as ‘Reading’ and ‘PaperKeyword’ entity types. Furthermore, entity occurrence is “a uniquely identifiable object of an entity type.” For example, a certain visit action is an entity occurrence of the entity type ‘Visiting’.

Connolly and Begg (2002) also pointed out that the relationship type is defined as “a set of meaningful associations among entity types,” and relationship occurrence gave the definition as “a uniquely identifiable association, which includes one occurrence from each participating entity.
type.” An example of a relationship type shown in Figure 2 is the relationship called ‘L1FMake’, which represents an association between ‘Member’ and ‘First level feedback’ entity types. Each relationship occurrence of ‘L1FMake’ describes an association of a single ‘Member’ entity occurrence with a single ‘First level feedback’ entity occurrence.

Moreover, the degree of relationship type, according to Connolly and Begg (2002), is “the number of participating entity types in a relationship.” All the relationships shown in Figure 2 have only two participating entity types, thus they are the relationships of degree two. In other words, all these relationships belong to the binary relationship type.

As for multiplicity (Connolly and Begg, 2002), it is “the number (or range) of possible occurrences of an entity type that may relate to a single occurrence of an associated entity type through a particular relationship.” In Figure 2, one-to-many (1:M) binary relationships ‘L1FOwn’ between entity types ‘Paper’ and ‘First level feedback’ that one reference can have zero or many first level feedback, and each first level feedback must belong to one reference.

The relationships between entity types ‘Member’, ‘Visiting’, and ‘Paper’ shown in Figure 2 could be explained as follows. One member can visit zero or many references, and one references can be visited by one (owner who upload this reference) or many members. To record such navigation data as ‘who visit which reference at what time’ a table is need. Table 4 shows an example of this kind of table in the real world. To avoid data redundancy, three related tables are designed to record the same data. Each of these tables comes from an entity type shown in Figure 2. Their relationships are shown in Figure 3.

Table 5. Sample condition of reading action

<table>
<thead>
<tr>
<th>Paper I Title, Publication Year, …</th>
<th>Paper II Title, Publication Year, …</th>
<th>Paper III Title, Publication Year, …</th>
<th>Paper VI Title, Publication Year, …</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member 1 First name, Last name…</td>
<td>Visit time a YY:MM:DD</td>
<td>Visit time b YY:MM:DD</td>
<td>…</td>
</tr>
<tr>
<td>Member 2 First name, Last name…</td>
<td>…</td>
<td>Visit time c YY:MM:DD</td>
<td>Visit time d YY:MM:DD</td>
</tr>
<tr>
<td>Member 3 First name, Last name…</td>
<td>Visit time e YY:MM:DD</td>
<td>…</td>
<td>Visit time f YY:MM:DD</td>
</tr>
</tbody>
</table>

Figure 3. Three related tables for record of member, paper, and visit data
Similar to this situation, the relationships between entity types ‘Paper’, ‘PaperKeyword’, and ‘Keyword’ shown in Figure 2 could be implemented by three corresponding relational tables. One reference can own zero or more keywords, and each keyword can belong to zero or more references. Therefore there is a one-to-many binary relationship between entity types ‘Paper’ and ‘PaperKeyword’ and another one between ‘Keyword’ and ‘PaperKeyword’.

Other relationships shown in Figure 2 could be understood similarly. Directly coming from ER diagram shown in Figure 2, the integrated relationship diagram of tables is produced in Figure 4.

![Figure 4. The relationship diagram of tables for the entire system](image)

For each table, primary key is shown as an attribute associated with a key icon.

For each relationship line, key icon at the end of the line shows which table the targeted primary key exists.

### 3.3 System architecture (PHP, Apache web server, MySQL)

The system architecture based on the combination of Apache, PHP, and MySQL. Apache is now the most-used Web server in the world, PHP is a server-side, HTML-embedded scripting language, and MySQL is a powerful free SQL (Structured Query Language) database server (Zandstra, 2000). The system architecture belongs to Internet technology database applications, it can be illustrated as three-tire architecture (Kroenke, 2002) shown in Figure 5. From left to right, they are the browser, the web server, and the database server.
Figure 5. System architecture
CGI – Common Gateway Interface; ODBC – Open Database Connectivity standard
Chapter 4. System Implementation

To implement all the system design, a Website has been built. It would be quite time consuming to design a web page to support universal access, which means to accommodate different web browsers, various display resolutions, and different transmission speeds. Consequently, the current system implementation is performed on some assumption of certain basic running conditions. The Website is designed based on 1024*768 or higher display resolution, Microsoft Internet Explorer Web browser, and 112kbps or faster speed Internet access. These are quite common standards which should allow it to be used for system evaluation purposes without any problem.

4.1 Website Structure and global web page layout principle

When entering main function space through Website gateway, there are two separate major spaces – Guest Space, and Member Space. Member Space also has three sub-spaces called member’s profile space, member’s public space, and member’s individual space. In member’s individual space, users can insert new reference data, and edit existing data. In member’s profile space, a new user can sign up as a new member, and members can update their personal information. Member’s public space is the main area of the system, including a series of social navigation functionalities provided by the system. Members in public space could navigate through the whole reference database, search for particular references, order reference list through the use of several options, read other members’ comments about certain references, and locate related references by an “Also visited” list. Compared with member’s space, guest space only provides the users some basic information about references stored in the database and it is without any social navigation information. The whole Website structure is illustrated in Figure 6, which is a sitemap of the Website.

As shown in Figure 7, each web page has five functional areas that are arranged vertically from top to bottom. To ensure that the whole Website forms an integrated body, layout of both the whole web page and each function area in the page are consistent to a high degree for all web pages.
(Shneiderman, 1998, 74-75). Users navigating through different web pages will benefit from a very familiar interface. Any effort paid for understanding first several web pages will directly help users browse the Website in a progressively easier manner. Furthermore, the colour scheme usage within all the web pages is based on the principle of being soft but clear.

Figure 7. Web page function area illustration

4.2 Navigation guide system in the Website

Website needs to help users navigate through different space within the system conveniently. The first principle is to enable users to observe their location easily. That is to say, besides integration of the whole Website, users should easily notice the difference between different system space. The main design for this purpose is through the usage of colour schemes. In each web page, the biggest colour block is the search & navigation bar. Different colours of the search/navigation bar distinguish different spaces. A second technique that helps the users notice their location is concerned with the heading of each web page. They are all displayed at the top center of each web page.

A second principle of navigation guide in a Website is to minimize users’ effort of changing web pages. As shown in Figure 7, the system repeats the same navigation bars for each web page, one on the top part of the page, the other one on the bottom part. The same arrangement has been applied for reference list order option and page change icons. This solution assists users’ navigation by preventing any extra scrolling (Shneiderman, 1998, 575-576).

4.3 Individual Space

Member’s individual space provides users the functions of insert new reference data and edit existing reference information. The SQL query for inserting new reference is illustrated as follows.

```
INSERT INTO table reference (col_name1, col_name2, ...) VALUES (new_reference_data1, new_reference_data2, ...);
```

The SQL query for editing existing reference information is illustrated as follows.
UPDATE table reference
SET col_name = updated_reference_data
WHERE reference_id=current_reference_id;

One particular design should be mentioned here. When a user assigns keywords to a reference, the system first provides an existing list of keywords for the user to choose from. This approach is based on the thinking of the keyword selection problem. Sometimes members might use different form of words to refer to the same concepts. Some examples are singular and plural forms of works, such as network and networks, words with the same stem like graphics and graphical, words with similar meanings like open learning and distance learning, abbreviations such as CSCW (computer supported cooperative work), and alternative spellings like modeling and modelling.

Furthermore, when users edit existing reference information, if this document already has some keywords, the system will highlight these keywords by make them in bold. The function is demonstrated in Figure 8. The brief algorithm of this function is shown as follows.

FOR EACH existing keyword
{
 IF (this keyword belongs to the reference)
 Display this keyword by bolding it;
 ELSE
 Display this keyword in normal format;
}

Figure 8. Existing keywords selection interface

4.4 Search engine

The system provides two ways of keyword search. One is Quick Search which is placed on the left hand of the search/navigation bar shown in Figure 7. Quick search allows user simply type one keyword and search them in title, keywords, and abstract of references. The SQL query of the quick search is illustrated as follows.

SELECT reference data
FROM reference table
WHERE reference.table LIKE "%searched keywords%"
OR reference.keywords LIKE "%searched keywords%"
OR reference.abstract LIKE "%searched keywords%";
The second way of keyword search is Advanced Search which is located just to the right of Quick Search. The interface of advanced search is shown in Figure 9. Using advanced search, users could control the search condition more exactly. However, the search engine function provided by this version of system is quite simple, if users type some keywords combined by logical operators (AND, OR, and NOT) in a search option input area, the system could not recognize them separately. That is to say, if users type “navigation OR 3D” in title area, the current search engine can only search “navigation OR 3D” as one character string, but not search “navigation” or “3D” like those more powerful search engine.

![Figure 9. Interface of advanced search](image)

4.5 Order of reference list

In member’s public and individual space, the system provides users with the ability to order search result by several options including some social navigation information such as rating and visit count, and page changing function as shown in Figure 10. The later functionality is essential since system only displays twenty references in each page. The SQL query for ordering reference list and control the display lines is illustrated as follows.

```sql
SELECT reference data
FROM table reference
WHERE reference attributes = search conditions
ORDER BY order option
LIMIT start display reference number, numbers of references displayed in one page;
```
4.6 Comments and Reviews

In member’s public space, when users click ‘visit’ icon associated with a reference, the hyperlink will lead users to this reference page. This navigation information of this ‘visit’ action will be recorded by the system. The SQL query for inserting navigation data about this reference is illustrated as follows.

```
INSERT INTO table visiting (col_member_id, col_reference_id, col_visit_time)
VALUES (this_member_id, this_reference_id, current_time);
```

In this reference page, comments and ratings about this reference are displayed. Users can add their own comments and ratings as well. Users can also choose to review and rate a certain comment, which will lead users into a comment page which displayed all the reviews and ratings about that comment.

The SQL query for displaying comment list about a reference is illustrated as follows.

```
SELECT comment data
FROM table comment
WHERE comment.reference_id = this reference_id;
```

The SQL query for inserting comment and rating about a reference is illustrated as follows.

```
INSERT INTO table comment (col_comment, col_rating, reference_id)
VALUES (new_comment, new_rating, this reference_id);
```

The SQL query for display reviews and insert new reviews and rating about a comment is similar to what is shown above.

The comments about reference and reviews about comment web pages are shown in Figure 11.
4.7 ‘Also visited’ list

In member’s public space, when users click the ‘visit’ icon of a reference and enter the page for this reference, ‘also visited’ list could be found at the bottom. The algorithm for displaying this ‘also visited’ reference list is shown as follows.

MySQL QUERY

{  
  # Create temporary table
  CREATE temporary table also_visit TYPE=HEAP
  SELECT reference_id, 0 AS also_visit_count
  FROM table reference WHERE reference_id <> this_reference_id;
  
  # Select all members who have visited this reference
  SELECT member_id FROM table visiting
  WHERE reference_id = this_reference_id GROUP BY member_id;
}

# Accumulate also visit count from all selected members visiting history
FOR EACH selected_member_id
  
  # Get visit count for each visited reference from this member’s navigation history
  MySQL QUERY
  
  {  
    SELECT reference_id, count(*) AS also_visit_count_by_this_member FROM table visiting
    WHERE member_id = selected_member_id
    AND reference_id <> this_reference_id
  }
GROUP BY reference_id;
}

# Accumulate also visit count for each visited reference
FOR EACH reference_id visited by selected_member_id except this_reference_id
{
    MySQL QUERY
    {
        UPDATE temporary table also_visit
        SET also_visit_count = also_visit_count + also_visit_count_by_this_member
        WHERE reference_id = this_time_reference_id;
    }
}

# Display ‘also visit’ list order by also visit count
MySQL QUERY
{
    SELECT reference_data FROM temporary table also_visit ORDER BY also_visit_count;
}

The “Also visited” list results is illustrated in Figure 12.

---

Figure 12. ‘Also visited…’ list displayed in one reference page
Chapter 5. Evaluation

5.1 Introduction

The project system foresees three scenarios in which users could benefit from social navigation history information. The first scenario is in a new research area, new research students could locate their initial reference reading list more easily and get to know more about the references through previous average ratings and visit counts associated with the references concerned. The second scenario is when users finish reading some reference, having particular interest in certain reference, some extra reading recommendation related with this reference could be offered through ‘also visited’ list. The last scenario is after a period of research, when users found a particular reference is quite important for a research area, the system could help researchers widen their thought by reading previous comments about that reference.

Due to the “early rater” problem (Dieberger, Dourish, et al, 2000) in recommendation systems, it is nearly impossible to quantitatively assess this social system before a large number of real social navigation data has been accumulated. To evaluate the system qualitatively, over 6000 visit records and 2000 comments & ratings about 781 references are generated randomly by computer program. Based on these data, three time-measured tasks as well as interviews and questionnaires are designed for system evaluation.

The main purpose of the evaluation tasks is to introduce users to the system, request them to use several functionalities in a practical test, and obtain comments and feedback from the users. All three tasks only focus on the first scenario mentioned above, since those program-generated navigation data is not suitable for testing the second and the third scenarios. Furthermore, since relationships between those references illuminated by program-generated social navigation information are not real, there are no standard answers for the tasks, and the measured time can only be considered as how long the system has been used, but not the time the user gets the correct answer. Consequently, which system function the evaluator employed to achieve the task is more important than which references the evaluator found from the system.

On the other hand, from interviews and questionnaires, some constructive suggestions are expected about the questions of whether and how the social navigation is helpful for scientific references systems. User’s preference might be able to be proof of social navigation’s value in scientific references context.

5.2 Method

For evaluation, two system interfaces, guest space and member space, are used separately by two groups of users. The tasks and questionnaires are the same for both groups except the last question which invite evaluators use another interface and then state their preference.

Subject

There were 10 subjects, 3 females and 7 males, 9 of them between 20 and 30 years old, 1 between 31 and 40 years old. They were either computing students or students of other specialty but very familiar with the use of a computer. They were selected into two evaluation groups randomly. Each group had the same number of subjects. None of the subjects had any experience of the project system prior to the evaluation. Evaluators’ degree of familiarity to the scientific references systems could be demonstrated by using frequency shown in Figure 13. The average degrees of familiarity
of the two groups are almost the same since users’ average frequency of use is 2.0 in Group One and 2.2 in Group Two.

![Using Frequency of Scientific References Systems](image)

**Figure 13. Evaluators’ using frequency of scientific references systems**

**Hardware and Software**

Each evaluation was carried out using Internet Explorer web browser under windows 2000 operating system, accessing the System Website through the Internet. The Website is located on the Web server in Informatics Research Institute, School of Computing, University of Leeds.

**Tasks and procedure**

All subjects worked on a one-on-one basis with the system designer.

First, background information was obtained from each subject concerning their age and experience with scientific references systems.

Then, the scenario was introduced to the subject. The subject was supposed to undertake a new research topic in the field of “Spatial Knowledge”, and the supervisor had recommended one reference. The subject was given by the title of the reference and was told the details of this reference could be found in the Scientific Reference Database provided by the system. The subject was invited to log on to the system to find the paper and gradually build up a reading list.

Then, the subject was requested to log on to the system and carry out three tasks.

**Task 1.** Find the reference entitled “A new framework for understanding the acquisition of spatial knowledge in large-scale environments” in the database. What information you could get about the reference?

**Task 2.** Find from the database all references that are related to “Spatial Knowledge”. This will give you a list of many papers. Explain how you used the system to find this list of references.

**Task 3.** Find 5 references from the database that look most interesting to read for your research topic “Spatial Knowledge”. Use the Ordering facilities provided by the system. Explain how you have chosen the five references.

By the end of each task, a short interview took place between the subject and the designer regarding the methods, problems and suggestions based on the tasks that were recorded.
Finally, subjects were provided by a set of open-ended questions on the usability of the system and their preference. The questions are as follows.

Question 1. Do you think the system has provided all the functionality that you require to complete tasks 1-3? If not, which part of the system should be improved as a priority?

Question 2. Do you think the system speed is acceptable for the tasks?

Question 3. Are you satisfied with the interface?

Question 4. Return to the gateway of the system. Log on Website using another interface (member space, or guest space). Observe the different functionalities and try them. Do you now prefer to be a guest or to be a member when using the system? Why?

5.3 Results

Analysis of the data reveals an interesting result. Figure 14 show the user-performance times for each task and interface. Figure 14 indicates that there are obvious distinguish between different users’ performance time for each task. For instance, to complete task 1, user 3 of group 1 took two and a half times as long as user 1 did. It also should be mentioned that in Member Group, there was a user who refused to accomplish task 3 because the functionality of the search engine was thought not enough for the task.

![Figure 14](image)

Figure 14. User-performance time for tasks in two groups. Left plot is the result of group1 evaluators using the guests’ interface. Right plot is the result of group 2 evaluators using the members’ interface. In each plot, solid line associated with solid square represents the results of task 1, dash dot line associated with solid circle represents the results of task 2, short dot line associated with dot center top triangle represents the results of task 3.

Compared with the lack of order in particular user performance time, some common trends could be discovered from figure 15. Task 1 and 2 could be classified as easy tasks, and task 3 could be put into the difficult task category. For each group, average user performance time for easy tasks is about half as long as for the difficult Task 3, and the time for Task 2 is even shorter than for Task 1. The probable reason of the this result might be that Task 1 is user’s first task, so the users needed to spend some extra time to be familiar with the interface and understand various information provided by the system.

As for the comparison between Guest and Member Groups, the former group is the winner in easy tasks. On average, Guest Group achieved a 33% faster speed up over Member Group for Task 1 and
27% for Task 2. In contrast, Member Group had a slight (5%) improvement in user performance time over Guest Group in the difficult Task 3. Some possible reason could be presented. With the easy tasks, much more information produced by member interface need users to spend extra time to understand. While with the difficult task, these extra social navigation information begin to help users fulfill their tasks more easily.

Figure 15. Comparison of average user-performance time for tasks. The dark gray bar is the performance of group 1 using guest interface, while the white bar is the performance of group 2 using member interface.

Part of the results of the interviews is demonstrated in Figure 16. When answering the interview question “what is your first choice of reference list order option”, 6 out of ten users chose “Rating”, 3 out of the ten chose “Publication Year”, and 1 chose visit count. For the second choice of reference list order option, 4 of ten users chose “Title”, 3 of the ten chose “Publication Year”, 1 chose “Rating”, 1 “Visit count”, and 1 “Authors”. After that, only 8 users provided answers for the third choice, and 7 users made the forth choice. According to users’ average choice, it is clear that the first four choice of reference list order options should be Rating, Publication Year, Visit Count, and Title.

Figure 16. Order option choice count for reference list. Horizontal axis indicates order option ranking. Vertical axis indicates the number of evaluators who choose a certain order option.

Table 6 displays the results of the open-ended questionnaire. As shown in the table, in total 3 out of ten users prefer to use the system as a guest. There are mainly three reasons for their choice. The first one is that they thought the guest space had provided enough functionality to finish tasks and is simple enough to be understood. The second reason is that they did not want to become a member because of the anxiety about privacy problem, member’s responsibility and potential payment for
membership. The last and a seemingly unimportant reason is that even if they like to be member, they still did not want to remember their username and password since using the system could not be everyday work.

Compared with this, 7 out of ten users expressed that they would rather to use the member interface of the system. They stated that they could benefit from interactions between users. References list with social information order options such as rating, and visit count are helpful for their decisions. Related reference list is valuable for their extra reading. Furthermore, comments about reference could assist them in depth research by widening their academic review.

In summary, from the results of evaluation, we might be able to say that we need compact interface for easy tasks, and complicated interface for difficult tasks.

### Table 6. Users’ answers for open-ended questions

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Are functionalities enough?</th>
<th>Is system speed acceptable?</th>
<th>Are you satisfied with the interface?</th>
<th>Which interface do you prefer?</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Member</td>
</tr>
<tr>
<td>User 2</td>
<td>Yes</td>
<td>Yes</td>
<td>70%. Needed some help with the functionalities.</td>
<td>Member</td>
</tr>
<tr>
<td>User 3</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Member</td>
</tr>
<tr>
<td>User 4</td>
<td>Almost. Searched keyword should be highlighted in results</td>
<td>Yes</td>
<td>Almost. Interface of search engine needs some description or explanation.</td>
<td>Member</td>
</tr>
<tr>
<td>User 5</td>
<td>Yes</td>
<td>Yes</td>
<td>Almost. Interface of search engine needs some description or explanation.</td>
<td>Member</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 2</th>
<th>Are functionalities enough?</th>
<th>Is system speed acceptable?</th>
<th>Are you satisfied with the interface?</th>
<th>Which interface do you prefer?</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 1</td>
<td>Yes. But Search engine should be improved.</td>
<td>Yes</td>
<td>Yes. But need more instructions.</td>
<td>Guest</td>
</tr>
<tr>
<td>User 2</td>
<td>Yes, apart from items not changing colour after selection.</td>
<td>Yes</td>
<td>Yes</td>
<td>Member</td>
</tr>
<tr>
<td>User 3</td>
<td>Almost. Need to provide user the second order choice as well as the first choice.</td>
<td>Yes</td>
<td>Yes</td>
<td>Member</td>
</tr>
<tr>
<td>User 4</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Guest</td>
</tr>
<tr>
<td>User 5</td>
<td>No. Search engine needs to be improved. Need search result match degree. Searched keywords need to be highlighted in search results.</td>
<td>Yes</td>
<td>Yes</td>
<td>Guest</td>
</tr>
</tbody>
</table>

### 5.4 Discussion

Some particular problems have emerged from the evaluation. The first problem is about the search engine. Functionality of the search engine was emphasized seriously through the whole procedure of evaluation. This phenomenon could be due to the special context of scientific references systems. Currently almost all the academic references are in the form of text. To locate suitable destination in reference database, powerful and convenient search engine (searching for text) become indispensable. In fact, there was one evaluator that actually refused to complete task 3 because of the lack of suitable search engine. The second problem is being informative versus being compact. How can the social navigation information be visualized adequately but not excessively so that the system could help users but not confuse them, therefore new users could be familiar with the system much more quickly. These problems will need some extra research.
Chapter 6. Limitation and Potential Improvement

Since the extent of project research topic is quite wide and the time used for designing and implementation is quite limited, the project product has achieved only some of the basic functions. This session enumerates some limitation of the system, and proposes some possibility of potential improvement.

6.1 Database design

In current structure of the system, one member is linked to several papers, so that the member can add, update or delete reference information on the individual reference list. But it is quite possible that several members will select the same references.

On the one hand, if the system allows all of these members maintain their own references lists, then some papers would have to be stored for several times.

On the other hand, if the system only allows each paper to be stored for one time, then only the previous member can maintain the paper. Furthermore, in the most serious case, if the previous member wants to delete a paper, which appears in several members’ references list, then the following members will lose this paper in their references list.

One possible solution to allow different member own some common references is to add one more entity type ‘Read’ and two corresponding one-to-many (1:M) binary relationship types ‘Read’ and ‘PROwn’ into ER-diagram of the system structure, as shown in figure (?). However this problem surely need some extra cogitative designing.

6.2 Search engine

At this stage, the functionality of the system’s search engine is quite basic. When users type several keywords in one search option input area, the system could not recognize them separately. The evaluators expressed particular high interest about a more powerful search engine. This phenomenon could be due to the special context of scientific references systems. Based on the main format of the academic references, text, to locate suitable destination in reference database, powerful and convenient search engine (searching for text) will become indispensable.
One necessary improvement about search engine is to allow users to perform their search query by inputting several keywords in one search option input area linked by any combination of logical operators AND, OR, and NOT.

Another considerable improvement is to allow users to search for certain comments, reviews, and members. Currently, there is no search mechanism for any data except those of references. If users want to gain an overview of a certain member’s degree of authority, this improvement could be valuable.

6.3 Personal navigation (selection) record

When users perform evaluation tasks, they expressed some expectation for some system functions such as presentation of their own individual navigation history information within the member’s public space. The lack of designing a function like this is a shortcoming of the system. More research needs to be undertaken to solve this problem.

6.4 Time-related navigation history information presentation

When a visit action happens, three navigation data is captured by the system, they are “who” visit “which reference” at “what time”. Only the first two information has been presented as integrated social navigation history information to the user. In the future, the third information could be designed for presentation. This time-related information is helpful if users want to locate recently hot reference, or discover how a certain reference has been visited through a period of time.

One application is to associate each reference with an icon indicating the recent visit frequency. A good example of this presentation is Dieberger’s works (2002), CoWeb. Small footprint symbols with different colour and a ‘lack of activity’ marker, a little dinosaur, indicate the recent access frequency of the corresponding link in CoWeb. The advantage of this solution is that users could gain a global impression of how often a number of links are accessed recently by just a glance. The difficulty of this solution is the choice of the suitable time length to calculate the visit count for a particular social navigation system. Is two weeks sensible for a scientific references system? Or is one year more reasonable for accumulating the visit count for academic references?

Another application of the time-related information is to visualize the visit frequency plot against time. NEC ResearchIndex scientific literature digital library gives a good instance for this application. For each reference, a graph shows the number of citations based on citing articles’ publication year. Whether and how this application is helpful in the project system is worth researching in the future.

6.5 Other limitations and potential improvements

Information exchange through Internet must involve the problem of Web security. Although the project system is not a commercial Website, some basic attention still need to be paid in the future about how to protect the system from attack, and how to defend users’ personal information against any revealer.

Another improvement needed in the future is the system help/example mechanism. Online help mechanism could assist users to navigate the system space in a much easier and happier way.

One more problem that needs more research is keyword selection. Could we find out some more convenient means to select keyword when there are many more keywords in the system? This must be an interface design task for the future development.
Chapter 7. Conclusion

Although social navigation is quite normal in people’s every day life, it is only “slowly being adopted in software systems” (Dieberger, Dourish, et al, 2000). In daily life, people face a huge amount of information from various ways of media transmission. Some of this information have been sensed by people, less has been perceived, and much less still has been cognized and become really helpful for people’s actions. The bulk of information has just simply been ignored. On the other hand, in the electronic space it is quite hard for users to ignore those useless information, in other words, retrieve valuable information from a huge quantity of information is quite a hard work for users. Social navigation systems do provide information more readily, but being informative versus being compact is really a big problem for these systems.

Based on the review of social navigation research, and classification of social navigation information used in several social systems, this project has built a practical working scientific reference Website that supports some social navigation. The system supports some basic functions that allow users to upload and edit some reference information. Thanks to the navigation data captured by the system, the ‘also visited’ reference list is generated dynamically for each reference. To balance the ‘snow ball’ effect (Svensson, 2001) and indicate the advice provider’s reputation (Dieberger and Höök, 2001), a two level feedback and rating mechanism is implemented.

After generated a large number of virtual navigation data by a computer program, a user experiment evaluation was carried out for the system. The result of the evaluation shows that for easy tasks, extra social navigation information slow down the users’ performance time. While for a relatively difficult task, the information might help users to make their choice easier and better. The average user preference shows that social navigation should have some potential value in scientific references systems, but it needs some real navigation data and long-term experiments to give some proof. Overall, the users are satisfied with the system interface, while users feedback also give some useful suggestion about system limitation and potential improvement.

In the future, the first improvement could be enhancement of the search engine function. The system structure should be redesigned to support some more actual and complicated user cases. Some extra navigation information presentation should be supported such as individual navigation history, and time-related navigation information. Many more improvements could be performed about system interface, web security, and the help mechanism.

The project is just a first step to the studying of the usability of social navigation in the scientific references context. Many problems have just been mentioned, and the attempt to answer the questions will need some more future work.
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Appendix

A. Project Experience

My most valuable lessons from the project are how to perform related literature/systems survey, and how to do system evaluation.

At the beginning of my project, I spent quite a lot of time reading related literature including some books and papers, but it is not effective enough to give me some global view of the background of this project. Directed by my supervisor, Dr Roy Ruddle, I began to investigate several actual systems that support some social navigation functionalities. Over fifteen related Website and systems were observed, some of them were commercial Website, some were about scientific references, some were used in research settings. After collecting information on these systems, analyzing their functions, classifying the characteristics of those social navigation information used in those systems, I got a much clearer understanding about my project. All this work made my system design more reasonable, and gave me more confidence to complete my project successfully.

As for the system evaluation, even before starting my system design, Dr Ruddle have already advised me to spend some time thinking about the possible evaluation tasks. Following Dr Ruddle’s guidance, I worked out several scenarios in which social navigation might be helpful for scientific references systems. After that Roy advised me to cut down the possible evaluation tasks and focus on the basic scenario of new researchers locating their initial reading list for a new research topic. This became the main content of my final system evaluation. Furthermore, I have also benefited from Roy’s advice when I performed system evaluation. At the beginning, I wanted to just send out the evaluation task form and invite as many people as possible to do the evaluation without my presence. Roy advised, instead, that I should consider to do the evaluation one-to-one with the evaluators. Finally, the number of evaluators might be small, but the obvious advantage is the quality of evaluation results, and my benefit derived from the evaluation experience. More information has been captured from evaluators, the equivocality and uncertainty of the problems and the answers are reduced by immediate communication between evaluator and designer. In fact, I have practiced direct social navigation once more during evaluation.
B. Project objectives and deliverables

C. Project Interim Report