USABILITY ENGINEERING FOR GIS: LEARNING FROM A SNAPSHOT

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Introduction

Interest in Human-Computer Interaction (HCI) has been part of Geographical Information Science (GIScience) for a long time. Well before the term GIScience was coined (Goodchild 1992), and even before the term Geographical Information System (GIS) was invented (Tomlinson, 1967), researchers of "Man Machine Interaction" at MIT where utilising the display capabilities of the latest generation of computers to manipulate oceanic geographical information (Pivar at al., 1963). From this early start, HCI became an integral part of the GIScience research agenda.

After a flurry of interest in the mid 1990's in the way common users, those that use GIS everyday as part of their work life use these systems (Traynor & Williams, 1995, Davies & Medyckyj-Scott 1996), HCI research in GIScience changed its emphasis. The range of topics covered today by HCI research in GIScience include deeper understanding of cognitive aspects (Mark et al. 1999), development of novel interfaces (Blaster et al. 2000) and ontology in spatial data (Fonseca et al., 2000) among others.

While this current body of research is highly valuable and influential in many ways, it seems that in the process the common user have been neglected, almost forgotten. Today, the common user is one of the million or so people across the globe who work daily with GIS software, or one of the tens of million of users who uses public mapping sites - such as Google Maps or MapQuest – or uses digital geographical information in other forms, such as through Satellite Navigation Systems (Longley et al, 2001).

Significantly, the early studies, such as those that are included Medyckyj-Scott & Hearnshaw (1993) or Nyerges et al. (1995) focused on GIS use by engineers, draftspersons and scientists – specialised users who work in an environment where tasks are well defined and the function of the system is clear. Today, the range of users changed dramatically in terms of educational attainment, the tasks which they perform and the organisational settings within which GIS is used. Furthermore, GIS itself changed significantly. When Davies and Medyckyj-Scott (1996) conducted their research, GIS was mainly command-line driven and run on UNIX workstations, whereas current systems rely on Graphical User Interface (GUI), large databases, and the Internet.

It is therefore somewhat ironic that just as GIS became more commonplace at work and at home, there has been almost no research looking at how GIS is used in these environments. For example, while web mapping sites are in existence since 1994 (Putz 1994), to our knowledge Skarlatidou and Haklay (2006) is the first published study in which public mapping sites were compared in terms of their performance with users who are GIS novices.

The outcomes of this neglect are familiar to the GIScience community - as many within it are teaching GIS to new generations of students. The difficulties of learning to operate popular GIS packages are all too common. It is astonishing that, although written over a

decade ago, Traynor and Williams (1995) "Why are Geographic Information Systems hard to use?" is still accurate.

Is Usability Engineering for GIS the solution?

One explanation for the lack of interest in the common user is the limited development of Usability Engineering *for* GIS. Usability Engineering (UE) is a sub discipline of HCI which emerged in the mid-1980s with the aim to address "system usability in a reliable and replicable manner. UE provides systematic methods and tools for the complex task of designing user interfaces that can be readily comprehended, quickly learned, and reliably operated." (Butler, 1996, P. 59) UE builds on the lessons learned through HCI research, and turned them into a set of operational procedures, matrices and techniques that can be used by system designers and developers to ensure that the system is efficient, effective, engaging, error tolerant and easy to learn (also known as the 5 Es of Usability).

Importantly, Usability Engineering techniques have been widely used as part of HCI research in GIScience. Examples include Haklay and Tobón (2003) where UE techniques were used within a Public Participation GIS context, or Fabrikant (2001) where they served to study the scale metaphor in information visualisation.

However, despite of this cumulative knowledge in the use of UE as part of GIS research, there is no coherent body of UE knowledge *for* GIS - knowledge that can be applied in the development of new systems. It should include tools and methods that been designed or adapted in such a way that they take the special characteristics of geographical information and its manipulation into account, and assist in the design of user interaction. Noteworthy is that the most popular textbook on GIS (Longley et al., 2001), only mentioned HCI in passing, and the most complete treatise of HCI in a GIS textbook (Worboys & Duckham, 2005) dedicate less than a page to UE. A recent literature review revealed over 150 papers and book chapters discussing the use of UE methods as part GIScience and GIS research – but only few which can be categorised as UE for GIS.

Usability Engineering for GIScience can be immensely valuable to the developers of GIS. UE will provide a set of tried and tested methods that have been proven to be effective for GIS. This can be done quite rapidly through two activities. First, by consolidating the lessons that were learned from the use UE techniques as part of GIScience research, a basic body of knowledge can be assembled including methods and matrices that have been found the most useful for GIS designers and developers. Secondly, by developing UE research for GIS, focusing on the design of specific UE techniques which will take into account the special characteristics of GIS such as the size of the map or the representation of the information (see also Davies et al 2005).

By developing a focus on Usability Engineering *for* GIS, GIScience research can rekindle the interest in the common user, and due to the wide spread availability of modern GIS, make a real impact and improve the quality of working life of millions.

An example for Usability Engineering for GIS technique was developed at UCL in 2005. The technique is based on a snap shot study.

The Snap shot study

The aim of the study is to explore how the GIS interface is used when carrying out routing tasks. In ideal situation a representative sample from all applications areas and systems should be drown, and the same task should be tested across all applications in order to be able to run a comparison (Davies and Medyckyj-Scot, 1996). However, such a comprehen-

sive study is complex and requires very significant resources.

Instead of this ideal methodology, and in an effort to support the hypotheses that GIS still fails to fulfil basic usability requirements, such as allowing users to efficiently manipulate geographic information on their screens it seems valuable to collect evidence that demonstrate the necessity and the possibility of usability engineering for GIS. Therefore, the aim of this study was to explore the GIS interface by running a snapshot study that will reveal usage patterns and enable a comparison amongst the different GIS. The main concept behind the study is simple: requesting users to send, via email a screenshot of their GIS, and to evaluate how much analysis can be carried out with what seems to be very little information.

The main objective is to assess the effectiveness of the map area in the GIS interface and explore how it is used by common users. As the nature of this study is exploratory the following research questions where formulated, so that a more comprehensive picture and conclusions can be drawn:

Which is the most important part of the GIS interface?

How is the map area used? Is it enlarged to occupy most part of the screen?

What proportion of the interface is assigned to the map area and the rest parts of the interface such as toolbars and commands?

Do users customise their GIS interface?

Do they tend to use the windows tiled or overlapping?

Do they use a global view for context and navigation?

Is there any difference between the experienced and inexperienced users in the way they use their GIS?

What screens resolutions are generally available to GIS users?

The reason for the importance that was put on the area of the map is the fact that in most GIS, operations such as zoom and pan can take up to 30 seconds or even more. Thus, the larger the area of the map from the total interface, there is less of a need to spend time on operations that do not contribute directly to the user's task and enable the user to use the GIS in a more efficient and effective manner.

METHODOLOGY

There are several methods available for evaluating the usability of an interface. Their aim is to change one or more measures of usability, in order to attain increased usability (Nielsen, 1994). While a comprehensive discussion of the methods is beyond the scope of this paper, however, it is worth mentioning the range of techniques, including Heuristic evaluation, Guideline reviews, Pluralistic walkthroughs, Consistency inspection, Standards inspections, Cognitive walkthroughs Formal usability inspections, and Feature inspections (for more details, see Nielsen, 1994)

Perhaps the approach used most often since its introduction in the 1980's is usability testing (Shneiderman, 1998). It is based on the principle of trailing prototypes, analysing data captured about the system and the user performance (Lin et al., 1997). Often laboratories are used for user observation (Nielsen, 1994), and information can be derived on the execution time, accuracy, users' satisfaction as well as video tapes and system logs (Lin et al.,

1997). Because real users are actively involved, the approach can be more objective, and reveal serious and recurring problems (Lin et al., 1997).

Lastly, questionnaires are usually used to accompany usability tests. They can be used at any stage of the development and they are used to assess the perception of the users about a system (Shneiderman, 1998; Chin, Diehl and Norman, 1988). Their main advantage is that they are inexpensive and they can yield a big number of responses as opposed to usability testing. Furthermore, the users' satisfaction of a system is a critical measure for its acceptance and can be independent of the system's performance measure (Chien, Diehl and Norman, 1988).

All usability evaluation methods have their advantages and disadvantages, and they can be generally either difficult to apply or largely dependent upon the evaluator's experience (Chien, Diehl and Norman, 1988). As noted, the aim of the current study, however, is not to carry out a formal usability evaluation of a particular GIS, but to compare the effectiveness of the map area across the different GIS and explore the way people use the GIS interface, in order to derive conclusions and make recommendations that can lead to increased usability of GIS design in general. Therefore the questionnaire approach was chosen as a preferred method of evaluation. In order to gain an understanding in the way the GIS interface is actually used in practice, users were asked to provide a screenshot of their entire screen while they are in the middle of their work with GIS. The questionnaire is used to support the screenshots and provide additional information about the users and their tasks.

The questionnaire was emailed to GIS mailing list, asking users to take a screenshot of their GIS, paste it into their email client, answer the questionnaire, and send it back to UCL for analysis.

The screenshots constitute the primary means for collecting the essential information and achieving the objective of this study. Most importantly, they provide a more objective measure for assessing the usability of the GIS interface and they can be combined and correlated to the subjective measures derived from the questionnaire. The correlation between the two measures will help to examine and understand better the relation between the objective and subjective information (Hornbæk, 2006).

The finding of the study revealed the following traits GIS Users: The majority of the users (60%) that took part in the study are experienced GIS users, technically competent, and use a GIS on a regular weekly basis; Similarly the majority of the users (about 75%) stated that they have no difficulty locating desired functions on the GIS interface and find its structure logical, although quite a few experienced users reported that this is due to the rearrangement of the toolbars. ESRI products received the highest rate of a non logical interface; The majority of the users still use GIS mainly for displaying and managing data, thematic mapping, querying, and for basic types of analysis and basic geo-processing.

The screenshots themselves has shown that GIS users seem to use high resolution screens – 1280*1024 pixels or greater. This is expected, as the application is graphic oriented. However, this is above average for computer applications.

The map area of the GIS interface is the most important part of the interface for the user. However, the area available to the map area represents on average a mere 70% of the interface, while this figure can drop down to ½ and ¼ of the interface's area. ESRI products were found to allow for the lowest available space of the interface to the map area – an average of 56%. The layer's window occupies an important part of the interface especially for ESRI products sacrificing this way the area available to the map area.

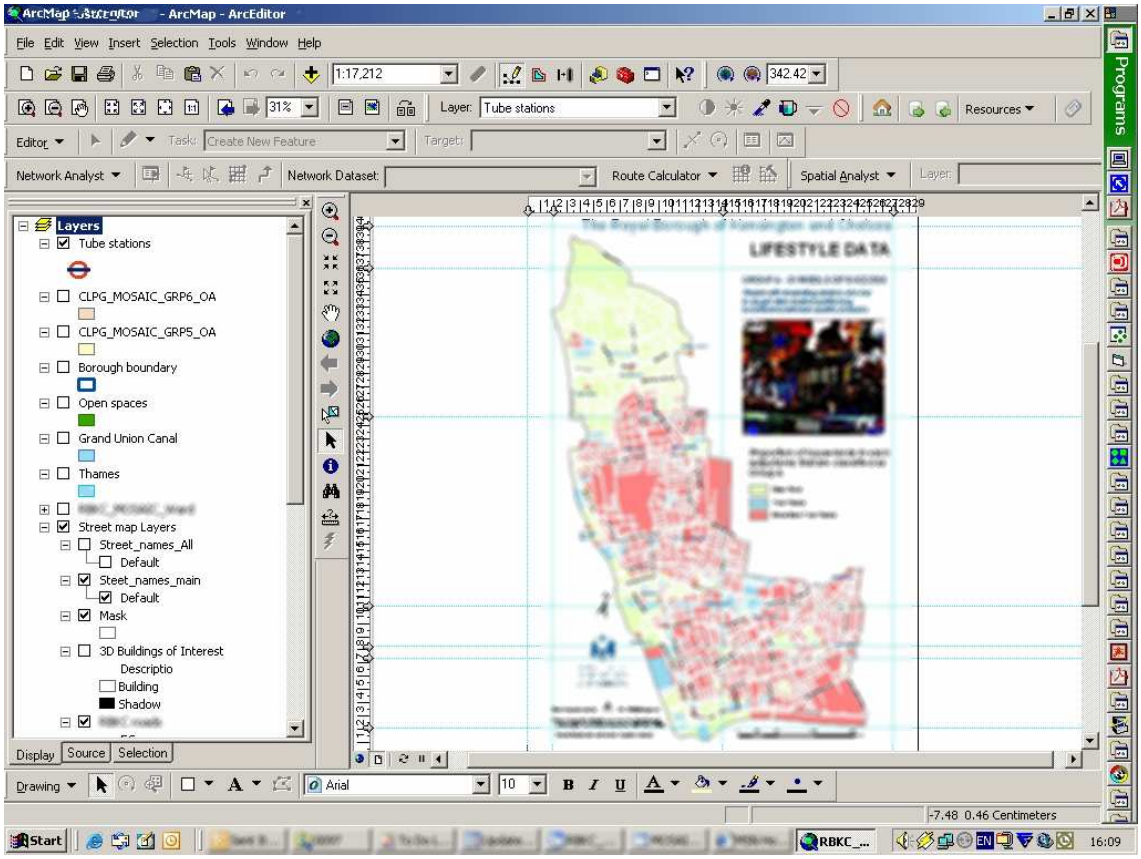

Figure 1 - Sample ArcMap Screenshot

The meaning of our findings is that in most cases, GIS users are sacrificing the map area in order to accommodate other parts of the interface (Figure 1). The study demonstrated that there is a very wider variety in the map area of the GIS, and therefore differences in productivity between users.

Conclusions

The snapshot study has demonstrated that it is possible, even with paucity of information, to learn about GIS users and their tasks. The method provided some insights into the screen size that is being used, the organisation of the GIS interface and other aspects of the work environment of common GIS users.

Importantly, the study demonstrated that when taking the specific characteristics of a GIS working environment, it is possible to develop fast and cheap methods for the analysis of the users' environment. For example, a snap shot study can be used by a vendor, to understand how the potential users of a future product are using their GIS currently. It can also be used to understand what users do with the software and what are the characteristics of their work environment.

Finally, the study has demonstrated that scope of usability engineering for GIS and the potential of developing techniques and methodologies within this domain.

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REFERENCES

Blaser, A., M. Sester and M. Egenhofer (2000). "Visualization in an early stage of the problem-solving process in GIS" Computer and Geosciences 26(1): 57-66.

Butler, K. A. (1996). "Usability Engineering turns 10" Interactions 3(1): 59-75.

Chien, J., P., Diehl, V., A. and Norman, K., L., 1988. Development of an Instrument Measuring User Satisfaction of the Human-Computer Interface. Proceedings CHI'88, Human Factors in Computing Systems, ACM, pp:213-218.

Davies, C. and D. Medyckyj-Scott (1996). "GIS Users Observed" International Journal of Geographical Information Systems 10(4): 363-384.

Davies, C., L. Wood, and L. Fountain (2005) "User-centred GI: hearing the voice of the customer" Paper presented at: AGI '05: People, Places and Partnerships, Annual Conference of the Association for Geographic Information, London, UK, 8-10 November 2005. (London: Association for Geographic Information).

Fabrikant, S.I. (2001). Evaluating the Usability of the Scale Metaphor for Querying Semantic Information Spaces. In: Spatial Information Theory: Foundations of Geographic Information Science. Conference on Spatial Information Theory (COSIT '01), Lecture Notes in Computer Science 2205, Montello D. R. (ed.), Springer Verlag, Berlin, Germany: 156-171.

Fonseca, F., M. Egenhofer et al. (2000) "Ontologies and Knowledge Sharing in Urban GIS" Computer, Environment and Urban Systems 24(3): 232-251.

Goodchild, M. F. (1992) "Geographical information science" International Journal of Geographical Information Systems 6(1):31–45

Haklay, M., and C. Tobón (2003) "Usability evaluation and PPGIS: towards a user-centred design approach" International Journal of Geographical Information Science 17(6):577-592.

Hornbæk, K., 2006. Current Practice in Measuring Usability: Challenges to Usability Studies and Research. International Journal of Human-Computer Studies. 64: 79-102.

Lin, H., X., Choong, Y. and Salvdey, G., 1997. A Proposed Index of Usability: A Method for Comparing the Relative Usability of Different Software Systems. Behaviour and Information Technology. 16(4/5): 267-278.

Longley, P. A., M.F. Goodchild et al. (2001) Geographic Information Systems and Science. John Wiley & Sons, London.

Mark D.M., C. Freksa et al (1999) "Cognitive models of geographical space" International Journal of Geographical Information Science 13(8): 747-774.

Medyckyj-Scott, D. and H. M. Hearnshaw (Eds.) (1993) Human Factors in Geographical Information Systems. Bellhaven Press, London.

Nyerges, T. L., D. M. Mark et al. (Eds.) (1995) Cognitive Aspects of Human-Computer Interaction for Geographic Information Systems. Kluwer Academic Publishers, Dordrecht.

Pivar, M., E. Fredkin and H. Stommel (1963) "Computer-compiled oceanographic atlas: an experiment in man-machine interaction" Proceeding of the National Academy of Sciences of the United States of America 50(2): 396-398

Putz, S. (1994) Interactive Information Services Using World-Wide Web Hypertext. Proceedings of the First International Conference on World-Wide Web (Geneva, May 25-27 1994)

Shneiderman, B., 1998. Designing the User Interface: Strategies for Effective Human-Computer Interaction. (3rd ed). Addison Wesley Longman, Inc.

Steinmann, R., Krek, A. and Blaschke, T., 2004. Analysis of Online Public Participatory GIS Applications with Respect to the Differences Between the US and Europe. Proceedings of Urban Data Management Symposium '04, Chioggia, Italy.

Skarlatidou, A. and M. Haklay (2006) Public Web Mapping: Preliminary Usability Evaluation. Proceedings of GIS Research UK Conference (Nottingham, April 5-7 2006)

Tomlinson, R. F. (1967) An Introduction to the Geographic Information System of the Canada Land Inventory. Department of Forestry and Rural Development, Ottawa Canada

Traynor, C. and M. G. Williams (1995) Why are Geographic Information Systems Hard to Use? CHI'95 Mosaic of Creativity, Denver, Colorado, ACM/SIGCHI, 288-289.

Worboys, M. and Duckham, M. (2005) GIS: A Computing Perspective. 2ed. Boca Raton, FL: CRC Press.