Human-Computer Interaction Aspects of GIS: A Cognitive Ergonomics Perspective

Andrew G. Turk
Department of Surveying and Land Information, University of Melbourne, Parkville, Victoria, 3052, Australia.

HCI in a GIS Context

Computerized geographic information systems (GIS) are combinations of hardware, software, data, procedures and people assembled for the capture, storage, retrieval, analysis and display of spatially and temporally referenced information. GIS may be defined as incorporating software for modelling of bio-physical processes and decision support. While expert systems can make a significant contribution to such analysis processes, people play a vital role, both as individuals and as members of decision groups. GIS design and implementation must therefore aim to optimize the sharing of tasks between the person and the computer, (cognitive ergonomics), as well as the more traditional interface, documentation and training aspects of human-computer interaction (HCI).

This perspective emphasizes the need to achieve appropriate levels of cognitive control, (modes of engagement), for GIS operations through the identification and analysis of the cognitive work to be performed and the design of graphics which cogently address the decision requirements. To facilitate the efficient and effective implementation of these principles, the preparation of a theoretical 'reference model' describing the relevant variables and their interrelationships is proposed. Successively more coherent and useful 'optimization models' can be developed from the 'reference model' through a program of psychological experimentation.

HCI Goals and Research Agenda

In Turk (1990, pp 51,52) the following HCI goals and research agenda were proposed:

**HCI Goals**

In his presentation to the Third International Conference on Human-Computer Interaction, Shneiderman (1989) discussed the potential for enhanced HCI offered by advances in multi-media interfaces. He also advanced a list of goals for HCI. The following paraphrase of these goals will serve as a useful background to the discussion of research needs in the GIS domain:

A. For Academic and Industrial Researchers:
   - utilize psychological experiments (various methodologies);
   - develop theories, models, taxonomy.

B. For Commercial Programmers and System Designers:
   - promote usability labs and interactive testing throughout system development;
   - develop guideline documents for interaction system design;
   - develop interface management software tools.

C. For Professional and General Users:
   - utilize HCI potential to increase quality of planning, products, services, etc.;
   - co-operate with researchers and system designers / producers to identify and refine HCI aspects.
Research Agenda for HCI in GIS

There is clearly a requirement for an integrated multidisciplinary program of cooperative research in HCI matters relevant to GIS. Such activity recently received a boost through the decision by the U.S. National Center for Geographic Information and Analysis to commence preparations for a new research initiative (I-13) on HCI issues.

The following is a list of some HCI in GIS research needs:

A. THEORETIC MODELS
   • The most fundamental need is for a sound, coherent, comprehensive, understandable and easily applied body of theory for HCI in GIS. Such theoretic models should generate the minimum of dissonance with established theories in human factors / cognitive engineering, psychology, cartography, computer science, engineering, geography, linguistics, philosophy, etc.

B. RESEARCH METHODOLOGIES
   • Appropriate research methodologies from psychology must be adapted and applied, preferably in an integrated fashion, to improve cognitive task analysis and system/output design;
   • The usability testing approach must be optimized for GIS applications.

C. COGNITIVE PROCESSES
   • Graphics aspects of cognitive style difference (and stability) need to be modelled;
   • The application of cognitive analytical models to complex graphics manipulation and spatial analysis must be explored.

D. INTEGRATION OF COGNITION / AFFECT / CONATION
   • Models of the impact of GIS use (under various circumstances) on affect (emotion) and conation (motivation/intent) need to be developed and experimentally validated;
   • While pursuing theoretic models and practical applications considering cognition, affect and conation separately, it is important to develop an approach for integrating ‘the divided mind’.

E. INTERFACES
   • The design and implementation of direct, graphic interfaces in the GIS context requires further attention;
   • The virtues of selectable and/or adaptive interface designs must be established for GIS operations, in conjunction with investigations of optimum training and on-line help arrangements.

F. AI, COGNITIVE ERGONOMICS AND VISUALIZATION
   • The modelling of appropriate arrangements for shared cognitive responsibility for tasks in a GIS environment needs to be informed by AI research and the application of cognitive control principles;
   • Understanding of the cognitive ergonomics role of visualization requires attention.

G. DECISION-MAKING AND POLICY ANALYSIS SUPPORT
   • HCI research, especially cognitive ergonomics needs to be integrated with developments in decision support and policy analysis.

H. SPATIAL QUERIES AND LINGUISTICS
   • Appropriate ways of expressing the logic of spatial query operations and the use of natural language for fuzzy concepts need investigation in an HCI context.

I. GROUP DYNAMICS AND ORGANIZATIONAL ASPECTS
   • Interaction with GIS must be researched at group and organizational levels as well with respect to individuals.”
References


Biographical Sketch

After graduating with a Bachelor of Surveying degree in 1971, Andrew Turk worked with the Australian Government’s mapping department for thirteen years. This activity spanned all areas of control surveys and compilation of medium scale topographic maps and included the implementation of computer mapping technology. Following completion of part-time studies for a Cartography Degree, he took leave from the government service and for a period of four years conducted research into tactual maps and graphics for blind and partially sighted persons, in the Geography Department at The University of Melbourne. Having decided to continue in the academic sphere, he moved to the Department of Surveying and Land Information where he has been employed since mid 1987 as a part-time Research Fellow while pursuing studies towards a PhD. His research concerns the optimization of human-computer interaction aspects of geographic information systems. In support of this research interest he has also undertaken a Bachelor of Arts with majors in psychology and philosophy. He spent the fall semester of 1990 as a Visiting Assistant Professor at the Geography Department, University of Hawaii, where he taught automated cartography and geographic information systems.