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INTELLIGENT AGENT ON GIS ENVIRONMENT

Maria de Fátima Mattiello-Francisco

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Intelligent AGENT on GIS environment

Fátima Mattiello Francisco
INPE - Institute for Space Research - Ground System Division
São José dos Campos, São Paulo, Brazil

ABSTRACT

In spatial data analysis application using GIS, users are led themselves to build a mental model of the GIS to be able to explore its capabilities. If the requirements is to meet the user on the high abstract level, the user interface has to be based on a considerable amount of knowledge about the user, the system and the communication process. Additionally, it must be adaptative to come close enough to different categories of users and developed as an user centred system. Knowledge about the users and the application are fundamental for making GIS interface intelligent. Intelligent AGENT as an agent in the interface instead of agent as an interface is the approach adopted in this paper to diminish the complexity level of the GIS user interface, creating an adaptive interface based on a model of the user and the task. It implements a complimentary style of interaction which has been referred to as indirect management. Instead of unidirectional interaction via commands and/or direct manipulation, the user is engaged in a cooperative process in which human and computer agent(s) initiate communication, monitor events and perform tasks. On a GIS environment, an AGENT as a personal assistent (metaphor used) cooperates with the user in the selection of the GIS functions in a specific application (such as deforestation monitoring). The AGENT learns how to assist the user and starts with very little background knowledge of the application. The main knowledge applied is that "typical needs of a specific application field of GIS are limited on specific functions of geoprocessing".

1. INTRODUCTION

Spatial data analysis is typically a multistep process where a tool, as GIS (Geographic Information System), and many types of data are involved. Both system size and size of the users task creates an overview problem. The users are led themselves build a mental model of complex system to be able to explore its capabilities (Fisher, 1989). A mental model is a simplified view that people build in mind for understanding things so they can interact with.

For instance, dealing with spatial data analysis in remote sensing applications, users often must keep themselves information of processing history of large amount of data handled during the task. Much has been done so far to improve algorithms and build powerful system for data analysis in GIS but little has been put on the human interaction aspects (Edgardh, 1991).

A better user interaction is a key issue to get a broader user acceptance of GIS. The user interface is probalbly the most important aspects of GIS usability (Medyckj-Scott *et al.*, 1990). It is the part of the GIS which the user sees and interacts with, and thus, to all intents and purposes is "the GIS" as far as the user is concerned. It is therefore important that the interface permits the user to achieve easily the goal which he/she desires, with minimal errors and limited task complexity. In this situation the interface must facilitate the user's completion of a task or series of tasks (Medyckj-Scott, 1992).

In order to reach the user desires above mencioned, it is proposed, in this paper, an AGENT on the GIS environment who acts as an assistant in the interface. The AGENT cooperates with the user in the selection of the functions used by a specific application. Additionally, the AGENT facilitates the user in the processing history of data analysis task being realized.

2. GIS ENVIRONMENT

Working in spatial data analysis applications using GIS, the user starts with a goal and is heading for a solution in terms of a sequence of actions. During use of a GIS, mental information structures and processes blossom according to the support given by the user interface.

Admittedly, the GIS community doesn´t have yet a coherent spatial theory to guide user interface design. But all areas of user interface researches in the Human-Computer Interaction - HCI field are directly applicable to GIS design (Gould,1992).

The best techniques recently developed in human-computer dialogue have been applied in GIS interfaces in order to improve the style of interaction. Dialogue is considered to be the major process by which users construct models of a system (Fischer, 1989). Thus, provinding users with a friendly and menu supported GIS interface greatly helps the user in taking a simplified overview of the system. Menus are increasingly being used in preference to command language because they avoid the problem of remembering commands (Booth, 1991). Althougth the GIS interfaces have evoluted to leave the user in control of the dialogue, these kinds of facilities don´t support user on the data analysis tasks. The user still has to memorize the sequence of operators used and parameter settings for future refinements.

Improvements have been done specifically to support the user in data analysis tasks with the development of High-level User Aid (Edgardh, 1991) which helps users in the sense of structuring user tasks as data flow diagrams as well as in terms of selecting operators in the data analysis process. Such user aids available today, like KHOROS (CANTATA Visual Programming Environment) and AVS (Advanced Visual System) are caracterized as an intermediary between the user and the different data analysis systems (like GIS and Image Analysis Systems). The user aid, as an user interface, is helpful for the user to master the task complexity problem in the sense of memorizing the sequence of GIS function, to be followed on the data analysis task. But it lacks knowledge of both user and application. Knowledge domains are necessary when the interface is intend to be adaptative to different users and different situations. It is impossible to design systems which are appropriate for all users and all situations. Adaptive systems are human-computer interfaces which change automatically to meet the changing needs of the user (Eberts,1989). An ideal user interface must be adaptive to come close enough to different categories of users. The problem is what terms the adaptive interface should be created (Fischer, 1989).

In GIS environment, the interface should be adaptive, not only to meet the changing needs of the different users (novice or experts on the application, for instance) but mainly to meet the changing needs of the different applications which work with geoprocessing functions. The experience shows that the typical needs of each application field of GIS (geology, urbanism, cartography, agronomy, etc) are limited on specific functions of geoprocessing. That means specific applications need only a subset of GIS functions available.

Multispectral image classification of satellite data is a typical user task in remote sensing. In this kind of applicattion the users work towards the final result by executing a multi-step process where a sequence of GIS functions with the operators and parameter settings is performed. The process is interactive in the sense that the whole process or part of it is repeted (changing the parameter settings, for instance) until a satisfactory result is reached. Thus it is very convenient for the user to be assisted by an agent in the memorization process of the task work-path.

3. INTELLIGENT AGENT

The need of an intelligent interface is based on indications of an excessive semantic distance between the user and the machine language and, also, when there are indications of high complexity in the application (Chignell and Handcock, 1988). The idea of employing agents in the interface to delegate certain computer-based tasks was introduced by Alan Kay when he pointed out that agents should be illusions that mirror the user's intelligence while restincting the user's agenda (Kay, 1984). Later on, it as extended agents as *grand collaborators*: computer processes that act as guide, as coach, and as amanuensis (Kay, 1990). The usage of Artificial Intelligence techniques for providing expert, autonomous assistance for a user dealing with a particular computer application has been explored in HCI as Intelligent Agents (Card, 1989). Three approaches for building interface agents can be distinguished. The first approach consists in making the end-user program the interface agent. The problem with this approach is that it requires too much insight, understanding and effort from the end-user to both endow the agent with explicit knowledge and maintain the agent's rules over time. The second approach, also called the knowlwdge-based approach consists in endowing an interface agent with a lot of domain-specific background knowledge about its application and about the user (called a domain model and user model respectively). At run-time, the interface agent uses this knowledge to recognize the user's plans and find opportunities for contributing to them. A first problem with this approach to building interface agents is that it requires too much work from the application engenieer. A second problem is that the knowledge of the agent is fixed once and for all.

The third approach to building interface agents heavily relies on Machine Learning Techniques. The agent is given a minimum of background knowledge and it learns appropriate situation-action rules from the user. This approach has some advantages. First it requires less work from the end-user and application developer. Secondy, the agent is more adaptive over time and the agent automatically becomes customized to individual user preferences and habits.

The interface agent can use several sources for learning. Among them the agent can learns by observing the user (learning by observation technique), which is adopted in this paper. The concept is that the agent learns continuosly by "looking over the shoulder" of the user as the user is performing actions in the shared work environment (Maes, 1993). The interface agent can monitor the activities of the user, keep track of all of his/her actions over long periods of time, find recurrent patterns and offer to automate these. A particular added advantage of the learning approach is that the user and the agent have time to gradually build up a trust relationship (Kozierok and Maes, 1993).

Another issue which has been discussed so far in HCI is the role of the intelligent agent on the interface. In almost all cases, the agent works as an intermediary between the user and the system. That means, the intelligent agent constitutes a barrier which doesn't permit the users access the system by any way other than throught the agent itself. A different approach deals with the agent in the interface (Maes, 1993) instead of with the agent as an interface. That means, the user can at all times bypass the agent. She/he can iniciate actions and observe results in the application directly. That is the approach adopted in this paper. The metaphor used by the agent is that of a personal assistant who is operating in the same work environment as the user. This work environment is the direct manipulation interface of the application. It includes graphical icons and gestures for the different objects, tools and actions that are relevant. Both user and agent share the same environment, they are engaged in a cooperative process. As well as the user, the agent might initiate communication, monitor events and perform tasks. It implements a complimentary style of interaction - indirect management (Kay, 1990) - because it acts as an user partner in the task..

4. KNOWLEDGE ACQUISITION

An implicit assumption often made in building intelligent systems is that intelligent support is synonymous with outputting an "answer" - that is solving the problem for the user.

In that view, the goal is to collect the knowledge from the human expert in order to develop a system that can mimic how the human expert goes about solving the problem.

In case of building system as an intelligent AGENT "who" seeks to cooperate with the user on a specific task rather than to solve the problem for the him/her, the knowledge acquisition must be based first on the problem space understanding. The cognitive task analysis is an approach to knowledge acquisition which focuses on the problem space understanding before dealing with specific domain knowledge needs. It is in contrast to iterative refinement approach where knowledge acquisition is based on describing specific domain of a small set of examples cases that often can lead to an oversimplified view of the problem. The cognitive task analysis approach redefines the knowledge acquisition problem: knowledge acquisition, first, is about deciding what kinds of intelligent system would make a difference (Rooth and Woods, 1989). Following this approach, the analysis of user´s claims and wishes on GIS interface (problem space understanding) gives support to the effective establishment of the goals and boundaries of the agent. Additionally, the agent metaphor of an assistant also helps explore the design issues.

Problem space domain in GIS application was discussed early in GIS environment session of this paper. Concerning to the usage of geoprocessing functions, users claim an adaptive interface to meet the changing needs of different applications. Typically, a specific application field of GIS only makes use of a limited set of GIS geoprocessing functions. Also, it is known that the behaviour adopted by a specialist in a specific spatial data analysis often is repeted many times before the solution is reached. That means it is important for the specialist to be supported by some kind of assistant who helps him/her to memorize the sequence of geoprocessing functions selected to realize the spatial data analysis. That enables an informed decision about the AGENT´s goal to be built, the range and boundaries of the problems that the AGENT will need to be able to handle, the computational techniques to adopt and the specific knowledge needs to be collected and encoded.

Concerning to the agent´s goals in GIS environment, it might be pointed out:

- to assist the user in the processing history of the data analysis task;
- to adapt the specific GIS user interface to the limited needs of the on going data analysis task in terms of the use of geoprocessing functions (for instance in case of a menu-based interface, by hiding the functions that are not used - Figure 1).

In order to reach theses goals the agent should handle the GIS user interface in two different ways. First, to get information about the users activities with it. Second, to make modifications for adapting it to the user´s behaviour.

Therefore, one of the possible solutions to the AGENT on GIS could be to endow it with very little background knowledge of the application which concerns of inicializing a table with a subset of geoprocessing functions, those functions which the user considers relevant to the application which he/she is working with. Althougth this procedure is not essential (since anyway these functions will be observed by the agent), it is considered good preparation to initialize the agent in the specific domain of the task. Mainly if the user already knows that some functions of GIS are completly not concerned with the application field, as in case of experient GIS user.

With this background the AGENT starts by observing the user interaction with GIS.

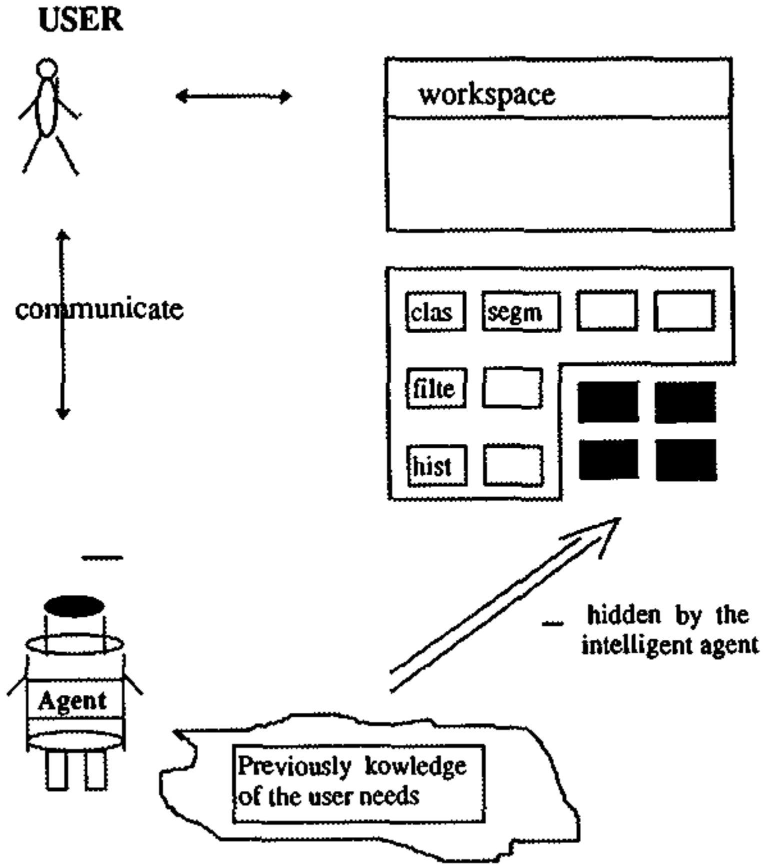

Figure 1.
The intelligent agent does not act as an interface or layer between the user and the application. It rather behaves as a personal assistant which cooperates with the user in the use of the tools.

The on going observing activity permits the AGENT to learn how the user performs the application task by building a path which states the sequence of GIS functions selected by the user and acomplished by the information of the operators and parameters related with.

Supposing that, in a GIS user interface context, events drive the GIS human interface by triggering actions that sequence through GIS functions screens, the screen might correspond to a state and actions might correspond to the transitions between the states of the state-machine in which the interface is designed. The format and sequence of screens will be determined by the GIS user interface adopted and will certainly vary from GIS to GIS. The proposed agent will work on this environment as well as the user. All the user actions on this shared work environment will be monitored by the agent. Over time the agent keeps track of all the events which enable it to have a history of the work-path followed by the user. On the subsequent similar situation, that means the use of the same GIS screen chain, the agent assists the user showing the work-path memorized by highlighting the previous options selected. Of course, on this point, the user can change the operators and parameters related with, as well as the sequence of geoprocessing functions chain.

Additionally, when the agent becomes customized with user´s habits in the use of

GIS functions, the work-path will be used by the agent in order to adapt the further interactions by changing the screen contents according to the usability of the functions.

5.CONCLUSIONS

"Ease of use" has become a popular goal in designing user interface for every computer system, in particular for GIS which addresses a broad variety of end-users, with the most diverses skills and background.

By providing the GIS interface with an AGENT, as proposed in this paper, means to give an intelligent support for human problem-domain communication, where the AGENT has extensive access to the state and actions of the application system without acting as intermediary between end-user and GIS. On the other hand, the user still works with the GIS interface, initiating actions and observing results in the application directly. The AGENT plays a role of a personal assistant who cooperates with the user in the use of the GIS tools. The price payed to built such agent is not expensive since the process adopted for collaboration with the user is based on the known machine-learning approach, more specificaly, learning by observation the user's behaviour on GIS interface.

In terms of knowledge, the AGENT is endowed with only a subset of GIS geoprocessing functions that caracterizes the specific space domain in which the agent will work on. The AGENT is designed around the understanding of what the end-users require and expect of it. The AGENT collaborates with user in two main activities:

- assisting the user in memorizing dinamically the process of the data analysis;
- simplifying the GIS user interface by hiding the geoprocessing functions that the AGENT observes to be out of context in that specific application. That is a result of the capability of the agent to be more adaptive over time and customized to individial user habits.

6. REFERENCES

Journal Article:

Fischer, G., 1989. Human-Computer Interaction Software: Lessons Learned, Challenges Ahead, *IEEE Software*, Vol. 6, No. 1, pp. 44-52.

Kay, A., 1984. "Computer Software", *Scientific American*, Vol. 251, No. 3, pp. 53-59.

Paper in Proceedings:

Gould, M.D., 1992. User Interface for GIS: Keeping Up With the HCI Community. In User Interfaces for Geographic Information Systems: Report on the Specialist Meeting. (Ed) Mark D.M. and Frank A.U., pp. 79-82.

Kozierok, R. And Maes, P., 1993. A Learning Interface Agent for scheduling meetings. In *ACM-SIGCHI International Workshop on Intelligent User Interfaces*, January 4-7, Florida.

Maes, P., 1993. Learning Interface Agents. In *ACM-SIGCHI International Workshop on Intelligent User Interfaces*, January 4-7, Florida.

Medyckyj-Scott, D.J., Newman, I.A., Ruggles, C. And Walker, D., 1990. Usability testing in user interface design for GIS and the role of rapid prototyping. In *First European GIS Conference Proceedings*, April 10-13th, Amsterdam, Netherlands, pp. 737-746.

Medyckyj-Scott, D.J., 1992. GIS and the concept of usability. In *User Interfaces for Geographic Information Systems: Report on the Specialist Meeting*, (ed) Mark D.M. and Frank A.U., pp. 123-129.

A Thesis:

Edgardh, L.A., 1991. *Design Aspects of a High-level User Aid for Photogrammetric and Remote Sensing Software*, Licentiate Thesis, FMI, Royal Institute of Technology, Stockholm, Sweden, 74 pages.

Chapter in a Book:

Booth, P.A., 1991. Human-Computer Dialogue, In *An Introduction to Human-Computer Interaction*, Eds Lawrence Erlbaum Associates, East Sussex - U.K., pp. 45-63.

Card, S.K., 1989. Human Factors and Artificial Intelligence, In *Intelligent Interfaces - Theory, Research and Design*, (eds) P.A. Hancock and M.H. Chignell, Elsevier Science Publishers B.V., Amsterdam, pp. 27-48.

Chignell, M.H. and Hancock, P.A., 1988. Intelligent Interface Design, In *Handbook of Human-Computer Interaction*, (ed) M.Helander, Elsevier Science Publishers B.V., Amsterdam, pp. 969-995.

Eberts R.E. and Eberts C.G., 1989. Four Approaches to Human-Computer Interaction, In *Intelligent Interfaces - Theory, Research and Design*, (eds) P.A. Hancock and M.H. Chignell, Elsevier Science Publishers B.V., Amsterdam, pp. 69-98.

Kay, A., 1990. User Interface: A Personal View, In *The Art of Human-Computer Interface Design*, (ed) Brenda Laurel, Addison-Wesley Publishing Company, New York, pp. 191-207.

Rooth, E.M. and Woods, D.D., 1989. Cognitive Task Analysis: An approach to knowledge acquisition for Intelligent Systems Design, In Topics in Expert Systems Design, (eds) G. Guida and C. Tasso, Elsevier Science Publishers B.V., Amsterdam, pp. 233-264.

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Maria de Fátima MATTIELLO-FRANCISCO

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