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SITUATED SPACE AGENT FOR 3D GRAPHICS DESIGN

Yong Cao and Ipke Wachsmuth
Faculty of Technology, University of Bielefeld,
Bielefeld, Germany

An important research topic in Virtual Reality is to develop and implement knowledge-based agents for interactive modeling (Computer Graphics, 26(3)). In recent years some work has been reported where virtual reality systems are supported by artificial intelligence technology, but it has been restricted on aspects of route planning or simulation of properties for physical objects to be illustrated. In this paper we concentrate on certain aspects of language communication with a virtual environment that involves reference to spatial relations.

Natural language is an important media in human-human communication. In such communication certain cognitive abilities play a non-ignored role, in particular, spatial cognition is very important for interpreting and reasoning about qualitative spatial relations between objects in an environment. For example, one uses spatial cognitive abilities to interpret which chair has been mentioned in the sentence "the chair at the left of the table" if more than one object is near the table. The Virtual Reality system and its interface don't need to interpret the cognitive meaning of "left of": in the usual setting with a "cybernaut" equipped with eye-phone and data-glove. The cybernaut must interpret the phrase and take out the selection by moving his head and pointing to the chair with the data-glove. In interior design with a 3-D graphics system such as SOFTIMAGE or INVENTOR the designer uses the mouse to support communication with the technical system.

Due to the need of having to communicate ideas of complex form to a technical device, the designer may face crucial obstacles in the process of designing. If the designer could use (simple) language together with other gesture input devices to communicate with the technical system, he is free from technical considerations and it might also be possible to change and illustrate the design according to the "thinking aloud" of the designer.

How can a virtual environment understand what we mean? For this purpose we want to design a situated space agent, as a part of a synthetic intelligent mediator, to translate the qualitative relation "left of" under the situation to coordination in the scene.

In our work, we perceive a situated agent as an "intelligent mediator." Such an agent P which may consist of many subagents P communicates and cooperates with a human user in an overlapping perceptual situation, that is, human user and situated agent have a shared virtual world. The agent's task (or the agents' task, resp.) is to support the user's actions in the virtual environment. The agent integrates skills of situated perception, action, and communication to achieve an adequate system behavior with respect to our application, the design and manipulation of a virtual environment. As one feature a synthetic agent graphically visualized is used to place the designer's eye in the virtual environment and to allow the use of gestures, in particular, of situated language in interactive modeling.

It is an important research field in knowledge representation how to represent the semantic meaning of qualitative spatial relations. It is known that the meaning of a spatial relation can be influenced by the size of objects, the distance between objects and the reference frame of the relation such as deictic, intrinsic or extrinsic, etc. A main obstacle is how to translate these qualitative describes to exact geometrical models in a virtual environment, because these rules are formed from a cognitive point of view and they can not be generally translated to numerical relations.

The spatial representation in a virtual environment refers also to the size, form of virtual objects and the distance between them. The deictic perspective would be preferred in a communication with a virtual environment; the intrinsic perspective can be used if the affected virtual object, such as a desk, has a permanent front. If the space agent is imaged in the environment, his perspective must also be considered. Because the user observes and controls the change directly, the spatial representation in a virtual environment has some special cases:

(1) Because the results of the spatial reasoning can be verified (illustrated) in a virtual environment directly, it is important that each object must be set in a determined

position, in contrast to some spatial representation schema (e.g., cf. Maienborn (ed.), 1991) that objects can be set in a region because there is not only one position and it is not easy always to pick out the best position that satisfies the given qualitative spatial relation. In our case the space agent supports a so-called situated communication. The space agent interprets a user's instruction by means of a relative default value, calculates the changes and then offers a resulting scene. The offer can be changed by a further interaction ("still more," "not that far"). To do so the intelligent mediator keeps the history of changes, compares the changes and offers a new resulting scene. That is, the user can negotiate the semantics of an instruction.

(2) In an identification task, i.e., to respond the WHAT and WHERE inquires, the space agent can not only reply symbolically but also display the identified objects or relations by highlighting these or moving the camera to a suitable position. For instance, the camera can be moved to a position to display a chair behind the desk. Emhardt and Strothotte (1992) develop the Hyper-Renderer that can display indicated objects enhanced, and all non-selected objects will appear in a ghost form. This strategy can be used to display an object included in another bigger object, such as a ball in a box.

(3) In the physical world we know that a lamp on the table would be moved together with the table if the table is moved. It is a well-known frame problem in Artificial Intelligence. In a virtual environment it is possible to realize if the "physical modeling" is present to the space agent. Furthermore, simple naive imaginations can also be considered in a virtual environment, for instance, the chair must be set in a suitable position, so that a "person" can sit down and work at the desk, if the space agent takes the chair to the front of the desk. This means, not only the position of the chair, but also its orientation is relation to the desk are aspects that need to be considered to influence the operations in a virtual environment.

The VIENA Project (VIrtual ENvironment and Agents) is one of four projects started in 1993 in the new research field of "Artificial Intelligence and Computer Graphics" at the University of Bielefeld (cf. Wachsmuth & Cao, 1993). The overall goal is to enable an intelligent communication with a technical device for the interactive design and exploration of 3D computer graphics. We have chosen interior design as an example domain. Instead of using the mouse and menus to manipulate objects we develop a set of agents (together then form an intelligent mediator) to keep the user (designer) free from technical considerations such as planning of geometric details, etc. Simple natural language (verbal, in the future we want also to use voice input) is considered for the communication.

To support intelligent mediator we build a agent including rules for spatial reasoning, physical modeling, and relative spatial relations between objects in the scene. The geometry data structure of SOFTIMAGE would be extended for our purpose: The history of changes must be kept in the data base so that the situated communication above can take place, that is, the intelligent mediator can offer a new resulting scene according to the history of changes. The front of an object will be represented for the intrinsic perspective, and the deictic perspective can be calculated by the camera position and orientation.

Currently, first instances of the intelligent mediator manipulate objects by means of channels in the environment of SOFTIMAGE (we have checked this possibility in the first prototype), or the intelligent mediator will be integrated into SOFTIMAGE by means of custom provided by SOFTIMAGE.

Main References

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