3D Electronic Institutions: Social Interfaces for E-Commerce

Anton Bogdanovych[1] **Helmut Berger**[1] **Simeon Simoff**[1] **Carles Sierra**[2]

[1]Faculty of Information Technology,
University of Technology, Sydney, NSW, Australia
{anton,hberger,simeon}@it.uts.edu.au

[2]Artificial Intelligence Research Institute (IIIA),
Barcelona, Catalonia, Spain
sierra@iiia.csic.es

Abstract

In this paper we propose the use of virtual worlds as a 3D social interface for Electronic Institutions. It is shown how the two metaphors, Virtual Worlds and Electronic Institutions are combined into a single metaphor, *3D Electronic Institutions*, while retaining the features and advantages of both. Its essence is to *open* Electronic Institutions to human users. The strong methodology and powerful tools provided with Electronic Institutions create the possibility of semi-automatic generation of 3D social interfaces. Using E-Commerce as the application domain for the new metaphor, important cues like social interactions, establishment of the long term contacts, enhanced product observation and other real world attributes that are missing from current on-line Web-based business environments can be introduced.

Keywords: Virtual Worlds, Electronic Institutions, social user interfaces, multi-agent systems, E-Commerce.

1 Introduction

Individuals today are the product of a particularly mobile and entrepreneurial society. As a result, in the everyday business activities, including e-commerce, the individual is socially constituted and socially situated (Solomon 2004). However, researchers point out that social needs of customers play a very important role and are of great importance in E-Commerce applications (Preece & Maloney-Krichmar 2003), this needs are mostly neglected in nowadays systems. At present, most *e-commerce environments* and their interfaces are designed with the assumtion that customers buying style (or behaviour) is *rational*, without much consideration of the needs of customers showing an *emotional* style of buying. Some conventional e-commerce solutions already try to meet social needs of their users. The popular web site Friendster.com, for instance, assists people in finding new contacts with the help of other people they know and trust. The answer to the question "Whom do you know?" appears to be a key characteristic of a businessman's success. Jung & Lee (2000) propose an environment which incorporates a spatially-organized and interactive site map. This site map visualizes the location of people and offers facilities for social interactions. Though a good starting point, this approach does not go far enough in terms of consistency. For example, the site map is a separate part of the web site and not an integral aspect of the user interface.

In contrast, 3D Virtual Worlds provide a consistent and immersive user interface which implicitly incorporates location awareness of other users and offers mechanisms for social interaction. Virtual Worlds support to a certain extent the way humans operate and interact in the real world. Such immersive environments incorporate the social context, allowing customers to meet and interact with other people, and, have the potential to address the needs of both *rational* and *emotional* customers.

Virtual Worlds go beyond the document and form based interface of the World Wide Web, representing users in a graphical form (an "avatar", cf. (Damer 1998)) and permitting them to operate, interact and communicate in a shared visual space, i.e. putting the human "in" the World Wide Web rather than "on" the World Wide Web. The underlying technology supporting these worlds have been created and hosted by variety of companies, ranging from computing technology giants like Microsoft and Intel, and ending with relatively smaller start-ups like Active Worlds and Worlds Inc. Overall, the design and development of virtual worlds has emerged as a phenomenon shaped by the home computer user, rather then by the research and development in universities or companies. As a result, virtual worlds are somewhat unregulated environments, which do not have the means to enforce technological norms and rules on their inhabitants. Hence, virtual worlds do not address the central issue of security in E-Commerce.

In order to make use of the benefits of virtual worlds interface we need to introduce methodologies on which reliable and secure E-Commerce systems build upon. Electronic Institutions, for instance, focus exactly at this issue and take control over security aspects, they guarantee that participants fulfill their obligations and adhere to institution rules. In general, actors in electronic institutions are software agents and practical applications of this methodology so far aimed at building societies of completely autonomous software agents – humans did not participate at all! The MASFIT project pointed out that humans participating in complex decision making tasks quite reluctantly delegate this activity to a completely autonomous entity, (Cuní, Esteva, Garcia, Puertas, Sierra & Solchaga 2004). This highlights that a better understanding and modelling of the relationship between humans and the agents that make decisions on their behalf is needed.

Our major objective is to bridge the gap between the two metaphors, Electronic Institutions and Virtual Worlds, and combine them in the metaphor of 3D Electronic Institutions. Electronic Institutions enable the specification of highly regulated and well structured environments which contrast the mostly unregulated nature of Virtual Worlds, cf. Figure 1.

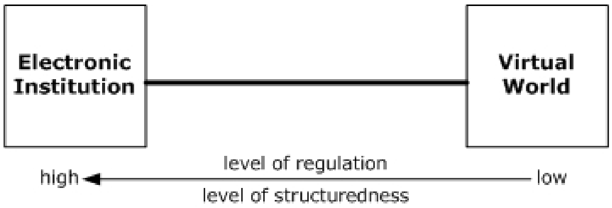

Figure 1: Relation between Electronic Institutions and Virtual Worlds

A 3D Electronic Institution is an environment that enables human activities and participation in electronic institutions. In order to achieve this goal we apply a three-layered framework and present a 3D social user interface that allows humans to interact efficiently in an immersive E-Commerce environment which builds on top of the Electronic Institutions methodology.

This paper is structured as follows. Section 2 outlines the framework for 3D Electronic Institutions. Considerations that have to be taken into account with respect to a 3D social user interface are presented in Section 3. Section 4 presents an example, through which scenario we describe the interface features. Finally, Section 5 summarizes the work so far and discusses some future directions of this research.

2 A Framework for 3D Electronic Institutions

This framework is based on two metaphors – Electronic Institutions and Virtual Worlds. Our approach aims at combining them into one single metaphor, *3D Electronic Institutions*, while retaining the features and advantages of both. Its essence is *opening* Electronic Institutions to human users. More specifically, we step beyond the agents perspective and take a *human centered view* on Electronic Institutions whilst still relying on this clear and strong metaphor. In order to allow this view, we present a 3D user interface which provides sophisticated means for humans to interact and, most importantly, to perceive social context. Basically, the framework for 3D Electronic Institutions consists of three layers as depicted in Figure 2. In this section a review of the Electronic Institution methodology is given and the task of the communication layer is outlined. The aspects of the 3D social user interface are detailed in Section 4.

2.1 Electronic Institution Layer

Electronic Institutions are software systems composed of autonomous entities, i.e. agents, that interact according to predefined conventions on language and protocol and that guarantee that certain norms of behavior are enforced. This view permits that agents behave autonomously and take their decisions freely up to the limits imposed by the set of norms of the institution. An Electronic Institution is in a sense a natural extension of the social concept of institutions as regulatory systems which shape human interactions (North 1990). The methodology of Electronic Institution acts as the basis of the framework and is determined along three types of conventions:

Conventions on language, the *Dialogical Framework*. This dimension determines what language ontology and illocutionary particles agents should use. It also fixes the organizational structure of the society of agents, that is, which roles agents can play, and what the incompatibilities and relationships among the roles are.

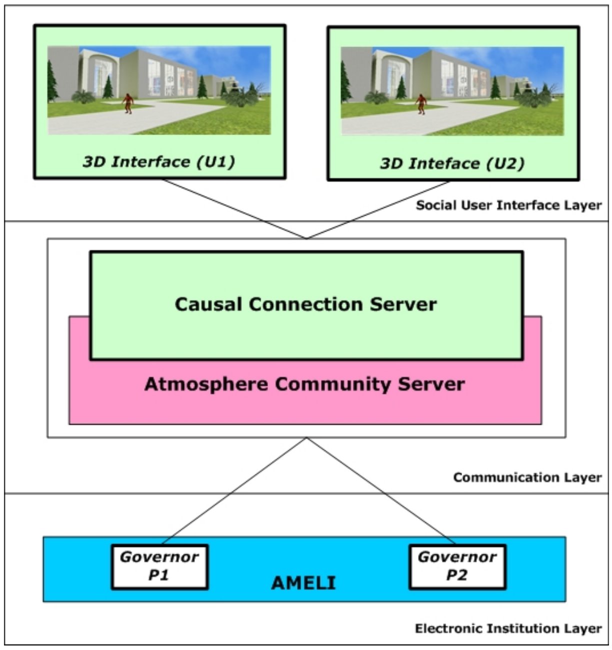

Figure 2: Framework for 3D Electronic Institutions

Conventions on activities, the *Performative Structure*. This dimension determines in which types of dialogues agents can engage. Each different activity an agent may perform is associated to a dialogue among the group of agents involved in that activity. These (structured) dialogues are called *scenes*. (The term is borrowed from theater scripts, where actors incarnate characters and follow strictly pre-fixed dialogues). The Performative Structure fixes which protocol (possible dialogues) can be enacted in each scene, which sub-language of the overall institutional language can be used in each scene, and which conventions regulate the in and out flux of agents in scenes. Agents can join and leave scenes at certain points of the dialogue, for instance, at the end of a round in an auction scene. These points are marked as concrete states in the finite-state machine that represents the protocol. Arcs of the finite-state machine are labelled with illocutionary patterns that make the conversation state evolve when correctly matched agent illocutions are uttered. Finally, the minimum and maximum number of participants is limited by the specification of scenes. Scenes are interconnected to form a network in order to represent sequence of activities, concurrency of activities or dependencies among them. Agents leave scenes where they have been playing a given role and enter other scenes to play the same or a different role. This transit of agents is regulated by special (simple) scenes called *transitions*. Transitions re-route agents and are where synchronization with other agents (if needed) takes place. Sometimes new scenes can only be enacted by a group of agents, or agent can only join scenes as members of a group. Transitions are the places where agents synchronies before moving on.

Conventions on behavior, the *Norms*. Institutions impose restrictions on the agents actions within scenes. These actions are basically restricted to: illocutions and scene movements. Norms determine the commitments that agents acquire while talking within an institution. These commitments restrict future activities of the agent. They may limit the possible scenes to which agents can go, and the illocutions that can henceforth be uttered.

In order to support the specification, design and deployment of multi-agent systems as Electronic Institutions, *IDE-eli* (Integrated Development Environment for Electronic Institutions) is being used[1]. *IDE-eli* is a set of tools whereof *ISLANDER* and *AMELI* are employed in the 3D Electronic Institutions framework. *ISLANDER*, as a graphical specification tool, provides a convenient means to design Electronic Institutions (Esteva, de la Cruz & Sierra 2002). It supports the specification of a common ontology, the set of activities (scenes) that the agents can get involved in, the flow of agents within the institution, and the dialogues that govern the enactment of the different scenes. The tool also performs several verifications on the specified institution (integrity, protocol correctness, and norm correctness). Note that *ISLANDER* is not depicted in Figure 2 for clarity issues. The latter one, *AMELI*, loads institution specifications and acts as the infrastructure that mediates the agent's interactions while enforcing the institutional norms. Agents may be heterogeneous and self-interested, and therefore we cannot assume that they will behave as specified. *AMELI* is a domain independent component that supports the execution of such heterogeneous agents. To execute an Electronic Institution, *AMELI* is launched up-front and then the external agents can join the institution through a simple connection to this infrastructure. Each agent that is connected to the infrastructure communicates in the Electronic Institution via a *Governor*. The *Governor* serves the purpose of "safe-guarding" the institutions, i.e. it checks whether a particular message is allowed to be *said* at the current stage or not.

2.2 Communication Layer

The task of *causally* connecting the Electronic Institutions runtime environment *AMELI* with the user interface is accomplished via the communication layer. A system is said to be "causally connected" to its representation if whenever a change is made in the representation, the system itself changes to maintain a consistent state with the changed representation, and whenever the system evolves, its representation is modified to maintain a consistent relationship (Maes & Nardi 1988). *Reflective systems* are a particular case in which the representation of the system is part of the system itself. The Electronic Institution (execution) has a representation of itself in the form of a 3D environment consisting of rooms, avatars, doors and other graphical elements. The 3D experience includes the possibility that humans interfere with the agent that represents their interests, and that runs over the institution infrastructure, through concrete actions on the 3D environment. These actions and the agent's actions have to be consistent. Therefore a causal connection between the Electronic Institution and the virtual world seems a must. This causal connection has to materialize in two directions. *First*, actions made by the agent in the institution have an immediate impact on the 3D representation. Movements between scenes, for instance, must make the avatar "move" in the 3D world accordingly. Messages said by the agent must be considered as said by the avatar. *Second*, actions performed by the human user via the interface in the virtual world are understood as made by the agent. This has as a consequence that those actions that the agent is not allowed to do in the current execution state cannot be permitted over the 3D environment. For instance, if an agent cannot leave a scene, opening a door must be prohibited to the avatar. Those actions that are permitted in the current state and are actually performed by the human, must have the same impact on the Electronic Institution infrastructure supporting the execution as if they were made by the software agent. For instance, if the human writes a message and the scene execution is in a state where this message is consistent with the protocol, the software agent and the infrastructure will change their state as if the message was said by the agent.

To address this issues, the communication layer features two components, namely the *Causal Connection Server* and the *Atmosphere Community Server*[2]. The latter one offers the functionality of sharing the 3D world among multiple participants and acts as the basis for the *Causal Connection Server*, i.e. it is build on top of the *Atmosphere Community Server*. Each user (interface) is virtually associated with a *Governor* at the electronic institution layer. Consider, for example, user interface U1 in Figure 2 which is associated with *Governor* P1. All events performed by a user are passed in terms of messages from the user interface to the communication layer. Such an event might be the action of opening a door in the virtual world or typing the price the user is willing to pay for an auctioned good. However, the *Causal Connection Server* captures these messages and sends them, in turn, to *AMELI* for "validation". More precisely, *AMELI* checks whether a particular message goes in line with the electronic institution rules or not. If a positive validation response is given by *AMELI*, the requested action (represented by the message) gets the permit to be performed. This action is then reflected at the user interface layer which is detailed in Section 4.

3 Design Considerations

The designs of virtual worlds and electronic institutions have been governed by different principles. Bricken (1990) has identified the shift of the user role to a participant in the actual design, the move from interface towards inclusion (i.e. embedding participants in the design process within the environment), and the change from visual to multimodal interaction. Bricken (1990) briefly mentioned that potentially the design of virtual worlds can change from using metaphors that are familiar to us to appearances that are completely arbitrary. However, in the design of virtual worlds there has been a tendency towards designs related to human everyday experiences. The emphasis has been placed on the design of the visual space. The concept of liquid architecture (Novak 1993) underlined the spatial features in information spaces and the aesthetics of navigation in such spaces. The new approach to architecture, unbound to the constraints of physical civil engineering has been further developed in the research in virtual architecture (Maher, Simoff, Gu & Lau 2000). Building on the function-behaviour-structure paradigm (Gero 1990) and the activity-space model (Simoff & Maher 1993) the research in virtual architecture focused on the relations between the intended functionality of different areas of the virtual world, their forms and topological arrangements. Though these works deal with multifunctional spaces, the design considerations were limited to *static spaces*. These designs have been generated by humans and the representations of the actors in this worlds considered mainly human actors. The developments and research in distributed game environments and computer-mediated collaborative design recognized the need for the dynamic generation of virtual worlds out of design specifications. For example, Smith, Maher & Gero (2003) looked at extending 3D

[1] http://e-institutor.iiia.csic.es

[2] http://www.adobe.com

virtual worlds into adaptable worlds by incorporating agents as the basis for representation the world's elements. The worlds of the *ActiveWorlds*[3] universes accommodate proactive automatic bots which inform inhabitants on different aspects of a world (static so far), hence, can be used to also inform about dynamic changes in the world. However, the rules of behaviour of the agents in both cases and their representation are tighten to the examples used by Smith et al. (2003) in the design of a virtual conference room. The emphasis in this works is placed more on the software side - on the "society of agents" model rather than on the *heterogenous society of humans and agents* operating in the same virtual environment. Below we discuss main design considerations that we address or have to address in our approach.

3.1 3D Virtual Worlds

The design of the user interface constitutes a crucial part of every virtual world. The aim is to combine the use of space with an immersive experience to construct a virtual representation of a particular domain. Space (or objects in space) can be used to model different impressions (Davis, Huxor & Lansdown 1996). *Social power*, for instance, might be expressed by means of "height". *Proximity* can indicate things of the same type or group. However, the perception of space is strongly related to a person's cultural background – yet another aspect to consider during the construction of *multi-cultural* virtual environments.

Human beings live in a well structured space following different metaphors. Ideally, metaphors such as *buildings*, *streets*... should be used in virtual environments as well (Russo Dos Santos, Gros, Abel, Loisel, Trichaud & Paris 2000). A 3D representation of Electronic Institutions could be mapped onto the metaphor of a small town. Each building constitutes a separate institution, public transport might be used to access different institutions, rooms relate to different activities that can be performed in the institution.

Virtual environments are spaces were people "meet". Social interaction is a key feature and virtual environments have to provide support for communication and collaboration of their participants (Smith et al. 2003). Furthermore, not all the inhabitants of virtual environments are under human control. Some of the participants are autonomous agents that have an embodied representation. Thus, a virtual environment, which is populated by automated embodied agents and agents driven by human beings, has to take care of their different *abilities*.

During the construction of a 3D representation of a virtual environment it is important to keep the benefits of traditional 2D interface design in mind (Bowman, Kruijff, LaViola & Poupyrev 2001). Participating in a 3D environment where users can manipulate 3D objects, doesn't necessarily mean exclusion of 2D interface elements. In fact, the interaction with 2D interface elements offers a number of advantages over a 3D representation for some tasks. Most efficient selection techniques, for instance, are widely realized in 2D, whereas, the selection process in a 3D user interface must consider the *user's viewpoint and distance* to the object. Combining the advantages of 2D and 3D design is a very powerful and intuitive approach for the construction of virtual environments.

Besides the benefits obtained by adding an additional dimension for visualization purposes, this new degree of freedom introduces new difficulties (Nielsen 1998). More precisely, not every application domain has a suitable and usable representation in a three-dimensional way. The more abstract (the more non-physical) an application domain becomes, the harder it gets to visualize it in 3D. Consider for example, a 3D representation of a hyperspace like the World Wide Web. Navigating through a three-dimensional representation of web sites will end up in a rather confusing task for most users. Thus, it is of great importance to consider carefully whether to use the "third dimension" for the particular application.

Usability is also a serious challenge for the modelers of virtual worlds, as the guidelines for designing suitable virtual worlds are still far from being complete. One of the key usability issues we would like to focus at is the believability of the user interface. The main reason for using virtual worlds is to provide a user with an interface that is similar to the everyday life surroundings. So we advocate that the major gains that we could get out of it could be easily lost if the believability is not achieved. Any interface that doesn't bring high usability will be immediately rejected by end-users.

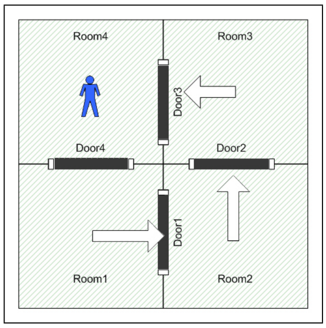

Figure 3: Euclidian representation. Human knows that Room 1 must be behind Door 4.

3.2 Euclidian Representation of the Virtual Worlds

Navigation is an important issue in the design of the virtual worlds. Navigation problems may break the immersive experience and lead to the rejection of the system by end users. Humans live in an Euclidian world: distances and angles help humans to navigate it. In our opinion, the better our system imitates real world, the more it supports social factors like communication and collaboration.

Virtual worlds could certainly be programmed without an Euclidian model in mind. For instance, a series of rooms interconnected by teleporting. However, we build whenever it is possible an Euclidian representation of the Electronic Institution, because we believe that it helps to learn the institution's structure and to navigate the institution.

Imagine the situation (Figure 3) where the user walks from *Room 1* to *Room 4* following the arrows. In *Room 4* the human should correctly expect that *Room 1* is behind *Door 4*, otherwise the believability of the interface will be lost. This expectation of *Room 1* is based on both the consistency of the navigational layout and intuitive feeling about the size of visited rooms.

In our case the Euclidian representation of the virtual world is generated from the graph representing the performative structure. To achieve this, we propose to apply *rectangular dualization* technology which is used to generate rectangular topologies for top-down floorplanning of integrated circuits. The algorithm proposed in (Jarbi 1988) removes the intersecting arcs of the source graph to force it being planar. We extend the algorithm in such a way that the vertex peers related to removed arcs are stored, and

[3]http://www.activeworlds.com

after the generation of the virtual world the interconnected teleports are placed in the rooms represented by those vertices.

3.3 Synchronization Issues

The Electronic Institution specification permits to model situations where several agents have to proceed to the next scene together. To do that, agents must synchronize. While synchronization is easily supported by the Electronic Institution infrastructure, it requires a detailed thinking for virtual worlds.

We want to provide an immersive environment where human beings are "driving" their avatars through different scenes. Moving to another scene in the virtual world is expressed by opening a door, walking through the transition and opening the entrance door of the next scene. When more than one participant is required to leave the scene (open the exit door) we propose the following approach: each participant approaches the door and tries to open it (showing the intention to leave). The last agent to synchronize approaches the door and is able to open it. When the door is opened all the waiting agents will be moved through it *automatically* (synchronized).

3.4 Humans and agents in 3D EI

The participants of a 3D electronic institution are two possible types of actors: autonomous (software) agents and human beings (principals). This couple agent/principal is represented in the 3D Electronic Institution by an avatar. The interface relation between humans and agents in 3D electronic institution is illustrated in Figure 4. Human-driven avatars are fully controlled by humans through an *interface* (metaphorically the interface is a sort of *glove puppet* that translates all decisions of its *puppeteer* into terms of the institution machine understandable language). Our view is that the agent and the human co-operate in the solution of the tasks the human has to deal with. We want to permit that either the human takes full control or that the autonomous agent is in full charge of the decision making process. None the less, we want to allow other types of interaction among them, such as the human giving guidelines to the agent, or the agent suggesting potential solutions to the human (via the interface), in a sort of "expanded intelligence" mechanism similar to the "expanded reality" that nowadays virtual reality tools offer. When there is no specific need to provide autonomous agents with visualization facilities, having a 3D representation of the institution will be very beneficial for humans to perceive the actions of the autonomous agents through avatars in order to decide whether to intervene or not, to interact with the agents and to implement decisions in an easy way.

As part of the institutional rules, we introduce the *avatar representation code*, which allows to distinguish between the same avatars when they are driven by a human being or the corresponding autonomous agent. Such representation code should accommodate the individual personal choice of avatar made by the human (e.g. it's geometry, texture, gestures and other specifics) and modify them to a certain extent when the this avatar is controlled by an agent (e.g. change trousers to a jeans type). Such explicit distinction is necessary for supporting awareness, i.e. seeing somebody's software agent present in a room may mean that the person is currently present in the 3D electronic institution but in another location. On the other hand, a principal may leave her agent in the institution when she is not currently there. This adds another requirement to the representation code (e.g. switching on transparency of the avatar).

3.5 Learning in 3D electronic institutions

In general, the design and implementation of electronic commerce environments is separated in time from their use, i.e. the environment is designed before it is used. This time lag results in environments that may not be directly related to the experiences of their users. Maher & Gu (2003) pointed that this is in general the case with current practices in designing virtual worlds. They proposed to associate an agent with the avatar, in which case the avatar can respond to events in the world either through the human control of the avatar or via the avatars agent. Using some simple design grammar the agent can automatically alter and build a portion of the world, which provides the virtual world with potential capability to evolve according to the human behaviour. As in 3D electronic institutions the agent (and the corresponding avatar) can be always present in the institution, there is an opportunity to observe the behaviour of the human counterpart or other avatars and learn behaviour patterns when the human being is driving the avatar.

Discovering patterns of behaviour in virtual environments is a recently established field of research. Simoff & Biuk-Aghai (2002) proposed a framework for analyzing data in collaborative virtual environments, elements of which have been presented in more details in their earlier works. The aim was to adapt the virtual environment as a result of what is learnt about the user behaviour. Similar view is taken by researchers in process mining (see (Van der Aalst, Van Dongen, Herbst, Maruster, Schimm & Weijters 1999) for details in current research and future directions in the area) who develop heuristics to mine event-data logs to produce a process model that can support the workflow design process. The techniques, developed in the field provide useful background for learning from behaviour in 3D electronic institutions, though these techniques operate over historical data sets that are taken out of the system, rather than on data streams.

In proposed framework, the duality, agent/principal, permits the introduction of a co-learning mechanism into the system. On the one hand, the autonomous part can learn from the principal how to take decisions, and after some period of learning take autonomous decisions in the same way the human would have taken them. On the other hand, the autonomous agent can help the human to learn about the structure of the Electronic Institution. It can assist the user in learning the institutional rules (expressed in a machine understandable language but made comprehensible to the human through the observation of the avatar controlled by the agent) or can advice the human on certain decisions on the basis of the information the agent may have gathered from external sources or from the observation of other participants' behaviour. Depending on the specification of the institution agents may also observe conversations of other agents and extract important information for their principals. For example, an agent can use different data mining techniques to gather additional information about the product a human being is about to buy, and interfere in the decision that is going to be taken by the human presenting him an important piece of information about the product ("I just read that this model is not supported anymore").

In the initial structure of the 3D electronic institutions we can identify areas in the visual space that have specific semantic features. For example, in an art auction user behaviour can include moving from room to room, examining the artworks, placing bids, initiation of information requests about specific artworks. In other words, we can associate particular

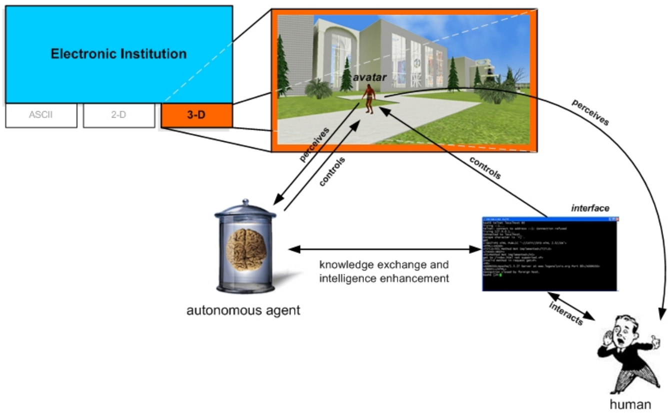

Figure 4: Interaction between automated agents and their principals.

activities with particular modes of interactions and interaction opportunities. The agent that observes the behaviour of a human controlled avatar can learn the specific style of individual behaviour in such areas, and later provide guidance in similar situations. This "personalization" is embedded in the 3 layer framework presented in the previous section. An aggregation of the patterns behavioural learned from user behaviour can provide the information for improving and adapting the structure of the initially generated 3D electronic institution. Our approach utilizes the results of the initial work in adaptive interfaces for 3D virtual worlds recently presented by Celentano & Pittarello (2004), which proposes the coordinated use of three approaches: structured design of the interaction space, distinction between a base world layer and an interactive experience layer, and user monitoring in order to infer interaction patterns.

Adding new dimensions and new degrees of freedom to a user interface provides new opportunities for collecting information and learning. Interaction in 3D virtual worlds involves typical real-world actions such as moving, changing directions of movement, changing the point of view without changing the position (1st vs 3d person view), turning around and inspecting objects, and so on. At each step on a trajectory in the world, there is a large number of possible actions.

New degrees of freedom appear also with the support of social interactions, the possibility to change participants' appearance and with different ways of interaction with the environment. The way users navigate in 3D space, the appearance they select, even the trajectory of their movement send implicit messages about their personality. Even just the user's location in the 3D space gives an important information. For instance, if a user spends a lot of time in the auction room of Henri Mattisse we can anticipate that the user is interested in buying paintings of this painter and perhaps paintings of other painters that follow Fauvism.

Another aspect of learning that is impossible in traditional electronic institutions is the discovery of social networks in such institutions. For example, the frequency analysis of conversational utterances of users (without analysis of communication content) can provide an initial structure of "connections" between this users. With a deeper analysis relating the structure of the network to the subject of activities of the electronic institution we can potentially identify some influence on the decision making. The analysis of the conversational content can explicitly provide information about the interests. For example, the user may say in a conversation: "I like Gauguin", which can be used by a guiding agent to immediately offer some paintings, without asking any explicit questions.

4 3D Social Interfaces

In order to describe the 3D social user interface metaphor we use the following scenario.

"Imagine a businessman who wants to buy contemporary art to decorate his office. The businessman is a customer of the 3D Electronic Institution and uses the fish market auction for buying and selling fish. One of the rooms in the electronic institution serves as the gallery for graffiti posters. During the vernissage the artist is present there and is looking forward to conversations with customers. The businessman instructs his software agent to participate in the fish market auction on his behalf, moves on to a poster auction and spends his time on browsing through the offers.".

One way to buy contemporary art could be to go to a conventional form-based online poster shop similar to the one shown in (Figure 5).

The user interface of this shop gives the buyer the possibility to browse through the posters, read all the corresponding information and bid for those she or he is interested in. All necessary information is explicitly mentioned in terms of text and the posters are shown as images. There is also some advertisement (text and images) present on the web page.

An alternative way to buy a graffiti poster is the virtual gallery realized as a *3D Electronic Institution*. In contrast to the form-based interface of the online poster shop, the 3D Electronic Institution offers a *3D social interface*, that stimulates the interactions between the participants. This 3D virtual gallery allows users to perceive, first, products and their associated information and, second, all other participants.

4.1 Prerequisites for 3D Electronic Institutions

A graphical user interface for a virtual gallery is generated from the Electronic Institution specification. This specification is created with the help of the ISLANDER tool. From the user interface point of view, the Electronic Institution specification determines the skeleton of the virtual world and the map of the institution. From the point of view of the Electronic Institution, the specification serves as the basis for the execution of the infrastructure, assigning governors to each participant, limiting the interaction protocols, conversations, and permissions for different roles.

The Electronic Institution specification does not contain any information related to user interfaces and

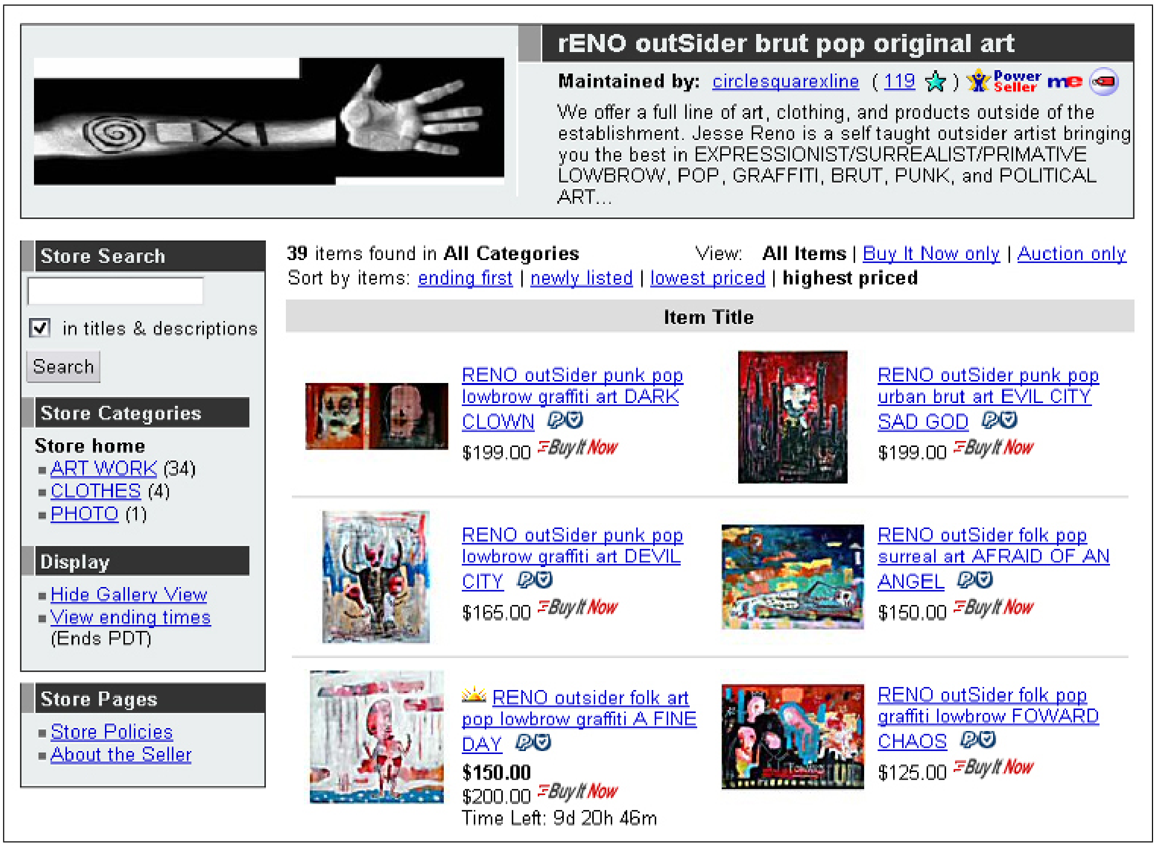

Figure 5: Graffiti posters auction on Ebay

visualization of the institution. As it was already mentioned, the Electronic Institution methodology dealt so far only with the institutions populated with software agents. Despite this fact both the skeleton of the virtual world and the Electronic Institution infrastructure can be generated in a fully automatic way. In this case the rooms in the newly created 3D Electronic Institution will not be furnished, however, the doors, transitions, door labels, internal agents and governors will be present. This institution will be fully functional, meaning that all the security issues of the institution will be imposed (e.g. permissions, protocols, obligations). The agents will be able to freely interact and take part in conversations, the consistency of those conversations and interactions with the institutional rules will be guaranteed by the infrastructure. The possibility to split into alteroids and learning aspect will be also granted.

Of course, an institution with unfurnished rooms is an example of a poor user interface design and can not be attractive for end users. To enrich the user interface we are going to provide the Annotation Editor tool which helps to *prettify* the institution. The annotation is done in a form of URLs, as Adobe Atmosphere (responsible for rendering) easily operates with URLs as the pointer to any resource type. For instance, the URL of the 3D model of the furnished room can be added as the annotation to the corresponding scene in the specification. Once the annotation is finished the virtual world is generated on the basis of the annotated specification. During the generation of the virtual world the 3D model of each room will be reshaped to reflect the required size and the doors will be placed on the correct place. If the designer adds the doors to the 3D model, they will not be used and can not be opened.

To give a rough impression on the Electronic Institution specification Figure 6 shows the performative structure of the 3D Electronic Institution from the scenario. The performative structure is only one part of the Electronic Institution specification, but it contains enough information for the purpose of this example.

On the basis of the performative structure the map of the institution and the virtual world are created. Each of the scenes ("registration", "picAuction" and "fishAuction" in our case) lay the foundations to generation of the 3D models of the rooms. The size of each room is determined by the maximal number of participants (specified inside each scene, not visible on the performative structure). The *root* scene is represented as a garden surrounding the institution. The *exit* scene doesn't have any visual representation. Transitions (small triangle-like shapes in the performative structure) are transformed into special types of rooms between the scenes. Connections (lines connecting the elements of the performative structure) are represented as doors. Each door is initially locked, and will be opened as soon as the user is granted the permission to the transition by the institution. Each connection between a scene and a transition is labelled with the set of roles, in this way the permissions of a role to access particular scenes are specified. For example, only instances of class manager (the manager in this case is the internal agent) and user are allowed to proceed to the registration room.

Usually each user appears in the entry scene of the institution (garden) as a guest (user role in our case) with the only possibility to access the registration room (however it depends on the specification and can be done in a different way). After successful registration user's role changes and according to this new role appropriate doors are unlocked. The doors are unlocked for each particular avatar, the same doors will be locked for a different avatar if the permissions are not granted. The infrastructure also prohibits sneak-

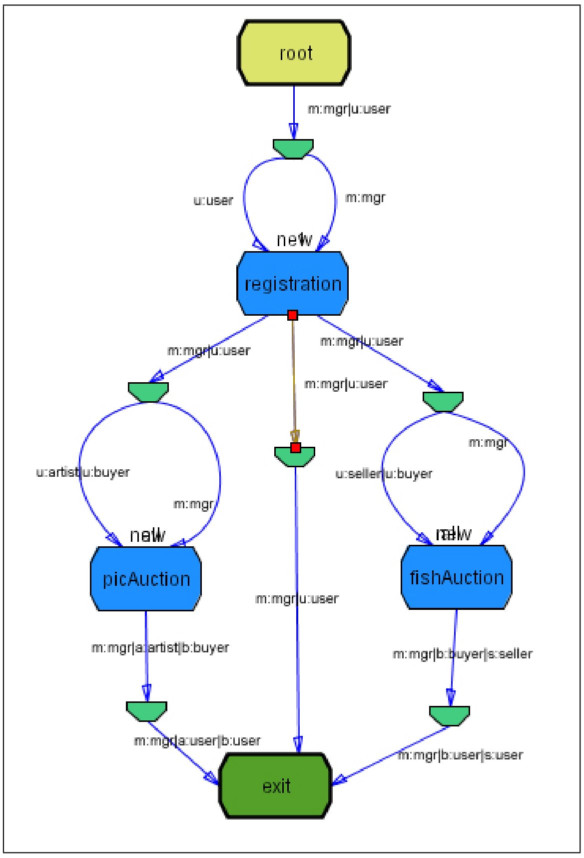

Figure 6: A performative structure of the very simple institution

ing in through the locked doors while another avatar enters. The invisible colliding doors are put additionally to the main ones and the collision is turned off for the users that are allowed to enter (so that they can freely go through) and is turned on for all the other users (so that they collide with an invisible door and can not go through).

There are 4 types of participants of the 3D Electronic Institution: humans, software agents, internal agents and governors. Each humans is represented as one avatar and can change avatar's appearance in every possible way. Software agents are the autonomous alteroids that are not controlled by humans. Their appearance is predefined in the Annotation Editor tool. Internal agents represent the institution and can not be manipulated by the visitors of the institution. All the internal agents are dressed in similar way which is also selected in the Annotation Editor. Governors can be seen as the mediators between participants of the Electronic Institution and the institution itself. They validate every action of the users and reply to the institution related questions of the users. Governors are usually not displayed, but they appear as avatars when a user tries to violate the institution rules. The default appearance of the governor is a police officer dressed in the uniform.

According to Chittaro, Ranon & Ieronutti (2004) following an embodied agent may dramatically improve the navigation. The trajectory of the avatar's movement may clearly indicate whether the user is lost or not. For this reason the trajectory of each avatar is observed and if the user appears to experience navigation problems the governor is displayed and helps the user to reach the target destination.

4.2 A 3D Social Interface exemplified by means of a Poster Auction

The 3D social interface reflecting the described scenario is depicted in (Figure 7). The gallery is visualized as a virtual world that reproduces a *cosy atmosphere* of a real world gallery. The posters are presented in a conventional way (hanging on the walls) as it is usually done in real world galleries.

The participants of the gallery are represented as avatars. The avatar of the internal agent is easily recognizable because of the uniform, it is responsible for putting the goods on the auction an taking the bids. The software agent has a robot-like appearance. All the other avatars are human participants with different appearance.

Additionally to the main 3D part, the user interface contains some 2D parts.

The chat window serves the purpose of the communicator between participants. To maintain privacy, engage users into the spatial interactions and filter the unnecessary conversations, the maximum *audibility distance* is specified. Only the avatars within the audibility distance can participate in the conversation. Due to this fact, the female avatar present in the left part of the window is not disturbed with the conversation between the artist and the businessman.

The next important 2D part of the interface is the *map* of the institution. It is only visible if the user moves the mouse cursor to the right border of the screen. The large rectangular blocks represent rooms and the smaller ones correspond to transitions. The solid figure with the arrow on top of it displays current location of the human driven avatar within the institution. The non-solid figures represent the software agents that are in the user's subordination. Electronic Institutions permit situations where user can split himself/herself into a number of *alteroids*. Only one of the alteroids can be controlled by a human and all the others are controlled by software agents. Software agents act autonomously trying to fulfill the task specified by a human. They may move around and even walk between different rooms, as they observe the user all the time and may try to imitate his/her behaviour to better represent the user in the institution. If in some situation a software agent is unable to proceed with the given task due to the lack of intelligence, the figure representing this agent on the map starts to blink attracting the attention of the human.

The human is able to control any of the alteroids at any time by clicking the corresponding figure on the map. This will lead to switching to a different view (determined by the position and head rotation of the alteroid). The control over the avatar the human was controlling before is automatically passed to a software agent, the appearance of this avatar is changed to the default appearance of a software agent. In the given scenario the software agent (non-solid figure) represents the businessman in the fish market auction, while the businessman drives the avatar (solid figure) through the graffiti auction room.

Another 2D element of the user interface is the rucksack with obligations. It helps the user to remember the obligations towards the institution that have to be fulfilled. The rucksack automatically opens and the pending obligation is displayed if the situation of not fulfilling an obligation makes it impossible to proceed to another scene or state in the institution. The user can also see the obligations on demand by clicking on the rucksack.

Figure 7: 3D Electronic Institution example: Graffiti poster auction

4.3 Beneficial Aspects of the 3D Social Interfaces

The 3D virtual gallery serves the same purpose as the form-based online shop, however, due to the different interface some conceptual changes are introduced into the shopping process. Embodied presence of buyers and sellers gives an additional *push* to the people to get engaged into conversations. The same participants could have been present in the form-based online shop, but due to the fact that they are not displayed, a user is unaware of their existence. The embodiment, in our opinion, makes the environment more open and informal, people are more likely to ask questions that they will never ask via e-mail. Social interactions may bring the participants new business contacts, more information about the products and even new friends.

The aim of the social interfaces is to stimulate social interactions. Additional possibilities to get people involved into a conversation appear with the ability of observing the position of participants and the direction of their eyesight. This gives information about the *environment context* of each user and helps to find a topic for conversation.

Another obvious difference between the two interfaces is that the buyer in the form-based shop is overloaded with text information. In contrast, 3D virtual gallery brings new degrees of freedom into the information presentation. It is not limited by using text and 2D graphics; information can be presented as sound or even have 3-dimensional representation (giving an observer the possibility to get full impression of an object). The level of details decreases with the distance, reducing the information overload. For example, the information on the price, the title, "Buy it now" button and additional information are only visible if the user approaches the poster (some detailed information describing each painting may also be presented in sound form).

The sellers have even more support in the 3D virtual gallery than the buyers. They can implicitly attract attention to their products using advanced decoration techniques, lighting and even music. The gallery can be organized in the way that to see the most interesting posters users have to see all the other posters as well. Sellers may help buyers with an advice, if they determine a need for this. They may attract the attention to themselves selecting unusual appearance or performing some actions. There is also a lot of space for statistical analysis, as each buyer is clearly observable and some software agents (controlled by sellers) may collect statistical information.

The 3D virtual gallery offers the natural way of product observation (similar to real galleries) due to the immersive and consistent interface. Additional 2D elements are integral parts of the interface. The map of the institution is not perceived as a separate component or different activity. In contrast to this, to see the site map of the form-based shop a user has to open another window or change to another activity. The chat window of the 3D virtual gallery is present all the time, where its form-based shop analogues (forum and sending e-mail messages) are completely different activities with totaly different interfaces.

We are convinced that the visualization of products and social interactions, appearing with 3D social interfaces, are crucial for E-Commerce.

5 Conclusion and Future Work

In this paper we described a 3D social interface which aims at *introducing* humans to Electronic Institutions. Social interactions play a very important role in E-Commerce and virtual worlds provide excellent means to represent and model them.

As the approach that we have developed results in visual interfaces (e.g. virtual architecture forms), governed by the functional requirements of a specific Electronic institution, we would expect the reverse step: the design of the digital electronic commerce spaces (hence, the spatial interface) to be reflected back in the designs of their physical world counterparts. The technology that supports such transition is already there - the rapid prototyping and computer aided manufacturing technologies (Kolarevic, 2001), which directly make use of 3D digital models for the production of full-scale building components. We can make an analogy to Zellner's (1999) vision of architecture as becoming firmware, where the digital building of software space is inscribed in the hardwares of construction engineering, that the 3D electronic institutions can modify the structure and architecture of existing instutional counterparts in the physical world.

Both the communication layer and the inteface are in a preliminary stage of development. As a next step we aim at implementing the communication layer.

We plan also to investigate further the utilisation of gestures and other social cues in 3D electronic institutions. Currently, avatars in virtual worlds are equipped with some set of general gestures or ways of expressing some social cue (for example, waving, jumping and spinning to express joy, dancing movements, etc.). The concept of the 3D electronic institution offers the opportunity to utilise a set of professionally specialised gestures as part of the social interface. The learning mechanism associated with the dual human/agent control of the avatar allows to associate the use of specific gestures to a particular person, scenes, or, on another level, class of scenes and type of people. This can make possible anticipation and dynamic customisation of the gesture sets associated with different avatars.

References

Bowman, D., Kruijff, E., LaViola, J. & Poupyrev, I. (2001), 'An Introduction to 3-D User Interface Design', *Presence: Teleoperators and Virtual Environments* **10**(1), 75–95.

Bricken, M. (1990), Virtual worlds: No interface to design., *in* 'In Proceedings of First International Conference on Cyberspace.'.

Celentano, A. & Pittarello, F. (2004), Observing and adapting user behavior in navigational 3d interfaces., *in* 'Proceedings of the Working Conference on Advanced Visual Interfaces, Gallipoli, Italy'.

Chittaro, L., Ranon, R. & Ieronutti, L. (2004), Navigating 3d virtual environments by following embodied agents: a proposal and its informal evaluation on a virtual museum application, *in* 'PsychNology Journal (Special issue on Human-Computer Interaction)', pp. 24–42.

Cuní, G., Esteva, M., Garcia, P., Puertas, E., Sierra, C. & Solchaga, T. (2004), MASFIT: Multi-agent systems for fish trading, *in* 'Proceedings of the 16th European Conference on Artificial Intelligence, ECAI04', p. In Press.

Damer, B. (1998), 'Avatars', Peachpit Press. an imprint of Addison Wesley Longman.

Davis, S. B., Huxor, A. & Lansdown, J. (1996), The DESIGN of Virtual Environments with particular reference to VRML, Technical report, Centre for Electronic Arts, Middlesex Univserity.

Esteva, M., de la Cruz, D. & Sierra, C. (2002), ISLANDER: an electronic institutions editor, *in* 'First International Conference on Autonomous Agents and Multiagent systems', ACM Press, Bologna, pp. 1045–1052.

Gero, J. (1990), Design prototypes, a knowledge representation schema for design., *in* 'AI Magazine, 11(4)'.

Haik, E., Barker, T., Sapsford, J. & Trainis, S. (2002), Investigation into effective navigation in desktop virtual interfaces., *in* 'In Proceedings of the 7th International Conference on 3D Web Technology,Tempe, Arizona'.

Jarbi, M. (1988), Automatic Building of Graphs for Rectangular Dualization, *in* 'Proceedings of the 25th ACM/IEEE Conf. on Design automation', pp. 638 – 641.

Jung, Y. & Lee, A. (2000), Design of a social interaction environment for electronic marketplaces, *in* 'Proceedings of the conference on Designing interactive systems', ACM Press, pp. 129–136.

Maes, P. & Nardi, D. (1988), *Meta-Level Architectures and Reflection*, Elsevier Science Inc., NY, USA.

Maher, M. & Gu, N. (2003), Situated design of virtual worlds using rational agents, *in* 'Proceedings of the 2nd International Conference on Entertainment Computing, Carnegie-Mellon University'.

Maher, M., Simoff, S., Gu, N. & Lau, K. (2000), Designing virtual architecture, *in* 'Proceeding of CAADRIA2000'.

Nielsen, J. (1998), '2D is Better Than 3D', http://www.useit.com/alertbox/981115.html. visited 22 June 2004.

North, D. C. (1990), *Institutions, Institutional Change and Economic Performance*, Cambridge Univ. Press, Cambridge, U.K.

Novak, M. (1993), Liquid architecture in cyberspace., *in* 'In M. Benedikt (ed.), Cyberspace: First Steps, MIT Press'.

Preece, J. & Maloney-Krichmar, D. (2003), *The Human-Computer Interaction Handbook*, Lawrence Erlbaum Associates Inc., chapter Online Communities: Sociability and Usability, pp. 596–620.

Russo Dos Santos, C., Gros, P., Abel, P., Loisel, D., Trichaud, N. & Paris, J. P. (2000), Mapping Information onto 3D Virtual Worlds, *in* 'Proceedings of the International Conference on Information Visualization', pp. 379–.

Simoff, S. & Biuk-Aghai, R. (2002), Data mining of collaborative virtual workspaces: The "space-data-memory" framework., *in* 'in J.S. Gero and F. Sudweeks (eds), Artificial Intelligence in Design 98, Kluwer Academic, Dordrecht'.

Simoff, S. & Maher, M. (1993), Designing with the activity/space ontology, *in* 'in J.S. Gero and F. Sudweeks (eds), Artificial Intelligence in Design 98, Kluwer Academic, Dordrecht'.

Smith, G. J., Maher, M. L. & Gero, J. S. (2003), Designing 3D Virtual Worlds as a Society of Agents, *in* 'Proceedings of CAADFutures'.

Solomon, R. (2004), *Aristotle, ethics and business organizations. Organization Studies.*

Van der Aalst, W., Van Dongen, B., Herbst, J., Maruster, L., Schimm, G. & Weijters, A. (1999), Workflow mining: a survey of issues and approaches., *in* 'Data and Knowledge Engineering, 47(2)'.

Vinson, N. (1999), Design guidelines for landmarks to support navigation in virtual environments., *in* 'In Proceedings of CHI99, ACM Press'.