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Opening new dimensions for e-Tourism

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Abstract In this paper we describe an e-Tourism environment that takes a community-driven approach to foster a lively society of travelers who exchange travel experiences, recommend tourism destinations or just listen to catch some interesting gossip. Moreover, business transactions such as booking a trip or getting assistance from travel advisors or community members are constituent parts of this environment. All these happen in an integrated, game-like e-Business application where each e-Tourist is impersonated as an avatar. More precisely, we apply 3D Electronic Institutions, a framework developed and employed in the area of multi-agent systems, to the tourism domain. The system interface is realized by means of a 3D game engine that provides sophisticated 3D visualization and enables humans to interact with the environment. We present ''itchy feet'', a prototype implementing this 3D e-Tourism environment to showcase first visual impressions. This new environment is a perfect research playground for examining heterogeneous societies comprising humans and software agents, and their relationship in e-Tourism.

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1 Introduction

Tourism is the leading market in B2C commerce (Werthner and Ricci 2004). The number of online sales is increasing steadily with a large number of successful online booking platforms in the various areas of tourism such as transportation, accommodation, package deals or regional offers (Gratzer et al. 2004). In addition, the Internet is a main source for gathering information since an abundance of online services concerning tourism information exists. These services are either created and maintained by editors, or are community-based such as Usenet groups, *Lonely Planet's Thorn Tree*[1] forum or *VirtualTourist*[2], to name but a few.

Even though the number of online sales of tourism products is increasing, people still appreciate social interaction with travel agents, their expertise and to

[1] http://thorntree.lonelyplanet.com/

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

receive help with impulse decisions. In general, the trust towards travel agents tends to be more distinct than when dealing with online tourism portals. Indeed customers feel more secure about booking with people. On the other hand, fast responses to requests and the possibility of accessing various information sources on the Internet are important advantages of booking online. Additionally, the personal experience of others is a valuable good and acts as a guidance for own decisions. Above all, people enjoy the convenience of making decisions in their familiar environment (Bogdanovych et al. 2006a).

Tourism products cannot be observed or manipulated through direct experience prior to purchase—they are ''confidence goods''. An a priori assessment of product quality is virtually impossible. Hence, customers need to rely on indirect or virtual experience when making their decisions (Liu 2005). Consequently, appealing presentations of products, e.g., travel destinations, have always been an important factor for success in tourism. Traditional media used by travel agents are quite effective in creating illustrated catalogs that provide potential customers with a significant amount of information and useful tips jazzed up with highly esthetic photos, maps and much more.

In a nutshell, we consider sophisticated visualization of tourism products, the consulting role of travel agents, the social interaction and information exchange between travelers, as well as the information richness of the Internet as being the key features for successful e-Business in tourism. We are currently developing a system that embraces all of these diverse issues. In particular, we describe the application of 3D Electronic Institutions in tourism embedding human support for online inquiries and offering customers an innovative visualization of tourism products. 3D Electronic Institutions are multi-agent environments where participants communicate via a predefined language and adhere to institutional rules (Bogdanovych et al. 2006b). A 3D game engine is used for sophisticated visualization of 3D Electronic Institutions allowing humans to interact with the environment.

Our 3D e-Tourism environment ''itchy feet'' provides an integrated, game-like e-Business application where customers are impersonated as avatars equipped with the possibility to interact with their surroundings in a variety of ways. They can perform commercial transactions such as booking a trip, or get advice from travel agents that are impersonated as staff of the virtual office. Potential customers, henceforth referred to as *e-Tourists*, can gather multimedia information and experience a 3D representation of the destination they intend to travel to. The following scenario illustrates the vision of our e-Tourism environment.

A travel agency and an independent travel advisory service constitute the e-Tourism environment and are visualized in terms of a 3D virtual world. Both the travel agency and the travel advisory service are located inside a building of the virtual world and designed similar to their real-world counterparts: offices, furniture such as counters or chairs, decoration, etc.

Elaine, a member of the tourism community and a potential customer, becomes an e-Tourist and is visualized as an avatar when joining the virtual world. Straight away she starts exploring the environment by walking through the building and sees a number of other participants in the virtual world. At this stage, *Elaine* can choose between entering the travel agency, visiting the office of the travel advisory service or engage in a conversation with one of the various other e-Tourists. Since *Elaine* had requested her software agent to gather information on potential destinations, she already has a pretty good idea of where she wants to spent her next vacation. She enters the travel agency. Immediately, *Fiona*, one of the keen travel agents, cordially greets *Elaine* and engages her in a conversation. In course of their conversation *Fiona* learns about *Elaine's* wishes and preferences. At certain points of the conversation, the travel agent suggests accommodations to *Elaine* and adapts recommendations according to her feedback. *Elaine* shows interest in a particular offer. *Fiona* encourages *Elaine* to make a virtual trip and visit her destination as well as her potential accommodation. She is teleported to a 3D representation of this accommodation and sees the featured scenic views and facilities such as heated spa and sauna. The 3D visualization conveys a natural and realistic impression that has finally convinced *Elaine* to book the suggested offer. After *Elaine* has paid, she leaves the travel agency and exits the e-Tourism environment.

At about the same time, *Sebastien*, a backpacker currently traveling Bali and not completely sure regarding the visit of a particular destination, drops by a local Internet Café. He joins the virtual world and becomes an e-Tourist in order to clarify his questions and concerns. Embodied as an avatar, *Sebastien* navigates through the virtual world passing by the travel agency heading towards the travel advisory service. He steps through the entrance and finds himself surrounded by numerous other avatars, some gathered together in small groups others involved in dialogs. The environment offers him the possibility to communicate with other e-Tourists, talk to professional travel advisors or to chat with an independent

travel advisor. *Sebastien* approaches *Seamus*, one of the professional travel advisors. *Seamus* greets *Sebastien* and offers his assistance. Since *Sebastien* is concerned about controversial safety statements regarding his intended travel destination, he asks *Seamus* to clarify the situation. During their discourse, the travel advisor supports his explanations with current news articles and video streams which helps *Sebastien* to get a clear impression of the actual situation. Gratefully, he leaves the travel advisor and strolls through the travel advisory service where he eavesdrops a conversation between two other visitors. By chance, these two visitors were recently touring Bali. *Sebastien* joins their conversation and enjoys an interesting discussion. However, meeting these particular e-Tourists was not as incidentally as it might seem. Keywords used during *Sebastien's* dialog with the professional travel advisor were analyzed in order to adapt the environment to his interests.

The remainder of this paper is structured as follows. In Sect. 2 we provide a review of related work. The design of the e-Tourism environment and its technological foundations are outlined in Sect. 3. Then, in Sect. 4, we present ''itchy feet'', a prototype of a 3D e-Tourism environment that allows interaction between humans and agents in a 3D virtual world. Section 5 provides an outlook on long-term goals. Finally, we draw some conclusions in Sect. 6.

2 Related work

Nowadays individuals are the product of a particularly mobile and entrepreneurial society. As a result, individuals are socially constituted and socially situated in everyday business activities. Preece and Maloney-Krichmar (2003) criticize that the satisfaction of social needs, despite its great importance, is widely neglected in contemporary interactive systems. A truly feasible e-Business system that supports business activities can hardly be obtained without taking care of the social issues behind these activities (Wyckoff and Colecchia 1999). Some operators of e-Business systems even believe that online communities supporting social interactions serve the same purpose as the ''sweet smell of baking cakes'' does in a pastry shop. Both evoke images of comfort, warmth, happiness and probably even trust. Most system analysts, however, perceive such systems from a purely technical viewpoint neither bearing in mind the social norms that companies and consumers comply with nor acknowledging the importance of human consultancy in a decision-making process.

Our particular domain of interest, tourism, is dominated by rather conservative approaches in user-interface design that disregard these social issues. A number of online booking platforms exist on the Internet where interaction is based on form fill-ins and selection from dropdown lists. As examples, consider *Tiscover*[3] and *Expedia*[4]. Still in line with this conservative view but with the goal of providing extensive support to customers, Ricci and Werthner (2002) developed a recommendation system for tourism, DIETORECS, that offers various form-based ways to interact with the system. In particular, users express their needs by choosing from a fixed set of attributes represented by radio buttons or dropdown lists. Due to the domain diversity a multitude of attributes is available, and unfortunately, this plethora of options results in a dramatically overloaded interface and creates confusion for those who are booking trips. As a possible way to compact the interface, we suggested to incorporate natural language dialog to access tourism information. The findings of a field trial show that natural language interaction is accepted by the tourism community. So the burdens associated with traditional form-based tourism environments can be reduced (Berger et al. 2004).

A current strand of research in e-Tourism is the delivery of content to mobile devices. This is especially important for on-trip assistance of travelers as addressed in (Nielsen 2004). A multi-agent systems in tourism is described in Yeung et al. (1998). In this system, agents are employed to gather up-to-date information from online sources. Another focus of e-Tourism research lies on the integration of B2B business processes rather than on the consumer. Chiu and Leung (2005), for instance, have designed a virtual enterprise of independent tourism service providers as a multi-agent system. An attempt to combine multi-agent systems with 3D visualization is described in Manojlovich et al. (2003). The authors propose a framework using 3D game engines in order to visualize military simulations in a 3D virtual world.

Immersive environments such as 3D virtual worlds address the satisfaction of users' social needs and are complemented with a realistic experience. Virtual worlds support the way humans act and communicate in real life to a certain extent and offer an environment to meet people. Such interfaces go beyond the form-based approaches dominating the Internet and graphically represent the user in terms of an avatar (Damer 1998). Users are literally *in* the Internet rather than *on*

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

[4] http://www.expedia.com/

it. 3D virtual worlds implicitly address the issue of social interactions since location awareness, presence, as well as direct communication are intrinsic elements. Inspired by the success of 3D graphical user interfaces in application domains such as computer games, computer-aided design as well as medical and scientific visualization, researchers applied this emerging technology to new domains (Jain 2003; Swartout and van Lent 2003; Tsang et al. 2003). The experiences of using a computer game as an interface to monitor Unix system processes are described in (Chao 2001, 2004). In this particular case the first-person shooter *Doom* is adopted. Other examples are a source code comprehension tool (Kot et al. 2005), an application for architectural design critique (Moloney et al. 2003) and support for landscape visualization and environmental planning (Herwig and Paar 2002).

Quite interestingly, the borderline between virtual and real world tends to faint in current online games such as *Second Life*[5] and *EverQuest*[6]. In particular, the buying and selling of items for the game provide some gamers with a notable source of real income (Wallace 2005). For EverQuest an economic study has revealed that the virtual *Norrath* has been the 77th richest country of the world in 2000, roughly equal to Russia (Castronova 2001; Cummins 2002).

Chittaro and Coppola (2000) propose a 3D e-Business environment featuring animated products, which act as navigational aids and guide users through the 3D representation of the online shop. 3D product visualizations literally move around and assist users in finding the appropriate lane within the shop. An e-Business environment fostering social interactions is described in Girgensohn and Lee (2002). It incorporates a novel, spatially organized and interactive site map that provides visibility of people, activities and mechanisms for social interactions.

A vivid area of applied VR research related to tourism is cultural heritage. One interesting representative is the virtual reconstruction of Leonardo da Vinci's ''Ideal City'' (Barbieri and Paolini 2001). Based on original sketches the city was realized as a 3D virtual world. The main objective was to provide an immersive virtual experience of da Vinci's ideas and concepts and to offer users the possibility to explore the city collaboratively. Lepouras and Vassilakis have realized a 3D virtual museum using a game engine (Lepouras and Vassilakis 2004). The focus of this 3D virtual museum was to investigate the feasibility of such technologies allowing visitors to experience a virtual visit from their desktop computer.

Overall, the design and development of virtual worlds have emerged as a phenomenon shaped by the home computer user rather than by research and development activities at universities. In general, virtual worlds are more or less unregulated environments. To exploit the benefits of virtual worlds interfacing e-Business systems, strong methodologies for reliable interactions need to be applied.

3 Foundations

3.1 Conceptual design

Bricken identified the shift from a passive user role to participation in the actual design, the move from interface towards inclusion, i.e., involving participants in the design process within the environment, and the change from visual to multimodal interaction (Bricken 1991). The development and research in distributed gaming environments as well as in computer-mediated collaborative design identified the need of dynamic generation of virtual worlds from design specifications. For example, Smith et al. (2003) changed static 3D virtual worlds into adaptable worlds by incorporating agents as the basis for representing the world's elements. The emphasis, however, was put on the software side, i.e., the *society of agents*, rather than on the *heterogeneous society* of humans and agents. Contrary to that, we concentrate on the latter issue and describe design considerations for our environment in order to address such heterogeneous societies.

We consider two types of participants, namely *humans* and *agents* as shown in Fig. 1[7]. An agent is either controlled by a human or acts autonomously. In the first case, the human is the *principal* of its agent. The couple principal/agent is represented as an *avatar* in the 3D virtual world. However, in case of autonomously acting agents, their visual representation depends on their task. In other words, a human-like representation is not necessarily appropriate.

Human and agent cooperate in order to collaboratively achieve a certain goal. This ranges from delegating simple tasks such as information gathering to complex ones as, for instance, participating in an auction. However, it is envisioned to provide intelligent mechanisms to extend the interaction between humans and agents. Consider an agent providing context-aware

[5] http://www.secondlife.com/

[6] http://eqplayers.station.sony.com/

[7] The faces of *Elaine* and later on *Sebastien* in the figures are taken from a report on face morphing (Braun et al. 2001).

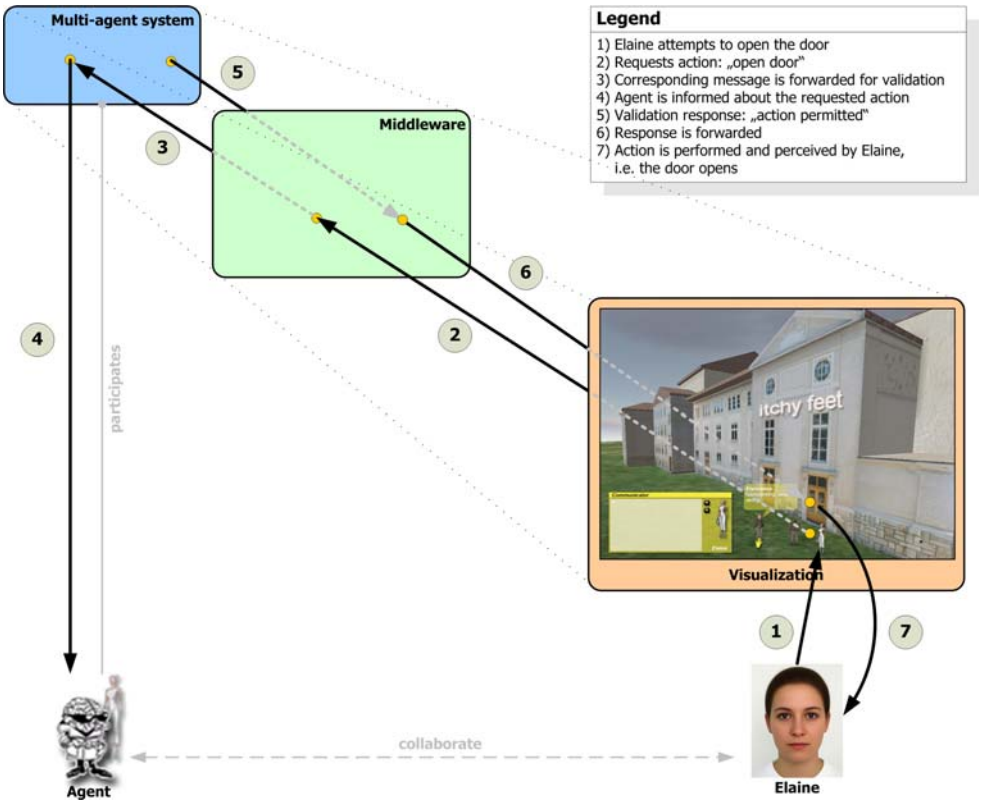

Fig. 1 Interrelationship between humans, agents and avatars

and location-dependent advices to a human in terms of *machine-augmented intelligence* comparable to *augmented reality* in virtual environments. The agent might learn from its principal to make proper decisions and might assist the human in learning the rules that apply in the environment. Additionally, a human might be advised by her agent about the consequences of certain actions by compiling information obtained from external information sources. Behavior patterns of other participants in specific situations might be observed in order to derive solutions for current tasks.

As Maes and Nardi (1988) point out, a system is ''causally connected'' to its representation when the following facts apply: firstly, whenever the representation of a system is changed, the system itself has to change as well. Secondly, whenever the system evolves, its representation has to be modified in order to maintain a consistent relationship. The middleware causally connects the multi-agent system with its visualization, cf. Fig. 1. The execution of the multi-agent system itself is represented in terms of a 3D virtual world consisting of avatars, rooms, doors and other graphical elements. So the causal connection needs to materialize in two directions. Messages sent by the agent in the multi-agent system have immediate impact on the 3D representation. Actions performed by the human in the 3D virtual world are translated to messages sent by the agent. As an example, consider *Elaine's* attempt to open the door. This triggers a sequence of messages that, eventually, results in granting or denying access to the building. These messages are symbolized as arrows in Fig. 1. Her action causes a validation check in the multi-agent system and, consequently, its outcome is represented in terms of an open or closed door.

Besides ensuring the causal integrity, it is important to guarantee that participants adhere to regulations of the environment. In fact, we distinguish two security levels; the societal and the technological level. On the societal level, we provide mechanisms to prevent malevolent behavior of participants. This includes an abuse reporting service, where offenses are collected, analyzed and, if necessary, appropriate sanctions are being imposed. To maintain the functionality of the environment and prevent, for instance, participants from deliberately blocking doors, members of an executive authority will monitor the participants' behavior and intervene if necessary. On the technological level, agents are authenticated with the system by means of digital certificates.

Appropriate user interface design is crucial for sophisticated human–computer interaction, which especially applies to 3D virtual worlds. Such interfaces are designed to emulate the way humans operate and

interact in the real world. More precisely, 3D virtual worlds aim at combining the use of space with an immersive experience in order to construct a usable virtual representation of a particular application domain. Space and objects in space are used to model different impressions. Proximity of things could indicate that they belong to the same group or are of a similar type. A particular role of a participant in the virtual world might be represented by means of a specific outfit. To address this issue we introduce the *avatar representation code* that allows the perception of visual cues associated to the roles of participants. This representation code accommodates the preferred avatar visualization including its gender, physique, outfit, gestures and other specifics. However, some attributes cannot be personalized since they express distinct characteristics of a particular role. Consider an example from the tourism domain. The visualization of a travel agent is constrained such that the avatar needs to be dressed in a specific workwear. Since an avatar can either be controlled by a human or an agent, this aspect has to be made obvious by means of an explicit visual cue.

Virtual worlds visualized in 3D are environments where people meet. Communication and interaction between participants are central in these environments. Smith et al. (2003) point out that these environments have to provide appropriate mechanisms that enable users to communicate and encourage social interactions. Participants, either humans or software agents, interact via a text-based chat facility for synchronous communication. Asynchronous communication is addressed by an instant messaging service.

3.2 3D Electronic Institutions

Multi-agent systems have proven to be a suitable paradigm for modeling environments that are composed of many autonomous individuals. In order to develop complex multi-agent systems, sophisticated methodologies supporting the entire development life cycle including design, analysis and deployment are needed (Iglesias et al. 1998, Jennings et al. 1998). Methodologies that distinguish between the social (macro-level) and agent (micro-level) aspects of the system are preferable. However, considerable research efforts take an agent-centered view while ignoring social aspects of individual participants. So, most research concentrates on the development of theories, languages and methodologies whereof MADKIT[8], Gaia (Wooldridge et al. 2000) and Electronic Institutions (Esteva 2003) are prominent representatives. Note that we have chosen the methodology of Electronic Institutions for realizing the multi-agent system of our 3D e-Tourism environment.

3D Electronic Institutions combine the two paradigms of *Electronic Institutions* and *3D virtual worlds* while retaining the features and advantages of both. An electronic institution is an environment populated by agents that interact according to predefined conventions on language and protocol. Furthermore, Electronic Institutions guarantee that certain norms of behavior are enforced. This permits that agents behave autonomously and make their decisions within the limits imposed by the set of norms of the institution (Esteva et al. 2001). 3D Electronic Institutions broaden this view and are environments that enable humans to participate in a heterogeneous society of individuals visualized in a 3D virtual world. The essence is to transcend the agent-centered view on Electronic Institutions, take a human-centered perspective and concentrate on the relationship between humans and agents in the amalgamation of the two paradigms.

Basically, 3D Electronic Institutions are built according to a three-layered architecture (Bogdanovych et al. 2006b). The system architecture following this framework is depicted in Fig. 2. The first layer hosts the runtime environment *AMELI* for arbitrary Electronic Institutions. These institutions are specified with *ISLANDER* (Esteva et al. 2002), a UML-like editor that verifies the institution with respect to integrity, protocol correctness and norm correctness. Both, AMELI and ISLANDER, are part of the electronic institution development environment, *EIDE*[9]. AMELI loads an institution specification and mediates the interaction of agents while enforcing institutional rules and norms. To execute an electronic institution, AMELI is launched up-front and agents can join the institution by connecting to the runtime environment.

The second layer contains the *Causal Connection Server* that causally connects the Electronic Institutions' runtime environment AMELI with the 3D virtual world at the third layer. Note that in this exposition the terminology of Electronic Institutions is adopted. *Scenes* are activities following a structured dialog that agents can engage in. Each participating agent adopts a specific *role* that determines its possible actions in a particular scene. *Transitions* control the flow of agents between scenes according to their role.

An arbitrary event, e.g., a mouse click on a door handle, caused by a human leads to a sequence of processing steps. Firstly, the event is caught by the user

[8] http://www.madkit.org/

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

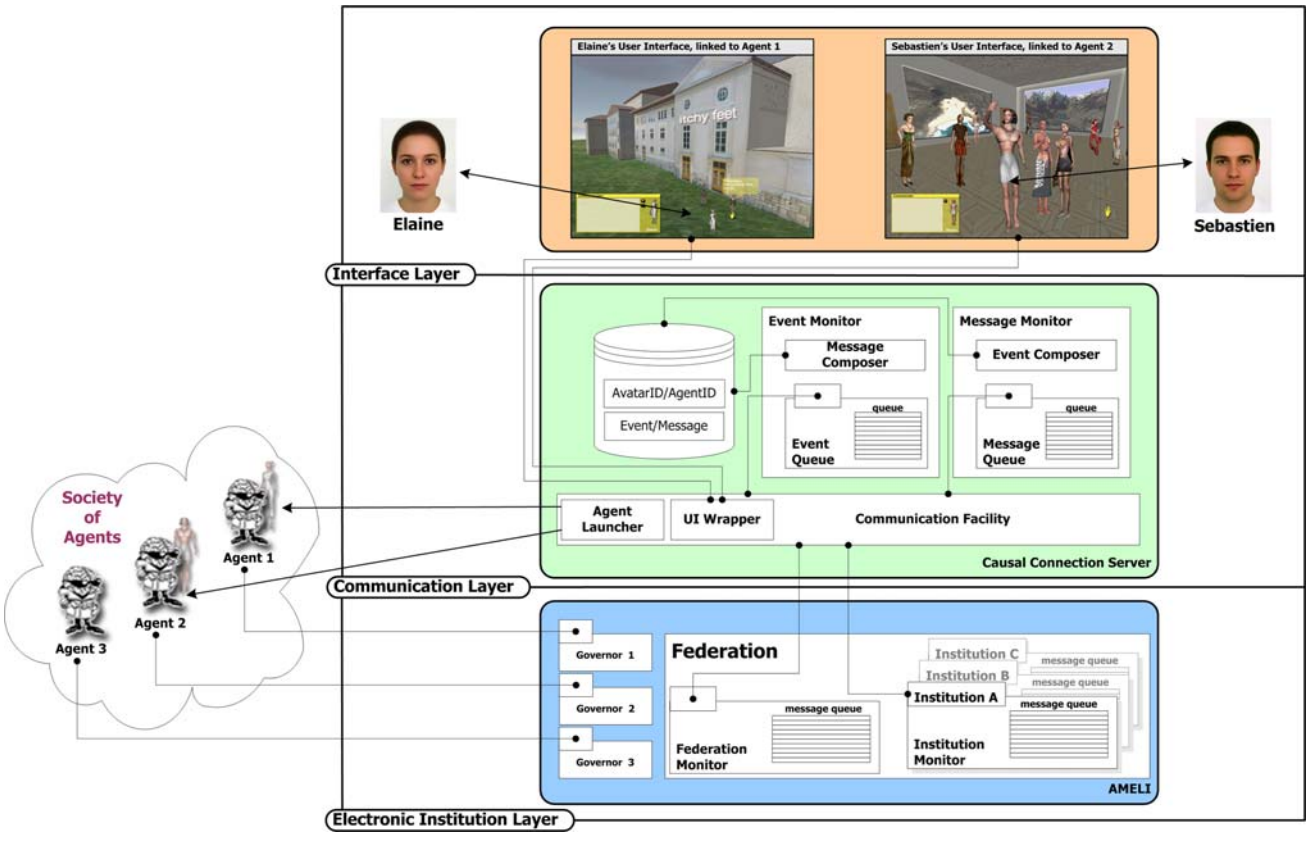

Fig. 2 The three-layered architecture of 3D Electronic Institutions

interface and transmitted in terms of a 2–tuple <AvatarID, Event > to the Causal Connection Server. Then the event tuple is stored in the *Event Queue* which is observed by the *Event Monitor*. As soon as the event monitor notices the arrival, it translates the event by means of the *Event/Message* mapping table into the corresponding message. In analogy to that, the *AvatarID* is mapped onto the *AgentID*, this time though, by means of the *AvatarID/AgentID* mapping table. A 2–tuple <AvatarID, Event > is composed and stored in the *Message Queue*. This time the *Message Monitor* detects the arrival and sends it to the corresponding agent using the *Communication Facility*. The agent sends the message and the state of the electronic institution changes. AMELI validates whether the received message adheres to the institutional rules and generates an adequate response. Messages, however, originating from AMELI need to be reflected in the virtual world and are processed in exactly the opposite way.

The *institution monitor* provides an interface to AMELI, which allows the observation of all messages within a single electronic institution. More precisely, the Causal Connection Server is connected to a socket provided by the institution monitor, and collects available messages. These messages assist in maintaining the synchronized and consistent relation between the 3D virtual world and the electronic institution. Since more than one electronic institution might be executed at one time, the *federation monitor* keeps track of all Electronic Institutions.

Humans connect to the system via a graphical interface. Consequently, a message is sent via the Causal Connection Server using the *agent launcher* that, in turn, spawns a new agent. This agent represents the human at the electronic institution level. Note that *Elaine's* interface corresponds to *Agent 1* and *Sebastien's* interface is connected to *Agent 2* in Fig. 2. Each agent participating in an electronic institution communicates via a *Governor*. The Governor serves the purpose of safeguarding the institution, i.e., it checks whether a particular message is allowed to be sent at the current state or not. Agents that are not controlled by humans contact AMELI directly. Each agent requests access and, if granted, communicates via a Governor as well. Consider, for example *Agent 3*. This particular agent is not controlled by a human, i.e., it is not required to visually represent the agent for its own sake. However, if it is necessary for humans to interact with this agent, it needs to be visualized as well. In this case, the Causal Connection Server generates a rep-

resentation based on the messages obtained via the institution monitor.

The third layer of the 3D Electronic Institutions' architecture contains the *user interface*. The *UI wrapper* component controls the flow of messages between the user interface layer and Causal Connection Server. We refer to the next section for the current realization of the 3D e-Tourism environment including the user interface.

4 The 3D e-tourism environment "itchy feet"

The role model for our e-Tourism environment "itchy feet" is the concept of massively multi-user online role-playing games (MMORPGs). Every day, millions of users interact, collaborate, socialize and form relationships with each other through avatars in such online environments (Yee 2006). We address the aspect of social interaction by providing instruments to interact and exchange experiences with other customers that go beyond the possibilities of conventional text-based chat rooms. "Itchy feet" offers sophisticated visualization of tourism products, integrates travel agents and enables access to the information richness of the Internet.

We have conducted an evaluation of several commercial and non-commercial 3D game engines whereof the *Torque Game Engine* by *GarageGames*[10] was the most adequate. This particular game engine runs on all major operating systems. It provides a comprehensive set of design and development tools including a *World Editor*, a *GUI Editor* and a *Terrain Editor*, which assist perfectly during the creation of arbitrary games. Moreover, it offers multi-player network code, seamless indoor/outdoor rendering engines, state-of-the-art skeletal animation, drag and drop GUI creation, and a C-like scripting language. For a smooth execution, Torque requires on the Macintosh platform a G4 processor, 128 MB RAM with an OpenGL compatible 3D graphics accelerator card. In addition to that and unlike most commercial game engines, the source code of the engine is distributed as part of the low cost royalty-free licensing policy, which facilitates the creation of the 3D e-Tourism environment.

A simplified specification of the electronic institution "itchy feet" is shown in Fig. 3. It consists of five scenes represented as nodes in the graph including *Entry Point* and *Exit*. Scenes are connected via one or more transitions. In this particular case, "itchy feet" is accessed via the *Travelers' Lounge*. The *travel advisory service* and the *travel agency* are connected to the *Travelers' Lounge*. Participants exit "itchy feet" through the *Travelers' Lounge*.

This specification is used to manually generate a floor plan of the e-Tourism environment, see Fig. 4. We have developed an algorithm to automate the floor plan generation from Electronic Institutions' specifications (Bogdanovych and Drago 2006). In a straightforward approach, scenes are mapped onto rooms, transitions between scenes are represented as doors restricting the access between scenes. Note that transitions are directed and, hence, two doors are needed to bidirectionally connect adjacent rooms. The maximum number of participants per scene determines the size of each room. This institution is already fully functional, i.e., all institutional norms are imposed, agents are free to join the environment, interact and engage in conversations.

Based on the floor plan we modeled a 3D virtual world that constitutes the user interface of the e-Tourism environment "itchy feet". This representation allows to integrate important aspects of e-Tourism into a single framework. For instance, there is a designated area, the travel agency, where travel agents conduct business transactions such as selling a holiday package. In this area the actual negotiation process takes place.

The travel advisory service mainly serves information gathering and visualization purposes. Agents are responsible to render this area information-rich. They access external, disparate information sources, aggregate the collected information, and present the material as an integral part of the environment. This information material ranges from highly reputable independent information sources of, say, the *Lonely Planet* type, over advertising brochures of tour operators to sometimes perhaps questionable resources from the Internet. Additionally, e-Tourists may travel to destinations that are represented in 3D. This may range from *Google Earth*[11] type presentations to virtual tours along, say, a particular slope in a skiing resort.

The Travelers' Lounge provides room for meeting other e-Tourists. The embodiment of e-Tourists as avatars in the 3D virtual world creates exceptional opportunities to involve people in social interactions just by the fact of their presence. Being aware of someone's position and line of sight allows observing the environmental context of each particular e-Tourist. The presence of others creates a more open and a less formal environment where people are more likely to engage in conversations if they perceive the social

[10] http://www.garagegames.com/

[11] http://earth.google.com/

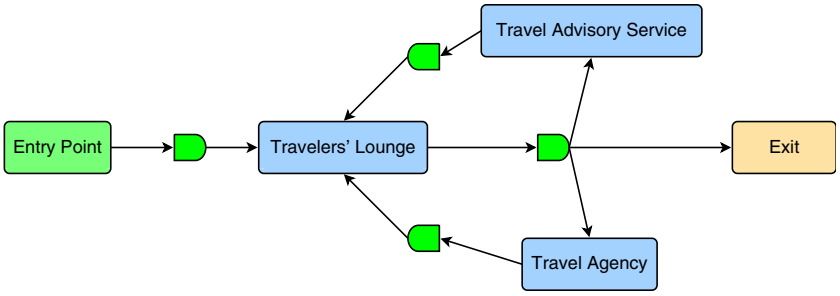

Fig. 3 A simplified specification of the Electronic Institution "itchy feet"

context. This may range from discussions with other e-Tourists, exchanging information about destinations, sharing personal travelogs and experiences, to visiting game zones or discussion groups. The goal is to foster the growth of a community feeling among the members of "itchy feet" where a particular person visits not only for travel booking but also for enjoying the interaction with other people.

However, according to Nonnecke and Preece (2000), recent reports indicate that lurkers make up over 90% of online groups. Invisibility of participants, as it is possible in most web-based forums, is not an issue in "itchy feet". However, people may still stand around inactively not talking to anybody. In order to lure out these lurkers and encourage active participation in the e-Tourism community, we introduce several counteracting methods. Firstly, a special tutorial area for newcomers and newbies, the technically challenged or the shy, helps to get to know the environment and to establish first social contacts. Secondly, the level of active participation within the community will be monitored and, in case of long-lasting inactivity, special animators are provided by the environment. The task of these animators is to engage passive members in conversations, ask if they need assistance, provide pointers and hints regarding their interests, and so forth. Thirdly, each participant has the possibility to explicitly communicate her particular "quest" by attaching a visual cue to her avatar. Pragmatically speaking, the concept of "quest" is borrowed from the area of MMORPGs where participants may indicate, say, "Looking for work" or "Looking for friend" by means of a textual label hovering above her avatar's head. In the context of "itchy feet", this might range from simple statements such as "Looking for information" to specific ones such as "Kazakhstani visa regulations for Spaniards".

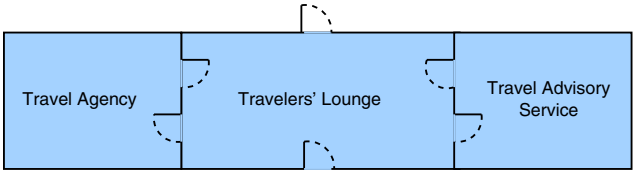

Fig. 4 Corresponding floor plan of "itchy feet"

We argue that the exchange of real-life experiences provides up-to-date information which is more complete and more personalized than any available guidebook. This claim is supported by the findings of the study described in Schwabe and Prestipino (2005) which assessed the quality of information available from online travel communities compared to commercial guidebooks. With that in mind and inspired by MMORPGs, we introduce reward mechanisms for competent and helpful members of the community sharing their travel experiences. Firstly, to show appreciation for their active participation and, secondly, to tie them to the online platform in order to establish long-term customer relationships. As an example, an e-Tourist might receive a gift for repeatedly providing informative travelogs. The usefulness of the travelog is assessed by other participants of the community.

Godwin (1994) points out that online communities need to provide durable records of the history of the community members. This encourages the development of reputations, which can be a vital source of social information and control. The participant's reputation is influenced by the amount of helpful tips or travelogs provided. This may alter the look of the avatar to make it visually obvious to other customers that this person is a valued e-Tourist with expertise in, say, traveling Queensland, Australia. We are well aware that such reputation mechanisms might be the target of manipulation. An interesting approach to prevent exploitation is implemented in Second Life where the act of rating other participants incurs costs.

It is important to understand that the purpose of the e-Tourism environment goes beyond the traditional "just selling trips" business. In fact, the agent stays in contact with the human during her travel—even at a time when the human is not actively participating. It remains proactive and collects potentially useful information based on the e-Tourist's profile. The agent

Fig. 5 The entrance to the premises of ''itchy feet''

Fig. 6 The Travelers' Lounge of ''itchy feet''

provides tips and pointers to, e.g., local events in the travel region or sends recently gained information. As on-trip assistance, the information can easily be transmitted to the traveler by means of SMS or e-mail communication and alike.

The user interface of our 3D e-Tourism environment ''itchy feet'' is presented in Figs. 5 and 6. It is visualized in terms of a 3D representation of a building surrounded by a grassy area. As soon as an e-Tourist enters the e-Tourism environment she is impersonated as an avatar and positioned somewhere near the premises of ''itchy feet''. In this particular case, Fig. 5 depicts the view of *Elaine*. The appearance of *Elaine's* avatar is guided by the preferences kept in her profile. Moreover, the profile stores information on her travel likings, special interests and maintains a history of interactions she made during previous sessions. *Elaine* interacts with the environment via mouse and keyboard. The mouse is used to change the viewpoint and to trigger events such as opening doors, selecting other participants, etc. If the mouse is pointed towards an avatar, the individual's name as well as her interests are displayed in a transparent bubble. In this case, *Elaine* points her mouse on *Francesca* and reveals that she is interested in backpacking, skiing and traveling Asia. The lower left area of the interface features the interaction module, i.e., the *Communicator*. This module allows to chat with other e-Tourists including agents, to obtain messages regarding the status of the environment, e.g., number of participants, to receive news from the maintainer of the e-Tourism environment, and to send and receive mail. Additionally, the *Communicator* is used to change the appearance of the avatar. This is accomplished by clicking on the little figure to the right of the *Communicator* window which opens the repository of available avatars and accessories such as clothes, bags, headdresses or gestures.

The premises of ''itchy feet'' is accessed via the main entrance located beneath the ''itchy feet'' sign, cf. Fig. 5. The interior contains different areas including a room for conducting business such as booking trips or auctioning, an area for information gathering and information exchange, a section devoted to gaming as well as a community area, the Travelers' Lounge as shown in Fig. 6. This area enables e-Tourists to engage in conversations, talk about experiences they got during their travel, recommend or dissuade particular tourism destinations or just enjoy a relaxed get-together with other ''travel addicts''. In this particular case, Fig. 6 depicts the view of *Sebastien*, impersonated as an avatar, on the Travelers' Lounge. Besides *Sebastien*, a number of other visitors are present, some engaged in a conversation or about to join, others just waiting and observing the scene. The two video walls in the rear of the room are visual representations of agents. In this scene, the agents deliver information about particular travel destinations based on the requests of e-Tourists standing in front of the video walls.

5 Outlook

The principal goal of ''itchy feet'' is to support the complex interaction patterns of providers and consumers in an e-Tourism setting. In particular, these providers and consumers, either humans or software agents, are members of a heterogeneous society cohabiting in a multi-agent based 3D virtual environment. This environment provides visualization of and interaction with tourism products, support tourism business activities and provide the grounds for a lively

tourism community that fosters social interaction and the exchange of personal experiences. This principal goal subsumes three sub-goals:

1. Provide a 3D e-Tourism environment for providers and consumers that enables versatile interaction between participants including the trade in tourism products.
2. Provide a 3D e-Tourism environment that becomes a community facilitator to create and establish a lively and sustainable community involving both, providers and consumers.
3. Provide a 3D e-Tourism environment that is information-rich and multimedia-based to offer transparent and unified access to disparate information sources.

As a result we will obtain an instrument that allows to examine a broad set of research questions in the areas of e-Tourism, human–computer interaction, multi-agent systems and online communities:

1. From an economic perspective, we will be able to analyze the implications of such 3D virtual environments on ''real-world'' tourism business. This will enable the deduction of trends and clues as to how the markets and interests might evolve. This evolution is not limited to the tourism business. We anticipate the participation of additional business branches in the e-Tourism environment, such as outdoor gear retailers, with a more or less close relationship to the core domain of tourism.
2. Since trust towards commercial transactions is integral for successful online business, we will be able to examine how and to which extent the participation in a regulated 3D virtual business environment can influence this issue.
3. The innovative approach of marrying 3D gaming technology with electronic business allows to investigate the extent to which gaming technology can elevate the interaction with ''serious'' e-Commerce applications to a social, joyful and playful experience.
4. We will be able to investigate the effects of cohabitation of humans and agents forming a mixed society in an e-Commerce setting. This will enable the investigation of completely new aspects of online communities emerging in such environments, including the possibility to research social as well as business networks.

Since ''itchy feet'' is a radically new approach in e-Tourism, we are well aware of the necessity to evaluate the environment. To this end, we adopt a methodology for user-centered design and evaluation of virtual environments that comprises four phases (Gabbard et al. 1999). The first phase, i.e., the *user task analysis*, is about to be completed. Its purpose is to identify a complete description of tasks, subtasks, and methods that are required to interact with the system. This ranges from the description of universal tasks such as travel, object selection and manipulation, to specialized ones such as bargaining (Bowman et al. 2001). We expect to derive important clues on the sequences, relationships and interdependencies of these tasks. This will impact the complete application development life cycle including the usability design and evaluation. In the second phase an *expert guidelines-based evaluation* will be conducted. This usability inspection aims to uncover potential usability problems by comparing our user interaction design to a set of design guidelines specifically for virtual environments. A handful of user interaction design experts will perform an analytical evaluation of the interface and assess ''itchy feet'' by determining which usability guidelines it follows or violates. As a result we will obtain recommendations to improve the design which will lead to a revised version of the system. The third phase, i.e., the *formative user-centered evaluation*, comprises an empirical and observational evaluation that ensures usability of interactive systems by including users early and continually throughout the development process. Again, usability experts will be responsible to carry out this evaluation phase which aims to improve the design by observing users performing tasks which were identified during phase one. The third phase is carried out iteratively. In the final phase, i.e., the *summative comparative evaluation*, an empirical assessment of our interaction design in comparison with other interaction designs for performing the same user tasks is carried out. This evaluation will be performed with the more or less final prototype of ''itchy feet''. The purpose of this step is to statistically compare user performance with different interaction designs. To this end, a particular interaction design is defined to be better in advance and, subsequently, it is compared to the new design. In a nutshell, this evaluation phase can be seen as an experimental evaluation with users comparing two or more configurations of user interface components, interaction paradigms or devices, etc. This methodology will support the assessment and iterative improvement of the user interaction design of ''itchy feet''.

6 Conclusion

Tourism has illustrated how the Internet can change the structure of an entire industry and, in the process,

create new business opportunities. The development of more specialized services and further consumer integration will lead to smart marketplaces integrating all stakeholders. However, current e-Tourism applications are dominated by rather conservative approaches in user-interface design. Considering the current success of MMORPGs on the one hand, and the growing market share of tourism products being bought online on the other hand, the combination of entertainment and business has the potential of creating enormous synergies for e-Tourism.

Therefore, we argue that appealing visualization of tourism products, the consulting role of travel agents, the social interaction and information exchange between travelers, as well as the information richness of the Internet are the key features for successful e-Business in tourism. With ''itchy feet'' we are developing a system that embraces all of these diverse issues. This e-Tourism environment follows a community-driven approach to foster a lively society of travelers who exchange travel experiences, recommend tourism destinations or just listen to catch some interesting gossip. Moreover, business transactions such as booking trips or getting advice from human travel agents are constituent parts of this environment. All this happens in an integrated, game-like e-Business application where each e-Tourist is impersonated as avatar. More precisely, we applied 3D Electronic Institutions, a framework developed and employed in the area of multi-agent systems, to the tourism domain. The system interface is realized by means of a 3D game engine that provides 3D visualization and enables humans to interact with the environment. We have showcased first visual impressions of ''itchy feet''. This new environment opens a playground for exciting research to examine the collaboration in heterogeneous societies comprising both humans and agents and investigate their relationship in e-Tourism.

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References

Barbieri T, Paolini P (2001) Reconstructing Leonardo's Ideal City from handwritten codexes to Webtalk II: a 3D collaborative virtual environment system. In: Proceedings of the conference on virtual reality, archeology, and cultural heritage, Glyfada, Greece, 2001. ACM Press, pp 61–66

Berger H, Dittenbach M, Merkl D (2004) User-oriented evaluation of a natural language tourism information system. Inform Technol Tourism 6(3):167–180

Bogdanovych A, Drago S (2006) Euclidean representation of 3d electronic institutions: automatic generation. In: Proceedings of the 8th international working conference on advanced visual interfaces (AVI 2006), ACM Press, Venice, Italy, pp 449–452

Bogdanovych A, Berger H, Sierra C, Simoff S (2006a) Travel agents vs. online booking: Tackling the shortcomings of nowadays online tourism portals. In: Proceedings of the 13th international conference on information technologies in tourism (ENTER'06), Lausanne, Switzerland, Springer, Berlin Heidelberg New York, pp 418–428

Bogdanovych A, Berger H, Simoff S, Sierra C (2006b) Narrowing the gap between humans and agents in e-commerce: 3D electronic institutions. In: Proceedings of the 6th international conference on electronic commerce and web technologies (EC-Web'05), Copenhagen, Denmark, pp 128–137

Bowman DA, Johnson DB, Hodges LF (2001) Testbed evaluation of virtual environment interaction techniques. Presence Teleoper Virtual Environ 10(1):75–95

Braun C, Gründl M, Marberger C, Scherber C (2001) Beautycheck: Ursachen und Folgen von Attraktivität. PDF document available from http://www.beautycheck.de/english/bericht/bericht.htm

Bricken M (1991) Virtual worlds: no interface to design. In: Benedikt ML (ed) Cyberspace: first steps. MIT Press, Cambridge, pp 363–382

Castronova E (2001) Virtual worlds: a first-hand account of market and society on the cyberian frontier. The Gruter Institute working papers on law, economics, and evolutionary biology, 2(1)

Chao D (2001) Doom as an interface for process management. In: Proceedings of the SIGCHI conference on human factors in computing systems (CHI'01). ACM Press, Seattle, pp 152–157

Chao DL (2004) Computer games as interfaces. Interactions 11(5):71–72

Chittaro L, Coppola P (2000) Animated products as a navigation aid for e-commerce. In: Extended abstracts on human factors in computing systems (CHI'00). ACM Press, The Hague, The Netherlands pp 107–108

Chiu DKW, Leung H (2005) Towards ubiquitous tourist service coordination and integration: a multi-agent and semantic web approach. In: Proceedings of the 7th international conference on electronic commerce (ICEC'05), ACM Press, Xi'an, China, pp 574–581

Cummins N (2002) Integrating e-commerce and games. Personal Ubiquitous Comput 6:362–370

Damer B (1998) Avatars: exploring and building virtual worlds on the Internet. Peachpit Press, Berkeley

Esteva M (2003) Electronic institutions: from specification to development. PhD thesis, Institut d'Investigació en Intel.ligència Artificial (IIIA)

Esteva M, Rodriguez-Aguilar JA, Sierra C, Garcia P, Arcos JL (2001) On the formal specifications of electronic institutions. In: Dignum F, Sierra C (eds) Agent mediated electronic commerce, The European AgentLink Perspective. Springer, Berlin Heidelberg New York, Germany, pp 126–147

Esteva M, de la Cruz D, Sierra C (2002) ISLANDER: an electronic institutions editor. In: Proceedings of the 1st international conference on autonomous agents and multi-agent systems (AAMAS'02), ACM Press, Bologna, Italy, pp 1045–1052

Gabbard JL, Hix D, Swan JE (1999) User-centered design and evaluation of virtual environments. IEEE Comput Graph Appl 19(6):51–59

Girgensohn A, Lee A (2002) Making web sites be places for social interaction. In: Proceedings of the 2002 ACM conference on computer supported cooperative work, ACM Press, New Orleans, LA, pp 136–145

Godwin M (1994) Nine principles for making virtual communities work. Wired 2.06:72–73

Gratzer M, Werthner H, Winiwarter W (2004) Electronic business in tourism. Int J Electron Bus 2(5):450–459

Herwig A, Paar P (2002) Game engines: tools for landscape visualization and planning? In: Proceedings of the conference on trends in GIS and virtualization in environmental planning and design. Wichmann Verlag Dessau, Germany, pp 162–171

Iglesias CA, Garijo M, Gonzales JC (1998) A survey of agent-oriented methodologies. In: Proceedings of the 5th international workshop on intelligent agents: agent theories, architectures, and languages, Springer, Paris, pp 317–330

Jain R (2003) Experiental computing. Commun ACM 46(7):48–54

Jennings NR, Sycara K, Wooldridge M (1998) A roadmap of agent research and development. Auton Agent Multiag Syst 1(1):7–38

Kot B, Wuensche B, Grundy J, Hosking J (2005) Information visualisation utilising 3D computer game engines case study: a source code comprehension tool. In: Proceedings of the 6th ACM SIGCHI New Zealand chapter's international conference on computer–human interaction (CHINZ'05). ACM Press, Auckland, pp 53–60

Lepouras G, Vassilakis C (2004) Virtual museums for all: employing game technology for edutainment. Virtual Real 8(2):96–106

Liu S (2005) A theoretic discussion of tourism e-commerce. In: Proceedings of the 7th international conference on electronic commerce (ICEC'05), ACM Press, Xi'an China, pp 1–5

Maes P, Nardi D (1988) Meta-level architectures and reflection. Elsevier, New York

Manojlovich J, Prasithsangaree P, Hughes S, Chen J, Lewis M (2003) Utsaf: a multi-agent-based framework for supporting military-based distributed interactive simulations in 3d virtual environments. In: Proceedings of the 35th conference on winter simulation (WSC '03), Winter simulation conference, New Orleans, LA, pp 960–968

Moloney J, Amor R, Roberts J, Furness J, Moores B (2003) Design critique inside a multi-player game engine. In: Proceedings of the CIB W78's 20th international conference on construction IT, construction IT bridging the distance, CIB Publication, Waiheke Island, pp 255–263

Nielsen LB (2004) Post disney experience paradigm? some implications for the development of content to mobile tourist services. In: Proceedings of the 6th international conference on electronic commerce (ICEC'04), ACM Press, Delft, The Netherlands, pp 657–666

Nonnecke B, Preece J (2000) Lurker demographics: counting the silent. In: Proceedings of the SIGCHI conference on human factors in computing systems (CHI'00). ACM Press, The Hague, The Netherlands, pp 73–80

Preece J, Maloney-Krichmar D (2003) Online communities: focusing on sociability and usability. In: Jacko JA, Sears A (eds) The human-computer interaction handbook, Lawrence Erlbaum Associates Inc., Mahwah, NJ, pp 596–620

Ricci F, Werthner H (2002) Case based querying for travel planning recommendation. Inform Technol Tourism 4(3):215–226

Schwabe G, Prestipino M (2005) How tourism communities can change travel information quality. In: Proceedings of the 13th European conference on information systems (ECIS'05), Regensburg, Germany

Smith GJ, Maher ML, Gero JS (2003) Designing 3d virtual worlds as a society of agents. In: Proceedings of the 10th international conference on computer aided architectural design futures (CAADFutures'03), Tainan Taiwan, pp 105–114

Swartout W, van Lent M (2003) Making a game of system design. Commun ACM 46(7):32–39

Tsang M, Fitzmaurice G, Kurtenbach G, Khan A (2003) Game-like navigation and responsiveness in non-game applications. Commun ACM 46(7):57–61

Wallace M (2005) The game is virtual—the profit is real. New York Times, May 29

Werthner H, Ricci F (2004) E-commerce and tourism. Commun ACM 47(12):101–105

Wooldridge M, Jennings NR, Kinny D (2000) The Gaia methodology for agent-oriented analysis and design. Auton Agent Multiag Syst 3(3):285–312

Wyckoff A, Colecchia A (1999) The economic and social impacts of electronic commerce: preliminary findings and research agenda. Organization for Economic Cooperation and Development (OECD)

Yee N (2006) The psychology of massively multi-user online role-playing games: emotional investment, motivations, relationship formation, and problematic usage. In: Schroeder R, Axelsson A (eds) Avatars at work and play: collaboration and interaction in shared virtual environments, vol 34 of it computer supported cooperative work, Springer, Berlin Heidelberg New York, pp 187–207

Yeung C, Tung PF, Yen J (1998) A multi-agent based tourism kiosk on internet. In: Proceedings of the 31st annual Hawaii international conference on system sciences (HICSS'98), IEEE Computer Society Press, Kohala Coast, HI, pp 452–461