# A SCENARIO-BASED AGENT SYSTEM FOR DIGITAL CITY INTERACTION

CHIUNG-HUI CHEN
*Department of Spatial Design*
*Kun Shan University of Technology, Tainan, Taiwan*
*7451616@ms94.url.com.tw*

HUI-TIN LIN, MAO-LIN CHIU
*Department of Architecture*
*National Cheng Kung University, Tainan, Taiwan*
*akilalin@pchome.com.tw, mc2p@mail.ncku.edu.tw*

**Abstract.** Urban design involves coordination and communication for collecting consensus among citizens and developing the design strategy and spatial program. While these are web-based systems for representing the real world actions, there is lack of human interaction for receiving feedbacks during the process. Therefore, the purpose of this study is to introduce the agents into the participatory design process (PDP) based on scenarios. This paper has developed a web-based system prototype to demonstrate how the agent can interact with users and how the interface facilitates incremental design. We present a participatory design project in an old street to illustrate how the Scenario-Based Agent System (SBAS) model functions in a real application. Meanwhile, four issues will be discussed in regarding with building a learning interaction agent as an actor.

## 1. Introduction

The emergence of the internet and information technologies clearly influences how people live and gradually extend their life and activities from the physical space to the cyberspace. It provides the opportunity to extend the transformation of the physical city into the digital city. Currently, most 3D digital cities are often created by a collection of huge spatial information to represent the real world and less concern about the interactions between the users and the created virtual world. Our previous studies (Lin and Chiu,

2003) found that a digital city is a social information infrastructure for urban life, while users or participants within the digital city are often foreign to the environment without navigational aids. Therefore, the creation of a digital city that can accommodate the social interactions between the users and the created virtual world becomes an essential issue.

Furthermore, agent-based computing started in the 1970s and recently has become important for internet applications. An agent is a computer program that is situated in some environment, and an agent is capable of autonomous action in the environment to meet its design objectives (Wooldridge, 2002). Therefore, the purpose of this paper is to build an agent-based system for PDP. The methodology undertaken in this research is as follows: (1) literature surveys and analysis, (2) implementation of an agent system, and (3) studies of user behaviours and interactions within the system to develop scenarios for a participatory design project. The demonstration and discussion are presented.

## 2. A Society of Agents

The agent typically interacts with other agents (Huhns and Stephens, 1999). An agent system considers issues related to agent communication and collaboration. The research area on multi-agent system usually conceives agents in human-like terms, a number of researchers have proposed to apply the multi-agent approach to the cognitive functions of intelligent behaviour (Minsky, 1988; Maes, 1994; Brooks, 1990). A virtual world as a society of agents provides the means for constructing flexible and dynamic worlds that adapt to user needs (Smith, Maher and Gero, 2003). Maher and Gero (2002) study a society of agents, in which a single agent is represented as a component of a virtual world with an existing infrastructure. Each person in the virtual environment is represented by a avatar agent, that is an three-dimensional animated character for navigation.

Our previous studies find that a scenario is developed as a script consisting of role, time, scenes, and event. A user can select an established scenario in the digital city, and change the scenes or time sequence of the scenario to make his personal experience. Meantime, cross-cultural communication is an advanced challenge for social interaction agent. For this reason, the role of agent in virtual environment is expected to support social interaction among users or participants. Therefore, this study adopts a scenario-based approach by the role-play model in which the particular behavior is called a role. The role agents system allows each participant (an user) participating in a scene under a set of tasks, Figure 1.

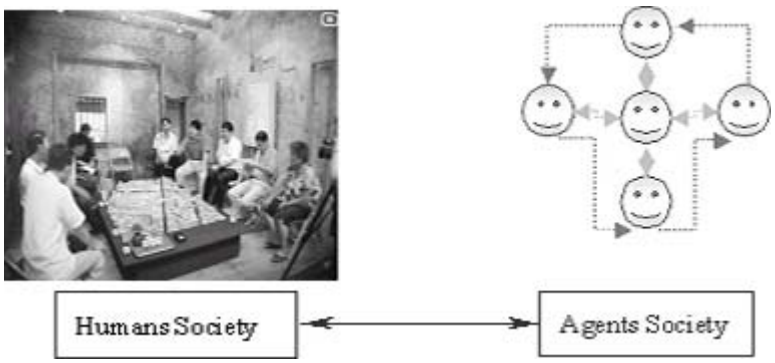


*Figure 1. Humans and Agents Society*

## 2.1. THE " SCENARIO-BASED " AGENTS

Scenarios can help to integrate the variety of experience and skills required in a design project by making it easier for different kinds of experts to communicate and collaborate. Scenarios include agents and actors. Every scenario involves at least one agent, one goal and has a story；they include sequences of actions, events and characteristic elements. Each scenario is described as state transitions, and state's semantic is depending on cues and actions.

Furthermore, based on the observation of human behaviors in an old street design project, scenarios are developed to define the relationship between people and places. Thus, two types of agents are proposed for the functional and social purposes：(1) the reactive agent: it re-acts to users' inquiries or pre-defined actions, such as provides city information or stories to supplement the rich visual environment of a digital city about its historical background; (2) the proactive agent：it pro-acts to undefined actions with scene-driven interaction derived from people to people and people to place activities. The interactions occurred by physical inhabitants and digital visitors will test the feasibility of scenario developed in the system. We have also proposed the Agent System which treats with Scenario-Based (SBAS) within 3D virtual place based.

## 2.2. WHY DO WE NEED THE PARTICIPATORY DESIGN

The built environment comprises not only physical forms - buildings, streets, and infrastructure；but also the humans acting on them. PDP is a common technique well established (Jensen, 1997) that allows the people who are actually going to be affected by a change in their place to have some input in the design process (Ehn et al., 1996; Harrison, 1996). In participatory design process, design concept is generated collectively through the interchange of

discussion and interactions. Traditional participatory design methods are seen as insufficient to fulfill an increasing demand for communication. The point of departure of the study is the assumption that new information technologies can satisfy this demand. Therefore, this research proposes a agent-system framework for PDP, using role-play model as the model of inter-communication described as a "conversation" with a situation comprising many interdependent members.

The design process is therefore a co-operation between the members of a group: the stakeholders，the developers，the planners，the inhabitants. The dynamics of the group members is determined by the social behaviours, such as positive and negative attitudes or the frequency of social interactions during the design decision process.

## 2.3. A PRE-CONCEPTUAL ARCHITECTURE OF THE AGENT SYSTEM

In order to clarify the relations between the problem domains in this research, we provide a conceptual architecture in terms of four perspectives：Agent-system, Users interface, Digital city model, and Scenario-Based model. The relations are shown in Figure 2.

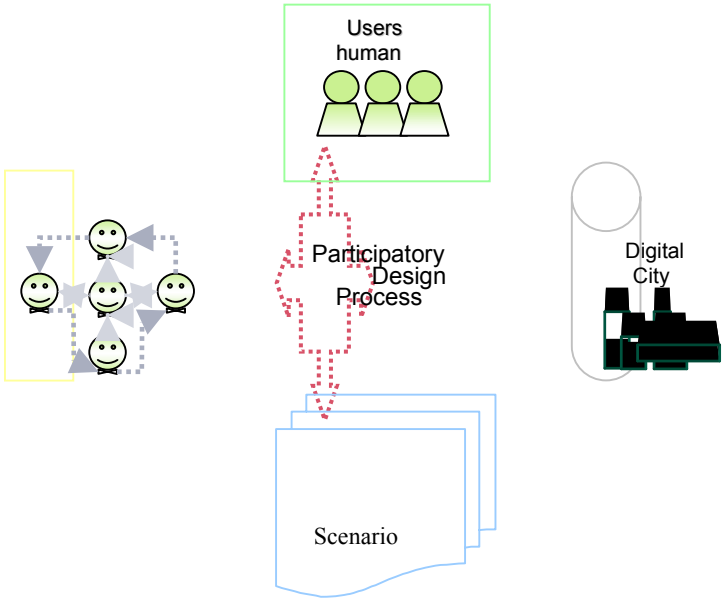


*Figure 2. A conceptual architecture of the agent system*

## 3. Experiment

In the current virtual environment, a human behavior is initiated by an event that a user performs on a specific object and the action is pre-determined by the type of events. In an agent-based virtual environment, a behavior may be triggered by any change in the data about the environment and the action is determined through the agent's ability to reason about itself in the environment and then modifying the environment. Therefore, in order to find out any differences that may be existed under the system examination section, we present a demonstrative project to illustrate how the scenario-based model functions in a real application.

### 3.1. PARTICIPATORY DESIGN PROJECT IN AN OLD STREET IN DIGITAL TAINAN CITY

In this study, the physical environment is referred to a project of demonstrating the development process, the physical environment is transformed to a virtual environment. At the beginning, we analyzed the physical configuration and the spatial requirement to build the 3D city model and then implemented it in an old street's lamp design, Figure 3.

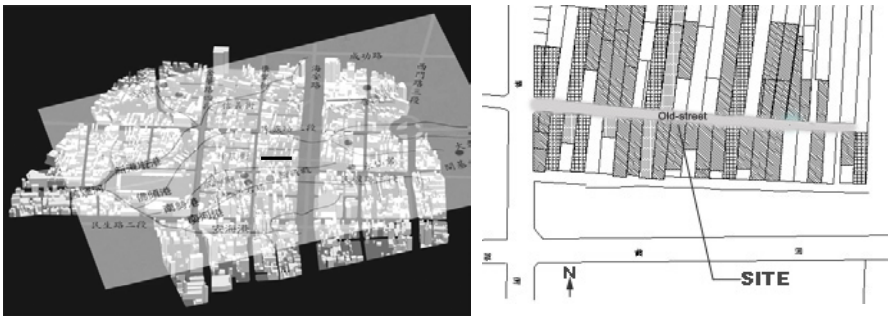


*Figure 3. Digital Tainan City and an old street design*

### 3.2. THE WORKSHOP INFRASTRUCTURE

The physical interaction is through the group meeting or discussion in physical environment. The group members (users) normally consist of planners, inhabitants, and developers. We construct the workshop developed as part of our project, and is located within the 3D-modeling environment and includes a meeting room. The system prototype and interface is implemented by Microsoft Agent and Flash MX, Figure 4. There exist four possible relationships between users and agents, i.e. one user to one agent,

many users to one agent, one user to many agents, and many users to many agents. We had observed and recorded various users' behaviors and interaction in physical environment. The observation will be the foundation for creating the workshop infrastructure. It is currently restricted to one user to one agent relationship and we are focusing on homogeneous agent type, i.e. agents perform similar actions or reactions.

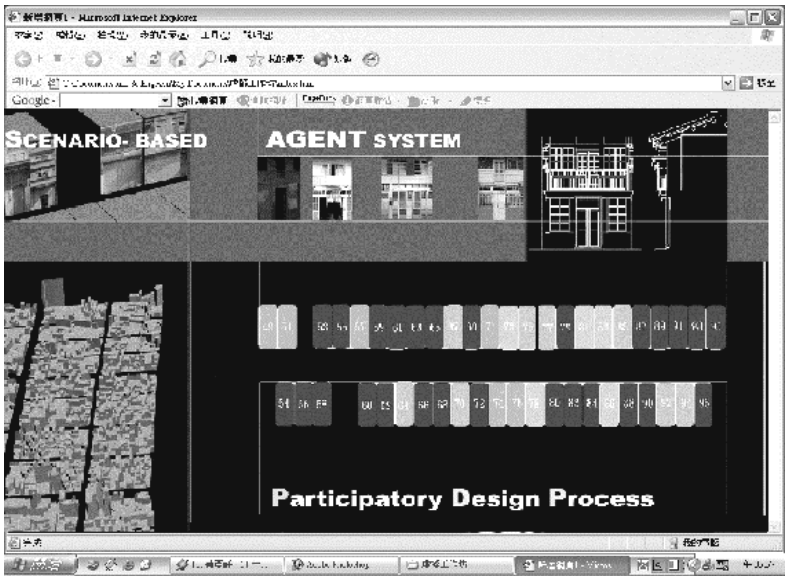


*Figure 4. The screenshot of the SBAS*

*3.2.1. Role-Play*

With agents identified and tentative behaviors described, the behavior can be explored by having people play the roles of the various agents. The primary responsibility of participants is role-play is to figure out the rules that should guide the behavior of the agent for which they are responsible. The structure of the social process among agents will emerge naturally from the interaction, and the internal rules need to be developed by the participants themselves.

In other words, role-play requires both identified sub-agent systems and several scripts of the desired system behavior. For example, role-play a system with homeostasis requires a list of the state variables that can independently change, the range of variation that they can expect, and the corresponding corrections needed in other variables. These scripts guide the role-play activities.

*3.2.2. The Agent Scenario*

We show an example construction of the Lamp-agent scenario in an old

street. The initial scenario is as follows.

At first execution, while the user walking along the old street, the agent may keep up with the user or get ahead of the user. When the distance between the agent and the user is more than some threshold, the agent say " follow me" into the current scenario.

After that, the user stops in front of a housing and says "What is that housing …about it's history?" The agent turns to another agent. If the user asks the agent of related design tasks, for instance, about the lamp design of the old street, and the Lamp-agent knows some contents, another rules will be added into the current scenario, Figure 5.

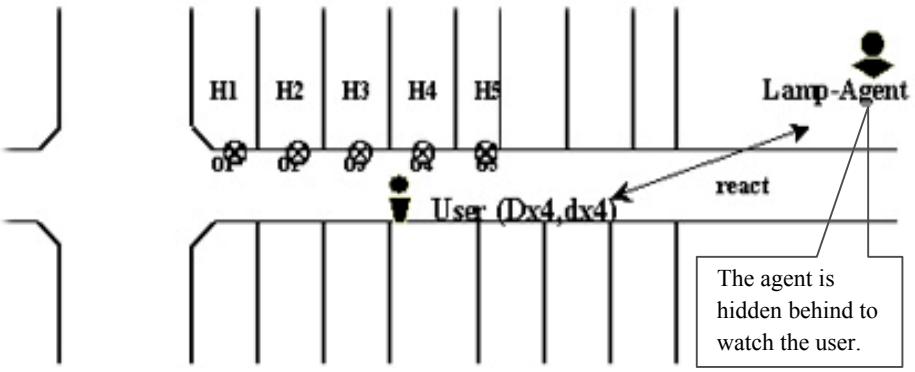


*Figure 5. Relationship among User and Lamp-Agent*

### 3.3. AGENT AND USER INTERACTION APPLIED

People communicate to share experiences, provide information, elicit responses, negotiate agreements and modify behaviours. Instructions from an important communication place that addresses physical or behavioral actions performed by or with other people. Instructions provide a rich environment in which people must understand and carry out meaningful actions. Naturally, those actions must be done in a physical context and may vary across people or situation. While we substitute humanlike characters in instruction interpretation, a suitable computational framework must be used transform language commands into agent actions.

To define agents and their roles in play, we develop scenarios. A scenario consists of some scenes. A scene is used for describing state transitions. For example, the Lamp-Agent and User mode： the agent's action is defined by states and based on the distance and location plot, the lamp-agent can communicate with the user or another agent. The "(Dxi , dxi)" is refer to user's Direction ; the "(Hi , Hj)" is refer to lamp's Location ; the " T " is

refer to lamp's Type ; the "C & M" is refer to one lamp and anothor lamp's distance ; and the " Ri " is refer to applied rule , see Table 1.

TABLE 1. An Agent's Movement

| Scene | State_1 (Dxi,dxi) | State_2 (Hi,Hj) | State_3 T | State_4 C & M | Applied Ri | Action |
|---|---|---|---|---|---|---|
| 1 | (Dx1,dx1) | Between(H1,H2) | Type1 | corner | R1 | watch |
| 2 | (Dx2,dx2) | Between(H2,H3) | Type1 | middle | R2 | watch |
| 3 | (Dx3,dx3) | Between(H3,H4) | Type2 | middle | R3 | watch |
| 4 | (Dx4,dx4) | Between(H4,H5) | Type2 | middle | R4 | watch |
| 5 | (Dx5,dx5) | Between(H5,H6) | Type1 | corner | R5 | watch |
| 6 | … | …….. | …… | ….. | … | … |

*3.3.1. State and Action-Script*

Scene scripts
symbol：*" **P** "*is refer to planners; *" **I** "* is refer to inhabitants; *" **D** "* is refer to developers; *" **A** "* is refer to agent ,and *" **SA** "* is refer to subagents.
function：if ( ***P , I , D*** ) *cue* ( ***A***.) then [ ***A*** ] *action* [ ***SA*** ]
An example of cue and action is as follows ：

Scene_1- if ( ***P*** ) *communicate with* [ ***A*** ]
Scene_2- then [ ***A*** ] *Asking* [ ***SA***_*Lamp-Agent* ]
goto Scene_3-1 [ ***SA***_*Lamp-Agent* R1. ]
Scene_3-2 [ ***SA***_*Lamp-Agent* R2. ]
Scene_3-n [ ***SA***_*Lamp-Agent* Rn..] go next-scene
Scene_4 [ ***SA***_*Lamp-Agent* ] *interact with* ( ***P*** )
Scene_5…..

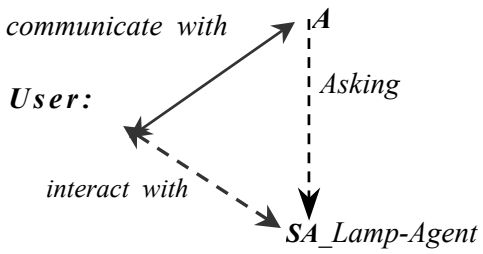


*Figure 6 . Interaction between Users and Agent*

## 4. Discussion

The study indicates the importance of people to people and people to place interactions in the transformation from the physical into the virtual environment. By observing human behaviours, the interaction in the virtual environment can be enhanced through agent. Based on the results of this study, some issues be discussed.

### 4.1. THE INTERACTION BETWEEN PEOPLE (USERS) AND AGENTS

Interactive indicates that the agents may be affected by other agents or perhaps by humans in pursuing their goals and executing their tasks. Interaction can take place indirectly through the environment in which they are embedded ( e.g., by observing one another or by carrying out an action that modifies environment state ) or directly through a shared language ( e.g., by providing information in which other agents are interested ).

Moreover , agent is not about specific methods, tools or process. However, Participatory Design is an dynamical process, it is about the recognition that all people have something to offer and that they, when given the actions to express themselves. Design process is participatory, people designing together. It can harness the collective and expanding set of ideas and opportunities that emerge when all the people who have a “stake” in the process are invited to “play the game ”.

This makes the deliverances of design more meaningful to the people who will ultimately benefit from them. Meantime, it emphasizes the direct and active participation of all “stakeholders” in the design development process. Thus, we can say that the interaction is an attitude about people and agent, and the relationship among people to people is contextual.

Anyhow, people’s needs change and their experiences change. Relationships between people change over time and place, as well. Interaction is not a linear process but a continual intersection of changing perspectives. It blends planners and the users with the applied social sciences and blends them both with new and emerging technologies.

### 4.2. AGENT-LEVEL AND GROUP-LEVEL STRUCTURE

Base on the study in which the agents “ do what they should do “ turns out to be particularly difficult in the system, and the elementary question faced is “when and how should which agents interact—cooperate and compete—to successfully meet their design objectives？ ”. Thus, we find that can follow the two types of routs to cope with this question；

(1) Top down：to search for specific group-level rules which are called conventions, norms that appropriately constrain the interaction repertoire at the level of the individual agents.

(2) Bottom up：to search for specific agent-level capabilities that result in appropriate interaction at the overall group level.

No matter which route is chosen, these characteristics are to enable the agents to interact appropriately. In other words, agent-level is individual and activity; group-level is societal, and their rules are related to each others is known as the simple-complex problem in sociology.

### 4.3. HOW AGENT CAN SUPPORT COMMUNICATION (SOCIAL PROCESS) FOR PDP

At the end of 1999, that there is a common ground, a new territory being formed by the reciprocal respect between planners and the social scientists. In participatory experiences, the roles of the planner and the researcher blur and the user becomes a critical component of the process. The new rules call for new tools. People want to express themselves and to participate directly and proactively in the design development process.

In this study process, we find humans interact in various ways and at many levels. For instance, they observe and model one another, they request and provide information, they negotiate and discuss, they develop shared views of their environment, they detect and resolve conflicts, and they form organization structures such as teams and committees.

Although, we are beginning to focus on "social process ", whose aim is to design users' experience of things, events and places. This influence on design can be attributed to a significant literature being written in the social sciences that has begun to acknowledge the role of emotions in human experience. But we can never really "design experience" experiencing is a constructive activity. That is, a user's experience (with communication) is constructed of two equal parts：

what the communicate brings to the interaction.

what the communicator provides.

Where the two parts overlap is where the actual communication occurs. Knowing about users' experiences, then, becomes vital to the process of create the communication among agents. If agents have access to both what is being communicated and what experiences are influencing the receipt of communication, then agents can design for support social process within PDP experiencing.

In other words, if agent can learn to access people's experiences ( past, current and potential ), and make inferences about what they do, then can make user experience the source of inspiration and ideation for design.

### 4.4. USER INTERFACE AND AGENT INTERFACE

Even though the results obtained with this first generation of agent is encouraging, many open questions for future research remain. Should there be one or many agents? What is the best metaphor for interface agents? How can the system of incentives be devised, so that users are motivated to share the knowledge their experienced agents have learned? Some of these are user interface issue. There are four main issues：

(1) we need to develop conversation interfaces. Developing general and natural language interfaces to support the decision making process of users. (2) users do not always give clear goals to the agents, the agents have to discover the users' goals and support them in making their goals clearer.

(3) to accomplish users uncertain goals using this system, the agents have to show related information to users and have views upon their reactions.

(4) there is a problem of how to filter the vast and unorganized information available on the www.

To construct the multi-agents system for PDP, we have to overcome all these problems, but we have to remember that PDP evolve continuously through interaction with users. We have to incrementally develop the agents while providing services to users.

## 5. Conclusion

The study indicates the potential uses of agent in the participatory design with a Scenario-Based Agent System (SBAS). In our study, each rule occurs between an agent and a user. However, in a group conversation, there are various kinds of interaction such as intervention or participation in other actors' conversation. To realize these kinds of tasks, each agent should have an ability of understanding complex context in a physical environment or a 3D virtual environment, multi-user techniques are required. This functionality will be one of the most important features of multi-agents in human community, while it is a challenging goal.

The first stage of our future work will apply a more complete scenario to further study the whole reasoning process of the agents. The second stage will extend and enrich the system beyond the limit of the users, to support the Participatory Design in virtual community and implementation of virtual environment in general. Thus, there are two main challenges:

(1) the agent social negotiation processes. In order to support the negotiation processes among users and agents, we will build a set of negotiation policy within participatory design process.

(2) the technologies developed through the scenario description to a group agents, and control the behaviors of multiple agents. Moreover, we

will run web services using Java programs. We have started using Microsoft Agent to create a character interface for users' queries in PDP. Users also can observe the process among the agents and join the conversation if necessary. In addition, to acquire a scenario from a specific example, an agent learning machine framework including automatically puts metadata tags to the database is also required.

The challenge ahead for the participatory design in virtual community is to create the theory with multiple agents infrastructure, interfaces and tools needed to support continued resonance with user experience.

## Acknowledgements

This project is supported by the Taiwan National Science Council, grant. NSC 92-2211-E-006-080.

## References

Caneparo, Luca and Matteo Robiglio, 2003, "UrbanLab: Agent-Based Simulation of Urban and Regional Dynamics", in Chiu et al. (eds.), *proceedings of the tenth International Conference of CAAD Futures 2003*, Kluwer, pp.279-290.

Carroll, J.M.:2000, *Making Use:Scenario-Based Design of Human-Computer Interaction*s, The MIT Press.

Champion, Erik, Dave, Bharat and Bishop Lan: 2003, *Interaction, Agents and Artefacts, Faculty of Architecture, Building and Planning*, The University of Melbourne.

Dijkstra J. and Timmermans H.: 1999, "Toward a Multi-agent System for Network Decision Analysis", *Proceedings of the fourth International Conference of CAADRIA 1999*, Shanghai, pp.372-382.

Hannes Hogni Vilhjalmsson: 1994-1997, Autonomous Communicative Behaviors in Avatars，B.Sc., Computer Science, University of Iceland, Reykjavik.

Huhns, M.N. and Stephen, L.S.: 1999, "Multiagent Systems and Society of Agents, in Weiss,G.(ed.), Multiagent Systems, A Modern Approach to Distributed Artificial Intelligence, MIT Press, MA, pp.79-120.

Ishida, T.: 2002, "Q:A Scenario Description Language for Interactive Agents", *IEEE Computer,Vol.35,No.11,pp.54-59*.

Jason I,Hong and James A.Landy: 2001, A Context/Communication Information Agent, Group for User Interface Research,Computer Science Division University of California,Berkeley,CA,USA.

Kalay, Y. and J. Marx: 2003, Changing the Metaphor: Cyberspace as a Place, in Chiu et al. (eds), *proceedings of CAAD Futures 2003*, p.19-28

Lin, H.T. and Chiu, M.L.: 2003, "From Urban Landscape to Information Landscape- Digital Tainan as an Example", *Automation in Construction 12*, pp.473-480.

Maher M.L. and Gero J.S.: 2002, "Agents Models of 3D Virtual Worlds", *ACADIA 2002*, Pomona, pp.127-137.

Marvin Minsky :1988, THE SOCIETY OF MIND, Touchstone Edition.

Nakanishi, H., Yoshida, C., Nishimura, T. and Ishida, T.: 1999, "Free Walk: A 3D Virtual Space for Casual Meetings", *IEEE Multimedia,Vol.6, No.2*, pp.20-28.

Saunders, R. and Gero J.: 2001, A curios design agent: A computational model of novelty-seeking behavior in design, in Gero, Chase, Rosenman (eds.), *Proceeding of CAADRIA 2001*, University of SYDNEY,pp.345-350.

Smith, Gregory J, Mary Lou Maher and John S Gero: 2003, Design 3D Virtual Worlds as a Society of Agents, *Proceedings of the tenth International Conference of CAAD Futures 2003*, Tainan, pp.105-114.

Van Veen, H. A. H. C., Distler, H. K., Braun, S. J. & Bülthoff, H. H.: 1998. "Navigating through a Virtual City: Using virtual reality technology to study human action and perception". *Future Generation Computer Systems,* 14, pp 231-242.

Wooldridge, M.: 2002, An Introduction to MultiAgent System, Chichester, England, John Wiley and Sons.