Introduction

The emergence of digital media and virtual reality technique clearly draws attention especially for changing the way we present architectural objects in cyberspace, and gradually affect our thought as well as activities in the physical environments (Chiu et al., 2000). Virtual environment or architecture that comprises designed virtual places that support a broad range of human activities has become the alternative for spatial creation and experience. The crucial question that the virtual continually poses on the real: How can the real expand itself? Previous attempts include the increase of immersion and interaction with the virtual environment enhanced by digital media and the creative content (Kalay, 2003). However, these attempts do not necessary to get more information or experience than the reality. On the contrary, the virtual environment often lacks of the sense of place and human-computer interaction. The purpose of this paper is therefore to explore the transformation from the physical to the virtual environment from a social and behavioral point of view, and the process is demonstrated by a museum exhibition project. This research had built both the physical and virtual environment, and studied the human behaviors and experiences from their presence at both environments. Furthermore,
interface agents are computer programs that employ Artificial Intelligence (AI) techniques to provide active assistance to a user with computer-based tasks (Wooldridge, 2002). The following sections will address the development process, the observations, the implementation of interface agent, and discussion based on the findings.

**Learning from the Physical Environment**

Spatial design in exhibition space is to create a scene to raise user involvement or participation. In the unique circumstance, the environment not only provides visual or acoustic performance but requires personal association and imagination. Ideally, "being there" reveals the personal spatial experience caused by their presence at places in a unique way (Chiu et al. 2004).

**Creating the physical environment**

In this study, the physical environment is referred to an exhibition project of demonstrating the life cycle of a historical building, the formal Tainan Governmental Buildings and now the National Museum of Taiwanese Literature, represented by photos, maps, illustrations, scale models, and building components. As illustrated in the development process in Figure 1, the design principle in the real environment is to define a continuous free-form without affecting existing configuration and provide a clear circulation for guiding people to understand the life cycle of the building and its historical background. Five exhibition themes or stories are used to illustrate the events about the building, i.e. search the origin and the architect, describe the life span, explore the renovation process and details, navigate the building, and appreciate other cultural heritages.

In the exhibition period (about 3 months), we had observed the interactions among the people-to-people and people-to-place, and use the findings to create a virtual exhibition gallery. In the following sections, the design and observation of both environments are explored.

**Observation in the physical environment**

At a physical place such as an exhibition gallery collecting all kinds of information in regarding with display objects or themes, an individual can relate himself to a particular scene or artifacts at the nearest location based on his familiarity or association. The physical presence of human being is both physically and psychologically situated. The distance between the observer and the artifact, the lighting, and the atmosphere are important to visual
quality of exhibition as well as human perception, Figure 2. Observers are the information processors to situate themselves to specific interests and react by movement, taking notes, discussion, or inquiries.

The findings reveal that different user profiles should be considered and there are needs to highlight specific interests in various information with appropriate instructions. The steering behavior in the exhibitive place can be categorized into individual and group behaviors, and tour with guide and self tour. Furthermore, human computer interaction requires a natural or intuitive approach to raise the sense of places. The social and psychological aspects also raise another dimension for exhibition design.

Creating Virtual Environment

What is a virtual environment? The definition and the role of virtual environments are continuously debated since the invention of the term. In this paper, a virtual environments (VE) is defined as "an environment is that which surroundings participants, the set of conditions and objects participants can perceive and interact with. It is also referred to the circumstances or conditions that surround one.

- Environment is referred to a series of status or events around people whom can perceive and interact with. It is also referred to the circumstances or conditions that surround one.
- Atmosphere is referred to an aesthetic quality or effect, especially a distinctive and pleasing one, associated with a particular place.
- Context means the correlated environments or states in which events occur.
- Orientation means placing oneself in relationship to point of the compass or a reference system (Cheng 1998).
- Navigation is the theory and practice of making one's way through space (Stuart 1996).
- Wayfinding is the act of using spatial perception and navigational awareness to reach a destination.

Therefore a virtual environment (VE) is designed for functioning as a three-dimensional interface to a repository of models, images and sounds for individual browsing or group interaction.

People are situated

In the virtual environment, we can represent it digitally by similar contents in the physical environment, and at the same time provide better interface to create atmosphere and new experi-
enence for users. The virtual does not refer to distinct elements, but rather to how they can be related. More importantly, function missed in the physical environment can be enhanced in the virtual world. Previous studies indicate the importance to situate people in constructing memories by spatial characteristics and atmosphere (Chiu et al., 2003, Lin and Chiu, 2002; Chiu et al., 2000). The studies also depict that the focus on the physical and the virtual ones can be different, while not all these behaviors can be transformed or compared with the virtual environment. Therefore, this study will take a different approach to design the virtual environment as a place of containing or recalling memories. This study is concentrating on the agent interface to facilitate the interaction.

Story-telling is one of the most popular approaches in exhibition design. Stories about events, people and places are collected and organized into narratives, while these are gradually transformed by a new logic of information technology. When the content is represented, human memories are recalled and augmented at the physical space due to the people-to-people and people-to-place interactions. It is important to enhance these interaction or experience in virtual environments through computer aids. The scenes provide the platform for evoking memories, while constructive memories are built with the atmosphere such as visual and sound effects.

**Agent Interfaces**

The agent-based research is initiated from the AI concept from 1990s (Maes, 1994). Agent-based systems have been applied to design in many aspects such as assist users to search information on the web or perform design tasks. Agents are rule-based entities, triggered by events, and run autonomously. Rules specify actions (create, move, talk, mail, etc.) to be taken by agents on entities (messages, hypertext links, etc.) when certain events occur. Because users can share objects, databases, or files, agents communicate through these shared entities to perform certain tasks and behaviors. If the people-to-people and people-to-place interaction can be initiated by agents, senses of places in the virtual environment will be enhanced.

Exhibitive objects can be considered as reflection of user minds or memories while they cannot react in the physical environment. If the user can "talk" to the exhibitive objects, then the agent behind the scene will be able to "respond" to the action or "answer" the question, Figure 3. Learning from the users is the best strategy to create agents. In the sensor-perception relationship, a visitor's position and his/her duration at certain locations are becoming useful for situation detection. Therefore, agents can react to provide better explanation of

![Figure 3](image.png)

*Figure 3*

*How agents react.*
the background information because the exhi-
bitive object cannot react itself. Furthermore, in the
group visit situation, a reactive agent can become a
proactive agent to extend the functions in addition
to story-telling.

**Curious Agent**

Curiosity is the motivation to discover new knowl-
dge when faced with an unfamiliar situation. It pro-
motes self-directed learning by rewarding behavior
that results in the assimilation of new knowledge.
Curiosity can be used to guide the search and ex-
ploration of unfamiliar design spaces to find new
knowledge with the goal of gaining a better under-
standing of a non-routine design task (Saunders and
Gero, 2001). For examples, we found that visitors are
curious about the spatial configuration of organizing
information, the unique way of representing history,
or unseen or wired objects. Curious search can be
used to guide problem solving to find interesting
design solutions. Curious exploration can be used
to guide problems finding to discover interesting
design problems. In this paper we concentrate on
the role of curiosity in the search for interesting
design solutions.

In this paper, two types of agents are proposed for
the functional and social purposes: (1) the reactive
agent: it "reacts" to users' inquiries or pre-de-
defined actions, such as provides building informa-
tion or stories to supplement the rich visual environ-
ment of a city about its historical background; (2) the
proactive agent: it „pro-acts“ to undefined actions
caused by curious objects with scene-driven inter-
action derived from people-to-people and people-
to-place activities. As shown in Figure 4, the agent
gradually learns how to better assist the user by: (1)
observing and imitating the user, (2) receiving posi-
tive and negative feedback from the user, (3) receiv-
ing explicit instructions from the user, and (4) asking
other agents for advice.

Based on the observation of human behaviors in the
physical exhibition project, scenarios are developed
to define the relationship between people and plac-
es. Thus, the interactions may be occurred among
virtual or physical visitors. Furthermore, most
VEs are implemented on the basis of simulative
interactions that all situation-reaction relationships
are pre-defined and the reactions are pre-set.
Clearly, not all situations in the real environment can
be easily pre-defined as games. Although all setting
can be the same in the real and virtual environments,
intuitive interaction can be natural and helpful to the
visitors in the virtual environment.

**Implementation**

If we consider cyberspace as a place, then design-
ers have to change the metaphor of the virtual
environment (Kalay, 2003). The following steps are
undertaken to implement the virtual exhibitive envi-
ronment, Figure 5:

1. define spatial organization and orientation
2. create scenes in 3D models for accommodating
   exhibition objects
3. define scenarios and roles
4. add metaphors – shapes, symbols, color, signs
   and sound effects
5. create agent interfaces and enable situation
   detection

Based on previous findings, the spatial configura-
tion of virtual environment is changed for easy
orientation and identification. Because the reactions
in the physical environment are recorded, therefore
simulative interaction at each scene can be recalled in the virtual environment. Two scenarios are provided for user, i.e. guided tour and self explorative tour. Each scenario consists of a set of rules in defining the role, time, activities, and location. Reactive agent will be present in the guided tour, while proactive agent will be shown in self tour.

The system prototype and interface is implemented by Director MX to examine the feasibility of scenarios. Then a revised version is built by Java and Microsoft agent system interface. If routine rules cannot be applied to the virtual environment, then a curious agents will show up to initiate social interactions. For example, the scene (a virtual gallery) is the representation of the physical environment with metaphors, Figure 6. An artifact agent or wall agent will respond to certain situations by detecting user position or duration at certain "hot" zone or points. When finishing the tour, agents can assist the direction or jump to another galleries.

**Discussion**

Currently, VEs as a medium for creating synthetic or interactive experiences are still in their infancy. It is important to enhance users' spatial awareness, and consequently facilitate the task of navigation and wayfinding within VEs. It is also necessary to study social and behavioral aspects of making place in VEs. We are concerned about what the physical place cannot express as well as what virtual places can add the values by observing the visitors in

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**Figure 5**
A virtual environment layout.

**Figure 6**
Virtual gallery and agent interface.
both environments. Basic findings include: (1) the contents, (2) the user behaviors, and (3) the agent interfaces. The findings from the above study raise the questions for further discussion.

**What are interesting to users**

It is clear that the contents are the foci of an exhibition, and consequently the selection and presentation of right content are important. While digital media can increase interactivity and represent the display objects in an interesting manner, the audience prefers the personal narrator than computer animation. Story-telling by experts or a person having previous experience can provide the most persuasive way to guide the users to understand the essence of exhibition. Therefore, agent's roles become critical in the virtual environment. Ideally, the smart agents are both curious and sensitive to user behaviors, and can assist the demonstration of an exhibition. Meanwhile, visitors may raise their curiosity by unique spatial settings, and consequently their interests as well as involvement in the virtual environment.

**What can users perceive from the virtual environment**

In virtual gallery, spatial organization with metaphors provides useful guidance for orientation. Without the physical restriction, virtual environments can be abstract as well as simple in contrast to the real environment. The metaphors of signs for directions such as opening, theme remarks, lights, and background sounds, can be more intuitive to the visitors. It is found that users or observers can perceive more than the representation of display objects and the surrounding environment but also the interaction from the others. By converting the physical into the virtual environment, we must carefully consider the scenarios or scripts developed for guiding users and enhancing their experience in both the mental and physical spaces. „Being there“ is involved with design issues, design style and user interfaces in respond to the content of information, spatial conditions and user interaction. The observation from the physical environment can add another dimension of information to the virtual exhibition. The dynamics of social interactions make the creation of virtual environments more meaningful to the creators and users.

**What can An Agent Do**

Agent Interfaces radically change the style of human-computer interaction. The user delegates a range of tasks to personalized agents that can act on the user's behalf. We have modeled an interface agent after the metaphor of a personal assistant. While a reactive agent can initiate "inquiries-and-answers" based on routine rules, while a proactive agent can initiate more unexpected interactions. Meanwhile, the society of agents should consist of various agent types or heterogeneous agents. However, the relationships of heterogeneous agents are more complex and unable to perform. Currently, we are focusing on homogeneous agent type, i.e. agents perform similar reactions or actions. The agent's action is defined by states/events. Therefore, rules can be applied to certain states and consequently action can be applied.

In terms of creating the agent environment, many of the languages proposed for describing agent behavior and inter-agent protocols are based on agent internal mechanisms (Smith, Maher, Gero, 2003). For further implementation, we chose a script language for describing interaction between agents and users based on agent external roles (Ishida, 2002). It does not depend on agent internal mechanisms; its goal is to describe how scenario writers should be able to request agents to behave. Even though the results obtained with this study of agents are encouraging, many open questions for future research remain. Some of these are user interface issues: Should agents use facial expressions and other means of personification? What is the best metaphor for interface agents? Other questions are more algorithmic and technical: How can heterogeneous agents built by different developers and using
different techniques?

**Conclusion**

Architecture is created as a place based on the needs or program through meaningful spatial definition and arrangement. Similarly, in virtual architectural design, designers define the content, characteristics and conditions of spaces based on needs. The study demonstrates the potential approach of presenting user experience in a museum exhibition project. The study indicates the importance of using places as metaphors and observing people-to-people and people-to-place interactions in the transformation from the physical environment into the virtual one. Visitors or users are physically and psychologically situated, and therefore can perceive the sense of places caused by a sensor-perception relationship. To perform recommendation or story-telling capability by a reactive agent can initiate social interactions. Furthermore, proactive curious agents can enhance the human computer interactions in VEs. The creation of creative spatial experience as well as intelligent agents based on context awareness will be a potential direction for future VE development. However, it requires in-depth studies to define the appropriateness of individual and group behaviors in VEs.

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**References**


