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VisTA : An Interactive Visualization Tool for Archaeological Data

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Abstract

We have developed the VisTA system which is an interactive visualization and simulation tool for archaeological and geographical data. The goal of the system is to support archaeologist's work in the formation and discovering of knowledge about the evolution of ancient villages. Specifically, the system permits visualization of ancient villages using 3D Computer Graphics and simulates formation of the village over time, letting users set the lifespan of each house and evaluate the settings. VisTA also allows users to walk through the village, greatly assisting archaeologists studying the village spatial and geographical layout.

1   Introduction

In Japan, unexplored areas have started to be used in new land developments. Before the land development starts, the area is excavated by archaeologists. Due to development, the number of excavations has been increasing and currently stands at more than 10,000 per year in the whole country. Most of the sites are destroyed after the excavations and covered by the new land development. Therefore, archaeologists cans not see the original landscape at the site. This is an unfortunate situation, since the main archaeological research is performed at this post-excavation stage and landscape is often one of the most important aspects of the research. Archaeologists are required to imagine the original landscape from the topographic maps they made during the excavation. This requires a very high level of skill.

Currently, GIS's have witnessed of applicability in many areas such as science and business. Similarly GIS's have been exploited in archaeological application [1, 5, 8, 10]. These applications mainly aim at relatively wide area investigation, for example, the distribution of ancient villages in one region. Using these GIS applications, archaeologists can study the relation among historical sites even after the sites are destroyed.

However, in many cases a close analysis on one site is also required and hence there is a strong demand for Intra-site GIS[9]. Intra-site GIS is considered to be useful for studying basic features of a site, including the arrangement of houses, religious buildings, and tombs, and the distribution of pits used for warehouses of food, material for tools, etc.

Hence we have developed the VisTA system as a part of an interactive knowledge discovery system for archaeological data called VisuArch [7]. VisTA assist visualization of the evolution of an ancient village letting users interactively set and modify the lifespan of each house in the village and allowing them to walk through the village.

The expected users are non-experts as well as experts since VisTA (and of course VisuArch) is being developed as an application of a project called the Meta-Museum [4] which is being carried out in our research laboratory.

Meta-Museum is a framework for knowledge sharing between museum staff (experts) and visitors (non-experts) via "communication" with each other in real, *not virtual*, museum space. In the Meta-Museum context, the VisTA system supports the archaeologist's work in the formation and discovering of knowledge about the evolution of ancient villages, and allows visitors to visualize the discovered knowledge of the village formation process.

The VisTA system uses 3D Computer Graphic techniques and a very simple and intuitive graphical interface. The user can set and interactively real time visualize how the the village formation process occurred, interpret the related evolution pattern and, if s/he deems necessary, adjust some data values and iteratively repeat these steps until they are satisfied with the formation process. Using this "what if" process in real time, the user can consolidate the discovered knowledge. The user can also check for and resolve potential conflicts with previously believed knowledge.

In our experiments, the excavation site of Otsuka [11] is selected for archaeological data. This site belongs to the Yayoi era. This era provides an interesting case of study since during this time the social and spatial organization of the Japanese villages evolved to cities. It is the opinion of the archaeologiststhat visualizing the evolution of the village in this era would be very helpful in their research.

The rest of this report is organized as follows. In section 2, the VisTA system is introduced in the context of the VisuArch system. Section 3 provides an overview of the VisTA system. In section 4, the process of excavated site reconstruction is discussed, followed by conclusions in Section 5.

2 VisTA in VisuArch

As mentioned in Section 1, VisTA is a part of the VisuArch system which is a system to discover new knowledge interactively from archaeological databases. This section provides a brief overview of the VisuArch system.

With the VisuArch system, the user can get new knowledge from databases following these steps:

1. First the user selects the data and then extracts patterns.

2. Based on the patterns, these user hypothesizes the relation among the data and evaluates the hypotheses.

3. Finally, the user gets new knowledge if the result of the evaluation step is new and meaningful for the user.

This process can be seen as a Knowledge Discovering in Database (KDD) process [2].

The KDD process often involves significant iteration cycles and may contain loops between any steps in the process. In the VisTA project, the efforts are originally focused on covering hypothesis evaluation and knowledge consolidation [3]. The VisuArch system spans from the low level preprocessing of excavation data to the new knowledge discovery process.

Initially, the goal of the system, the prior knowledge and the application domain are specified explicitly to the VisuArch system, to support the archaeologists work on discovering village evolution/development patterns. Our initial data are based on the data obtained from the excavation. Eventually, the new knowledge has to be incorporated in a shared space where the communication process between experts and visitor is going to be performed, since VisuArch is incorporated into the Meta-Museum project.

From the raw data of the excavated site, a useful set of data is selected and used as a basis for a data mining process. The selection, preprocessing and transformation of the data consists of considering the location of the pits obtained from the excavation site and finding a feasible constructive *related* set of pits [1]. Each set of pits composes a potential floor mark for one building. At this point, the floor mark data and the site terrain specifications are incorporated in the VisTA system. This process is translating the floor marks of the buildings and the land contours into a 3D model that create the virtual world. The data selection is currently performed manually, but research is underway to automate it. This work is explained in detail in section 4.

The process performed over the site data using the VisTA system's role in the VisuArch system is to implement the iterative and interactive part of the KDD process. In this process he archaeologist plays an evolution pattern of the village and then interprets and evaluates it, and if desired, readjust some variable and then replays all or part of the evolution process for reconsideration.

Once that the archaeologist agrees with a conclusion pattern, it becomes new knowledge, and it is incorporated in the Meta-Museum knowledge space. The visitors to the Meta-Museum may then enter into the archaeologists' space and visualize the knowledge discovered by the experts. Also copies of this knowledge may be altered by visitors or Meta-Museum guides in order to further understand the significance of the site.

3 VisTA system

3.1 Overview of VisTA

The first step the user does with VisTA is select a site database from the ones that are currently available. The user creates a personalized copy of the database, provides the duration of the simulation process and then interacts with. To visualize the evolution of the village the user starts the simulation. The user may manipulate the simulation in progress. The simulation controls are shown in Figure 1 (top left window). These controls allow the user to Play, Pause, Stop, Go forward and backward in the simulation time. The user may add buildings to the simulation process. This is done by selecting one of the marks in the land, pushing the "Add" button (Figure 1, top left window) and setting the life span and other related parameters of the building. The other main activity is users engage in editing the data related to existing buildings using the "Edit Building" window, illustrated in Figure 1 (bottom right window).

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[1] Pits is a term used by archaeologists to refer to human made holes in the ground. This holes could be used to store food or to settle columns.

Figure 1: A view of most of the application's windows

To simulate the development process of the village, we create a simulation engine based on events. Two different kinds of events are considered, "BUILD" and "DECAY" a building. The occurrence time of each event is obtained by the life span that the user assigns to each building. These existence values are transformed into real time visualization values. Then, a sorted list of events is assembled, and a simulation clock is initiated to travel over the list to trigger events. This scheme provides a simple mechanism to allow pausing and changing the current time in the simulation.

To support navigation in the village, as well as to provide a better understanding of the dimensions of the sites and the buildings, we introduce the presence of a human model that resemble the user in the site. The user can use this model as a reference point in the virtual site.

The graphical user interface is composed of four different windows in agreement with [7]. Two windows are used to interact and explore within the environment and visualize the simulation called the "Viewer" windows, and the other two windows control the application's functions and are called the "Control" windows. This section explains both viewers and control windows. A view of most of the windows is shown in Figure 1.

3.2 Control Windows

There are two windows used to control the functionality of the application; the "Console" wich handles files, as well as controling the look and feel of the of the application and some miscellaneous options, and the "Simulation Control Panel" to handle the actions that affect the simulation process by itself.

3.2.1 The Console Window

The "Console" window (Figure 1, long narrow window on the left) has four sections and one "Quit" button. The first section relates with the managing of "Files". The second one controls the display of the "Aux Viewer", the third one controls the "Track Human" functionality, and the fourth one controls the "Stereo Vision".

The "Track Human" functionality allows the camera[1] used by the "Aux Viewer" to follow the model of the human as it is moved in the scene, as discussed in section 3.3.

The "Stereo Vision" functionality consists of setting the "Walk Viewer" to display in 3D. It makes use of the Silicon Graphics "Crystal Eyes" system.

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[1]Cameras are the objects provided by OpenInventor to the viewers to obtain the image of the scene.

3.2.2 Simulation Control Panel Window

The "Simulation Control Panel" (Fig. 1, top left window) has three sections. The first section manages the "playing" of the simulation process. The second one displays the actual time state of the simulation, as well as allowing the user to set the preferences. The third one lets the user to manipulate the buildings' data (add and edit).

The "Play", "Pause" and "Stop" buttons are very intuitive. The "Forward" button advances the clock of the simulation to the next event time. The "Backward" button moves the simulation clock backwards to the previous event time. Both "jumps" in time update the village state to the correspondent time value.

The second section of the "Simulation Control Panel" contains a slider that indicates the current time value of the simulation clock. This provides the information of when in time the village is being visualized. By looking at this slider the user can situate himself in time, as well as feel the time elapsing during the simulation.

The third section of the "Simulation Control Panel" contains two buttons, "Add" and "Edit", which invokes routines to handle the data of the buildings.

Before add a new building, the user must choose one floor marks on the land where the building is going to be built. The specification of values related with the building is made through the "New Building" window. These parameters are "Name", "Life Span" and "Kind of Building". The "Edit Building" window (Figure 1, bottom right window) is very similar to the "New Building" window. The additional feature is the "delete" button, that allows the user to delete a building.

There are three different ways to select which building is going to be edited. Two of them make use of the "List of Buildings". The other one requires that the user previously select a building from the scene. The list may contain all the existing buildings, or can be restricted to show only the buildings related with a specific floor mark. Figure 1 shows a tipical edit action in the VisTA system.

3.3 Viewers

The paradigm for the viewers used in the system is a "walk-through" of an architectural model. Its primary behavior is going forward, backward, and turning left or right. It is also possible to stop and look around at the scene. The interface between the user and the virtual world is made using two different viewers. The first viewer, called the "Walk Viewer" (Figure 1, center window), is the perspective seen from the human model and as such is the "user's view point". The second viewer, called the "Aux Viewer" (Figure 1, top right window) provides a bird's eye view of the scene. The user can control all aspects of the views including the X, Y, Z axis position, azimuth and pan.

Figure 2 shows a typical example of the two views a user might use. Note that in the "Aux Viewer" (top right window) the human model is seen. This helps the user know where they are in the scene and how big the house is. In the "Walk Viewer" the user is looking at details of the house close-up.

4 Reconstructing the site

The site of Otsuka [11], at north of Kanagawa, Japan, is selected as an experimental site to be used in VisuArch system. This site is selected since most of the data preprocessing has been done. This is the floor marks already been provided by the archaeologists. Moreover, this site belongs to the Yayoi era, which is a critical time for Japanese villages evaluation and thus is very interesting for archaeologists. This site is a typical example village of this era, being surrounded by a ditch which is about 2 meters deep that was used to build a barrier of about 1.5 meters high. Archaeologists conjecture that in this period the Japanese villages changed and began to form cities. It is anticipated that by using VisuArch and VisTA archaeologists will hypothesize many new theories about the development of Japanese cities.

4.1 3D models

There are 4 groups of models: the models of the buildings, the models of the floor marks, the model of the land and the model of the human.
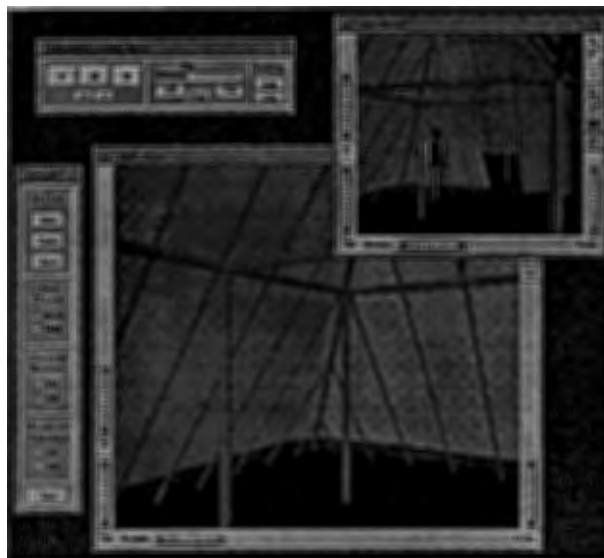
Figure 2: A view inside one building

In this version, two different kind of buildings are included. The "Kirizuma" and the "En-kei". These models correspond to archaeologist's hypotheses on how the architecture of the building was. First the structure of the building is modeled using geometric shapes, creating the columns, beams, and the wall supports. Next, the structure is covered with a surface that resembles the walls of the houses.

Each kind of building needs of its own kind of floor mark. For this reason, two different floor models are incorporated. The "Kirizuma Vestige" and the "En-kei Vestige" . These models are constructed as a small protrusion of land, in the same shape as the building's base. The dimension of the protrusion dictates the dimension of the building model so that it is automatically scaled properly.

The land model consists of the terrain of the site, the sky and bedrock that encloses the simulated world. The terrain model is made following the plan provided by archaeologists (Figure 3, top left). The sky and bedrock are rectangular objects that are independent of the archaeological data that place the site in a big box.

To construct the terrain surface, the contour curves from the site data were used as guidelines (Figure 3, top right). Once in the 3D modeling tool each curve is translated on the Y axis following the same scale provided in the blueprint. A "skin surface" operation is applied over the contour curves in order to get a surface that resembles the real terrain (Figure 3, bottom left).

The model of the human is very simple. Several cubes are resized and translated to make the head and body while different materials for each box provides the idea that the human is dressed. This model also has provided hair so that the user can recognize easily where the model is facing.

4.2   Transforming the data

Once the data of the floor marks is obtained, it must be transformed to use in VisTA. Each floor mark must be specified relative to a fixed reference point. A list with unique 3 dimensional transformation vector of each vestige is required. The transformation vector includes scale, rotation and translation, using a common reference point. This process is based on the ideas proposed in [6].

The transformation data is used as input to an external process which creates the model of the site for VisTA (shown Figure 3, bottom right). At this point, the reconstruction process is finished and the database of the site is available for the archaeologists to use.
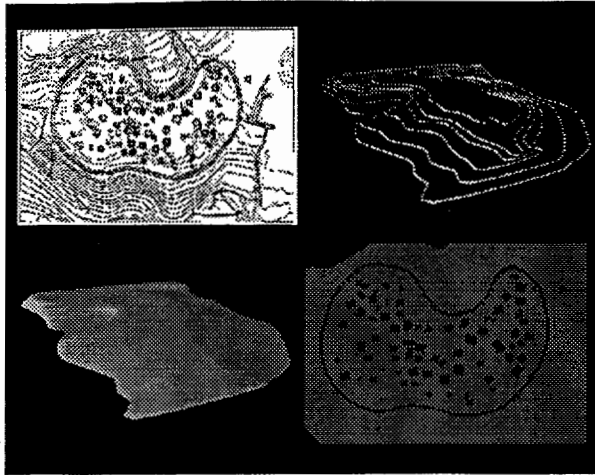
Figure 3: Land model

5   Conclusion

We have briefly described the VisTA system as one of the sub-projects and testbed of the Meta-Museum project. The VisTA system provides the means needed to interactively visualize a simulation of the development of ancient villages, based on archaeological and geographical data obtained from the excavations.

This tool supports archaeologists in the formulation and evaluation of hypotheses about the formation process of ancient villages. Using 3D computer graphics and village evolution simulation the user can iterate over the hypothesis development process and perceive the village evolution in novel ways. The users can interact with the system and adjust parameters on-the-fly following "what if" investigation.

In the case of the Otsuka site, the excavation site has already been covered by land development. The data of this site was obtained 30 years ago. By using VisTA archaeologists can today continue the research about this site exploring new dimensions of knowledge using this novel tool.

We are planning to have experts (archaeologists) and non-expert (visitors) users test the system. The VisTA system will be exhibited in this fall in a museum in Osaka, Japan.

In addition to analyzing the effectiveness of VisTA, we hope to observe how the communication process between experts and non-experts is going to be facilitated using a shared knowledge space. Also, by incorporating new features such as a comprehensive environment and CAD terrain representation in the archaeologist's tool box, new frontiers of research should be opened allowing discovery of knowledge.

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