# LAND FORMING WHILE YOU ARE ON SITE

RUEI-WEN TSAI
*Graduate Institute of Architecture, National Chiao Tung University, Hisnchu, Taiwan, R.O.C.*
*totoro@arch.nctu.edu.tw*

AND

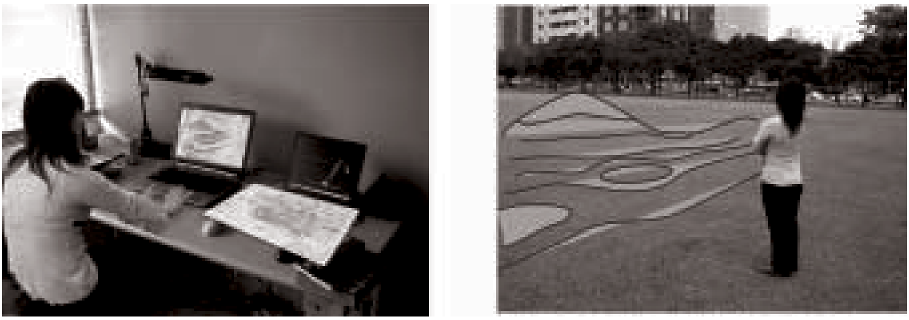
TENG-WEN CHANG
*Graduate School of Computational Design, Natural Yunlin University of Science & Technology*
*Douliou, Taiwan, R.O.C.*
*tengwen@yuntech.edu.tw*

**Abstract.** In landscape architecture design, land forming is the key to trigger many design concepts. However, the design media we currently use doesn't provide suitable data or better visual feedback to designers when they are on site. In this paper, we develop a framework as well as a ubiquitous device called MODA comprised of five components. These are sensors, representation, display/viewing, motion and control that result from behaviours observation and analysis. According to the framework, a practical example of landform design is conducted and examined with one version of MODA combining both hardware and software.

## 1. Introduction

Land forming plays a key role that triggers many design decisions in the landscape architecture design process. In addition, the land-forming process often occurs during the early design stage and the consequence will go along through the whole design process. For example, for getting site information, a large portion of landscape architecture depends on the representation of particular media, such as maps, aerial photos and topographic charts. Although information gained from such media might just be suitable for the need of doing design in the office, the media itself is the problem. Being totally dependent on such represented media will prevent us from physically going to the site which should be the essential part of landscape architecture design. Furthermore, according to Lynch, designers might lose the opportunity to carry out implicit information of the site when they have only a virtual and past experience (Lynch and Hack, 1984).

While only working in the office virtually, we not only lose the opportunity to carry out the information of the site, but also lose the physical experience with the site itself. Two main behaviours when designers are designing on the site are (i) looking around the site and feeling some concepts of design; (ii) writing down or sketching anything which merged, or keeping it in mind and back to office to continue the design process (Figure 1).



(a) (b)

*Figure 1.* *(a)* The designers often design land forming at the studio with abstract media. *(b)* To design on the site is more dynamic than at office.

Regardless whether the ideas are captured on papers or in memory, the design media we currently used doesn't provide enough or better information that designers encounter on site. The stimulation has to be interrupted and the design recontinued when they are at office. Moreover, the information gained is analog but needs to be transmitted digitally for further design steps. This faces another information losts. Most important, this loses the main spirit of landscape architecture design: location. It may have something we can do on site in addition to think about design and work from there.

Our approach is simple: creating an interactive device for the land forming design problem that can help to catch the ideas on the site. This device assists designers in collecting the site information, and modifying the design result. The methodology applied in this paper is divided two main parts: analysis and implementation.

Analysis means to analyze and observe the interactive behaviours of designers while they are on site. With the analyzed results, we develop a location-based system for testifying the computability as well as the exploration of design media. The interactive behaviours as well as location-based approach is still a new approach compared to other design research paradigms such as problem solving. Thus, each component as well its mechanism needs some explorative approach such as generate-and-test. Further details will be described in the corresponding session.

## 2. Visual Thinking in Landscape Design

Landscape design often focuses on the quality of visualization. (Honjo and Lim 2001) had presented a VRML system with terrain, plant and architecture data to simulate and design. They tried planning or designing for landscape architecture with virtual simulation. On the other hand, Yuda et al. (2004) developed the "Plug-in" design method to help designers to determine the design concepts in a real stadium planning project.

With landscape visualization thinking, the landform or terrain is the basic layer of most landscape designs (Ervin, 2001). For digital landscape model, Geographic Information Systems (GIS) and CAD systems provide different dimensions of information in aiding design. While GIS can create maps of landscape with suitability and visibility, CAD system can thus provide 3D rendering of alignment geometry and evaluation of cut-and-full volumes (Ervin, 2001). However, these researches are still adapting the traditional design methodology.

With modern technology, there must be some difference and significance for using digital media. For example, GIS can be useful in identifying the location in both virtual and physical sites. Inserting the geometry features like point, line, and region, GIS can further visualize the spatial information. In addition, NURBS surfaces can be created smoothly based on the information gained by GIS; these surfaces can then be modified easily by some controlling-points. Therefore, only combining both GIS and CAD for representing the digital landform model is not enough for our scope. By applying the combined information structure in the early design stage such as landform, design will gain more strength for capturing the design ideas.

## 3. Interaction with Physical Site

Another group of researchers discovered and recorded the location-based information with digital works. Augmented reality (AR) approach provides the opportunity of interaction between virtual and physical sites (Azuma et al., 2001) . The AR system proposed contains three properties:

- Combines physical and virtual objects in a mixed reality
- Runs interactively and synchronously
- Registers (aligns) physical and virtual objects with each others.

Recent studies have presented the applicability of AR in terms of diverse problems. For example, the Archeoguide project (Hildebrand et al., 1999) presents a new system that will provide multimedia and new media information according to user's location and interaction with this new system in a ruin space. In addition, Feiner et al. introduced an application that combines mobile computing with GPS position system to present place information (Feiner et al., 1997). Piekarski et al. (2003) thus present a more complex system that can work both indoor and outdoor with their developed AR location-based applications. The key to these researches is that they are finding suitable solutions for digitalizing the land or space information without human interference. Furthermore, the “Augurscope” project (Benford, et al., 2003; Schnadelbach et al., 2002) presents an interactive framework for outdoor activities. In their project (augurscope), they use the handheld display device instead of the head-mounted display (HMD) used by other AR studies frequently.

## 4. Behaviour Analysis

For understanding the behaviours of land forming design process on site, we survey and analyze the interactive behaviours that should be used during the design process. The analysis of these behaviours can be translated for computerizing with digital media.

In land forming design on site, there are several steps that designers commonly use while they are designing the landform of the site. While viewing the process of changing landform as a design process, a common practical design process metaphor called seeing-moving-seeing (Schön and Wiggins 1992) is applied for modelling our behaviours. The steps are:

- Walking around the site
- Choosing a suitable place where designer can overlook the site
- Finding some features of the site for defining the characters and zoning the site
- Thinking design concepts
- Recording the design concepts
- Evolving the design concepts by visualizing the design with site
- Completing the design process or
- Going back to recent stages until the design concept is chosen.

These stages of behaviours show that it is important to be on site while the concepts are evolved. Another interesting observation is that while walking around on site, design concepts are generated in memory and expressed with certain gestures naturally. For example, we might point at certain features and walk there. If we want to fill-up one spot, we might raise our hand like picking something up; on the other hand, we will put down our hand at the spot where we want to cut.

However, as information through gestures is insufficient, vocal expression is often needed for assisting the design concepts. For example, we might speak out a compendious numbers to describe how deep or high want to we design. This additional support can help designers to handle the concepts more sensibly. These are all perceptive behaviours during the landform design process. These gestures can be used as the input methods for our system.

In this research, we focus on those behaviours and gestures which contrast with the functions of 3D Computer Graphics (3DCG) software that is often used to model the virtual space. Designers can operate the 3DCG software to represent the design concepts and the scene of landform design. Furthermore, the gestures and vocal expression produced by designers is a most intuitive way to express the design concepts.

There should be certain relations between the functions of 3DCG software and the gestures/vocal expression of human behaviours. For example, when we arrive the site, we will search or look over the site. Then we should move to various points of viewing on the site that can be used to zoom-in, zoom-out and rotate functions to view the virtual model in 3DCG software. We can also translate the mouse-selected control point feature to simulate the behaviour motions for land forming of designers. Following the results from the land forming design process, we can get the main behaviours as seeing, walking, walking, gestures, vocal expression and thinking. After all, thinking is a way of describing feedback. The other behaviours can further match the functions of 3DCG software as shown in Figure 2.

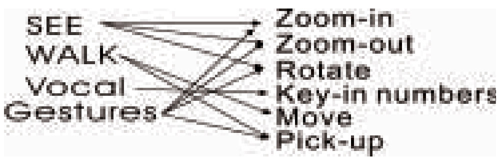



*Figure 2. Comparison of behaviours and 3DCG functions.*

## 5. Framework and Implementation

For testing the analyzed results, we propose a computational framework and implement it using AR approach. The features of implementation should contain collecting the data of the site, recording and visualizing the concepts, and displaying the landform result for reviewing and modifying purposes. Finally, the designers should be able to use the result made on site to develop their design work further without interrupting the exploration process by translating data between different media. Therefore, the interactive design behaviours might be achieved by using our system. And the question: “What can the designers do while they are on site more than now?” might well be answered. According to our main idea, the requirements of our device development for framework are:

- Reducing the difficulty in operating device
- Translating the commands and gestures which designers/users represented in thinking design and displayed in the device

- Calculating the model and displaying it on screen, designers/users can review the design result and modify it until finalizing the design
- The land form model can be modified by users on site
- Saving the result and transmitting the result to other device or continuing design work from the stored results.

## 5.1. FRAMEWORK COMPONENTS

Based on the foregoing analysis, we developed a design supporting system called *Mixed reality On site Design Assistance* (MODA). The framework is comprised of 5 components: gesture and vocal recognizer, landform representation, display/viewing of landform representation, display/viewing of landform representation, Motion component and Control component. The framework of MODA is showed in Figure 3. Each component is described as follows.

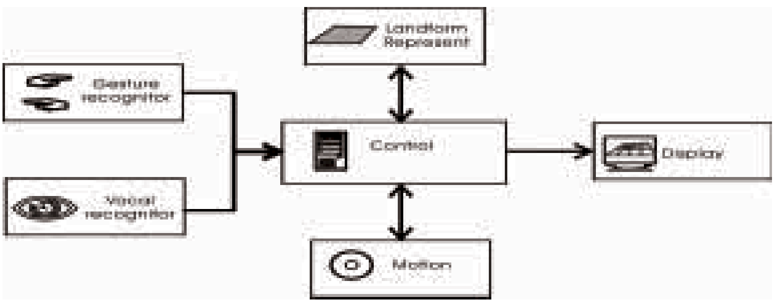



*Figure 3. Framework of MODA.*

*5.1.1. Gesture and vocal recognizer*: According to the result from analysis of functions, recognizing the gesture plays an important role. By using sensors, this component is concerning only with browsing the model and picking the control points to change the z value with keying-in the numbers. The gesture recognizer should be sensitive to motions and identify the colour to capture the designers' hand gestures and body movement to start the other functions of this device.

*5.1.2. Landform representation*: This component in our device is to represent the 3D landform of our design results. With this representation, the system can apply the modification commands triggered by other input components, and save the final result with files. Most 3DCG software, namely MAYA and 3D MAX, supply those required functions.

*5.1.3. Display/viewing component of landform representation*: While most of AR system is using HMD as their display system, in our approach, we used a large display screen to represent the data of the site for land forming design. Not only is it easier to read the display information on screen, but also more comfortable than using HMD on the head in outdoor for a long duration of use.

*5.1.4. Motion component*: For following the designers wherever they go, the device must have motion component include wheels and servos. The motion component should easily control the speed and direction to move around the site. And it can give feedback to the parameters to control component that can calculate the distance, angle to rotate to get the position of the site.

*5.1.5. Control component*: This component is the main part of our system. This component should supply a user interface to set the functions and synthesize the data input and output to related components, include the data of the site input/ output from the device and connect to other system/devices by network (LAN, wireless).

## 5.2. SYSTEM ARCHITECTURE DESIGN

For realizing the framework described above, the implementation adapted is a complex ubiquitous device for landform design on site which contains several sensors such as voices and gestures as the input for recognizer components. Regarding hardware support, we used the ER1 bundles to comprehend required components. The implementation of MODA is shown in Figure 4.

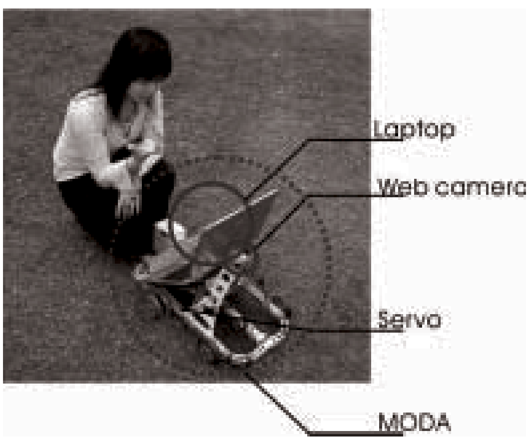



*Figure 4. Hardware components of MODA.*

In the main hardware component (Figure 5), the laptop acts as a brain for MODA. It compared with control component, landform representation component and display/viewing component. In addition, this laptop has a microphone and speaker to supply the multimedia requirement. The equipment satisfies for running the ER1 control software and 3DCG software. The 3DCG component used in current MODA implementation is MAYA. This laptop connects to Internet with wireless connection.

Additionally, the webcam acts as the visual sensor of MODA.

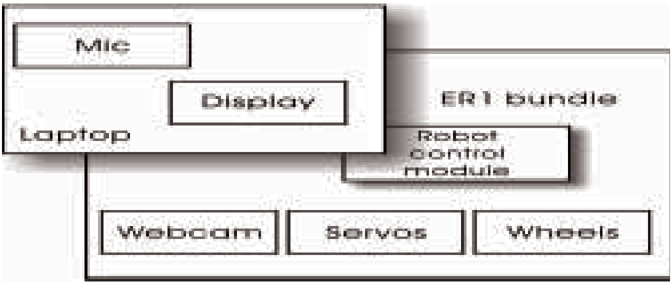



*Figure 5. Hardware system of MODA.*

Furthermore, about the software, the MODA system, we used the API for ER1 to build a Mata-program to connect the ER1 and 3DCG software within the MODA framework. The main implementation approach is to write scripts through the ER1-APIs in Java that can control ER1 directly. In addition, a programming component called *MODA bridge* is written for listening the event of input device like mouse and keyboard. Furthermore, MODA bridge can also connect with gesture/vocal recognizer. 3DCG software then are using the source from the input of ER1 and representing the landform on the screen. Therefore, users shall browse or modify the model created by MODA.

The process for running MODA is: (i) we run 3DCG software and open the model of the site; (ii) MODA bridge prepares to listen the events from the gestures and vocal component; (iii) MODA bridge sends the socket to inform ER1 that it is ready to listen the event; (iv) when the event occurs, MODA bridge translates the sockets to the brain, and keeps on listening; (v) with the design process, the landform model is changed according to the commands translated from the sensors; (vi) the landform models are modified and awaited for further modification; (vii) save the result and exit the program. The software architecture of MODA is shown in Figure 6.

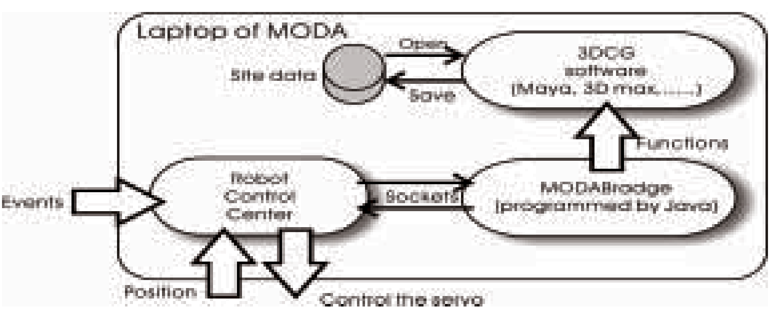



*Figure 6. Software system of MODA.*

## 6. An Example

The example we selected is a landscape design using MODA. This site is a flat plane covered by grass located at central NCTU campus (Figure 7). The southern part of current plane is higher than the northern part by about 2 metres. The current landform is not interesting and purely for passing, and surrounding by the boring flat factory elevation. However, since this site has massive traffic, the purpose of this design is to create a dynamic landform to create an interactive pleasure during the dry landscape around. We set some features like trees or sculptures as a datum point to help designer to identify the scene of direction.

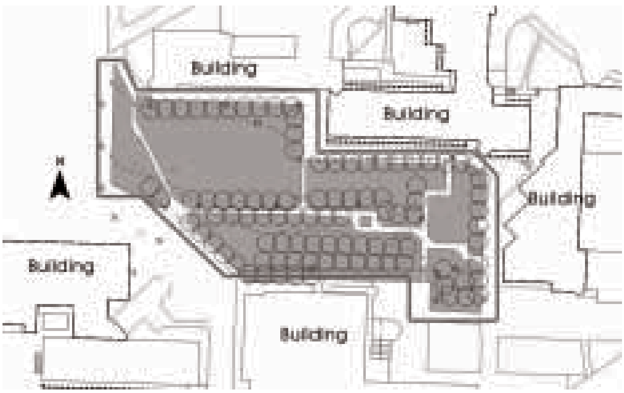



*Figure 7*. The original site plan of the testing project.

This project is used by a landscape architectural design (Amy). The behaviours she conducted by using MODA in this landform design process are documented as follows Figure 9:

- Amy arrives on the site with her MODA device. First, she stands at a corner of the site, thinking about the concept and starts the MODA.
- After 10 minutes, she walks on the site slowly so that MODA can follow her. Now she stops and overlooks the site to uncover which part of site should be changed according to what she has inmind.
- It seems that Amy has found the point and moves there right away. Later she feels that the speed of walking is too fast for MODA follow, Amy slows down and waits for the MODA.
- When MODA stops by her side, Amy turns left, raises her hand and says “up 1.5m”.
- Amy walks forward a few metres, than pulls down her hand and says “down 0.5m”.
- After half an hour, Amy had designed several points the site. She stops the

MODA, watches the model displayed on the screen. She browses the model carefully, use zoom-in, zoom-out. In addition to synchronizing with the view of eyes and MODA, Amy must rotate the model to datum the display for checking the design concepts (Figure 8).

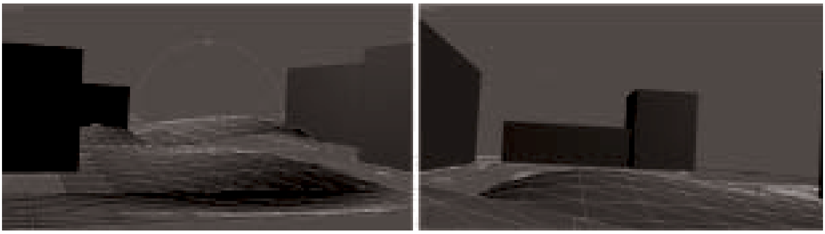


*Figure 8.* Two abstract landform alternatives produced by the testing project.

- She finds that some modifications are rquired. Taking MODA, Amy re-designs the place.
- To pass through 2 hours, Amy completes her design work. She save the file in MODA, and sends a backup file by e-mail.

*Figure 9.* Landform design with MODA.

## 7. Conclusion and future work

In this research, we have observed and analyzed the design behaviours while designing on site. We further match the behaviours with the commands of 3DCG software through a ubiquitous computerization device. As a landscape architect, this is a new design experience. As the outcome suggested, new design media should provide the chance to help designers interact with environment wherever design concepts emerged. By using natural gestures and human intuitive input to collect information about site, we can avoid the gap of computing skill and concept imagination on landform design. Meanwhile, the designers can gain the visual feedback of landform right on the spot and modify it according to this location.Most important, it avoids the loss of design concepts by data translation and helps designers to keep the spirit of space.

In the future work we will combine MODA with GPS technology that will provide more accurare location information. In addition, the mobility of MODA can be achieved by applying more robotic technology to conquer the problem of uneven site that is common in landscape architecture.

## References

"ER1 personal robot system." Evolution Robotics, www.evolution.com

Azuma, R., Baillot, Y., Behringer, R., Feiner, S, Julier, S & Macintyre, B. 2001, Resent Advances in Augmented Reailty, *IEEE Computer Graphics and Appilcations*, vol. 21, no. 6, pp. 34–47.

Benford, S., Schnadelbach, H., Koleva, B., Gaver, B., Schmidt, A., Boucher, A., Steed, A., Anastasi, R., Greenhalgh, C., Rodden, Y. & Gellersen, H. 2003, Sensible, Sensable and Desirable: a Framework for Designing Physical Interfaces, *Technical Report Equator-03-003*.

Ervin, S.M. 2001, Digital Landscape Modelling and Visualization: A Research Agenda, *Landscape and Urban Planning*, vol. 54, no. 1–4, pp. 49–62.

Feiner, S., MacIntyre, B., Hollerer, T. & Webster, A. 1997, A Touring Machine: prototyping 3D Mobile Augmented Reality Systems for Exploring the Urban Environment, *in*, *ISWC'97, International Symposium on Wearable Computers*, pp. 74–81.

Hildebrand, A., Dahne, P., Seibert, F., Christou, I.T., Demiris, A., Diorinos, M., Ioannidis, N., Almeida, L., Diogo, A. & Weidenhausen, J. 1999, "Archeoguide: An Augmented Reality Based System for Personalized Tours in Cultural Heritage Sites."

Honjo, T. & Lim, E.M. 2001, Visualization of Landscape by VRML System, *Landscape and Urban Planning*, vol. 55, pp. 175–183.

Lynch, K. & Hack, G. 1984, *Site Planning*, 3rd, MIT press.

Piekarski, W., Avery, B., Thomas, B.H. & Malbezin, P. 2003, Hybird Indoor and Outdoor Tracking for Mobile 3D Mixed Reality, *in*, *ISMAR, International Symposium on Mixed and Augmented Reality*, Tokyo, Japan.

Schnadelbach, H., Koleva, B., Flintham, M., Fraser, M., Izadi, S., Chandler, P., Foster, M., Benford, S., Greenhalgh, C. & Rodden, T. 2002, The Augurscope: A Mixed Reality Interface for Outdoors, *in*, *ACM Conference on Human Factors in Computing Systems (CHI 2002)*, Minnesota, USA, pp. 9–16.

Schön, D.A. & Wiggins, G. 1992, Kinds of Seeing and Their Structures in Designing., *Design Studies*, vol. 13, pp. 135–156.

Yuda, Y., Yeo, W., Oh, S., Kaga, A., Sasada, T. & Sato, R. 2004, "Plug-in" Method as Used in the Initial Study Stage, *in*, *CAADRIA 2004(Computer-Aided Architectural Design Research in Asia 2004)*, Korea, pp. 535–543.