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Application of 3D terrain representation system for highway landscape design

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The current methods of highway alignment planning and construction include the use of 2D topographic maps and the planners' creativity and experience of interpreting images and other information. A highway planner has to mentally reconstruct a 3D topographic image from 2D maps using his/her experiences and intuition. Therefore, the accuracy of such images depends on the planner's ability and experience. To solve this problem, believing that a tangible interface will help solve the above-mentioned problems, the authors have been working on the construction of a tangible terrain representation system (TTRS) for highway design. This paper introduces the mechanism of the TTRS, its application to highway design, and the construction of an improved version of the TTRS for landscape design.

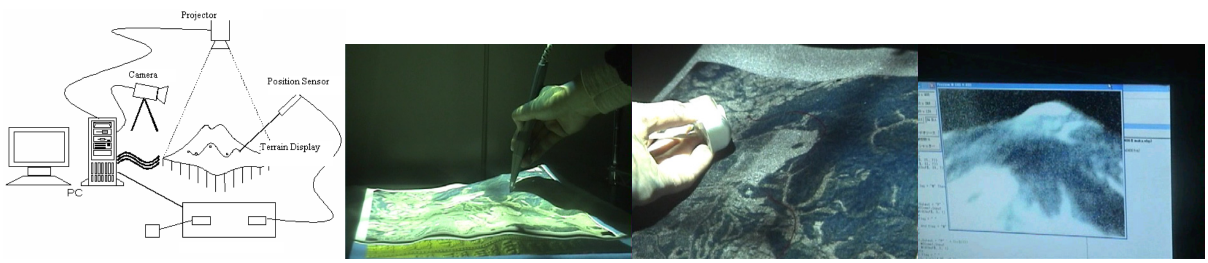
Virtual reality (VR) is a technology that enables a person to experience a realistic virtual world defined on the computer. The technology uses an interface that makes an effective use of stereoscopic visualization. This is made possible by the use of two human eyes in order to visually enhance the degree of reality. In recent years, research efforts associated with mixed reality, which aims to integrate virtual space and real space, have also been developed. One of these efforts is the research and development of a tangible interface. The MIT Media Laboratory, for example, has developed a system called "Illuminated Clay," which projects information onto a terrain surface created with clay (Piper *et al.*, 2002).

We have been working to develop terrain representation methods making use of VR technology and to construct design support systems using these methods. From these researches, we have identified the following problems of terrain representation and design support system:

-Difficulty in comprehending the relative positions of the terrain surface and the object of interest
-Need for a special stereoscopic visualization device
-Limited field of view
-Not usable for group work

Some of these problems can be solved by using large-scale display systems such as a CAVE system. They have no field of view limitation and can support more intuitive positioning and group working. However, these systems require the users to wear a stereoscopic device and are thus expensive. Believing that the introduction of a tangible interface will help to solve these problems, we have been working on the construction of a tangible terrain representation system. The system represents a terrain surface by controlling the shape of a stretchable screen used for representing the terrain surface by means of 64 actuators (8 × 8) and projecting an aerial photograph onto the screen. The size of the screen is 60 cm × 60 cm, and the moving range of each actuator is approximately 250 mm(Makanae and Dawood, 2009).

Although the screen size of the TTRS is 60 cm2, its portability is limited. To improve the portability, we are constructing an improved model of the TTRS that can be used on a desktop. The new TTRS has a 24.5-cm2 screen that is manipulated by the small type of actuators. The stroke of this actuator is 60 mm, and the weight is 60 g. It is expected that portability will be improved. The configuration of the new TTRS system is shown in Figure 1. The basic system is the same as the first prototype of the TTRS. The 3D magnetic tracking system Polhemus Fastrak is used as a positioning device. The system has a small CMOS camera device that can output live-view images on the surface. In Figure 2, an example of the image of the live-view system is shown. By using this system, a highway designer can acquire landscape images from the point on the terrain.



(a) Configuration (b) Drawing (c) CMOS camera (d) Live-view

Figure 1: Desktop TTRS

To evaluate the prototype of the desktop TTRS, a small experiment is performed. The experiment is to draw a highway on the TTRS and answer the questionnaire. In the experimental evaluation, the ability of drawing a highway is low although a high score is shown for operability and relief recognition. This result implies that the TTRS with a live-view camera is a very useful tool for the recognition of the terrain and the landscape. This is an advantage of the new TTRS as compared to the previous TTRS and the current design method. The subject of this system is to improve the drawing system using a magnetic positioning sensor, which has some problems related to stable positioning, and to improve the projection system to resolve the shadowing problem by hand during the positioning process.

This paper describes terrain representation methods and their application that should assist planners with imagining the terrain feature and therefore plan highway routes more effectively and efficiently. Further, the new version of the TTRS, which has a 24.5–cm^2 screen is shown and evaluated in this study. The new system has a CMOS camera using which a planner can acquire landscape images as if he/she were present on the terrain. Tangible technologies have been developed in the recent several years, and these technologies help the recognition of complicated 3D features such as the terrain considered in this study. Further research and development is required to develop more advanced systems for highway designing using these technologies.

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