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Illuminating Clay:
A Tangible Interface with potential GRASS applications

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1 Introduction

The development of cheaper and faster computation and the multiplying effect of open source initiatives such as GRASS have led to an increasing sophistication is GIS landscape analysis algorithms. However, little research has focused on the design of the computer interface through which users interact with GIS simulations. The conventional interface comprising of screen, keyboard and mouse is used by default and as such has an enormous impact on the process of computational landscape analysis. This paper introduces *Illuminating Clay*, an alternative interface for manipulating and navigating landscape representations that has been designed according to the specific needs of the landscape analyst.

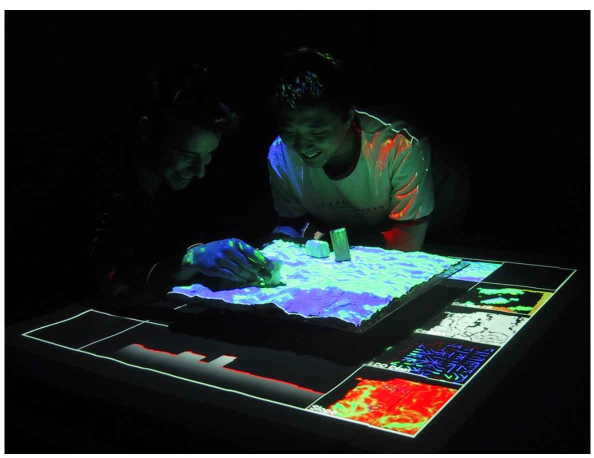

Figure 1: *Illuminating Clay* in use by two landscape analysts.

2 Scenario

A geo-science professor and his student sit around a physical clay model of a landscape that is illuminated by computer projection. The projection displays the direction of water flow in different regions of the model. As the professor flattens the crest of a hill the student observes how the drain direction changes within the model. The student wishes to explore the likely velocity of the water in the same region and so requests the computer to project the slope value onto the model. Based on the projected colour map the student gains an intuitive sense of slope and likely water velocity.

3 Illuminating Clay

The scenario described above demonstrates the role *Illuminating Clay* can play in allowing a more intuitive undestanding of GIS analysis techniques. Users of the system interact directly with a clay model of the landscape and observe the effects of geometric changes on standard GIS functions.

The system was recently developed with in the *Tangible Media Group* at the *MIT Media Lab*. The approach was inspired by the pioneering work of other research within the computer interface design comunity. Frazer's *Universal Construction System* [1], Hinkley's *Neurosurgical Interface* [2] and Underkoffler's *Urban Planning Workbench* [3] also take the approach of using physical objects to provide an means of interfacing with digital information. This approach can be broadly classified under the category *Tangible User Interfaces* (TUIs) as described in [4] as an alternative paradigm to the *Graphical User Interface* (GUI) which is broadly used today in the conventional computer interface.

Illuminating Clay uses a sensing technology to capture the surface geometry of a physical landscape model. This geometry is translated into a two-dimensional matrix of elevation values in the manner of a Digital Elevation Model (DEM). The set of values in the DEM is processed by one of a libarary of landscape analysis functions. The results of the function are projected back onto the surface of the model using a color map. The sensing technology and projection are callibrated to allow a direct correspondance between the recorded elvation points on the model and the projected outcome of the analysis functions [1].

Sensing Technology

The first implementation of *Illuminating Clay* was built using a Minolta *Vivid 900*[2] laser scanner. This scanner is used to capture approximatly 40,000 elevation points from the surface of the clay model. This scanning process is repeated continusly and takes a little under one second. The laser scanner provides a high degree of accuracy and allows any material, whether clay, paper, wooden blocks or sand to be used as a medium to represent the landscape [6]. A major drawback to this system is cost. At around €45,000 it is unlikely that in the system can be reproduced outside of a research context in the near future.

The second implementation uses infrared light to capture the surface geometry of a landscape model. A sand[3] box is lit from underneath with a powerful source of infrared light. A monochrome infrared camera mounted above the model records the intensity of light passing through the model. Where the sand has less depth – in the valleys - more light passes through. Where the sand has more depth – in the hills – less light passes through. From the image of the backlight sand model it is possible to determine the surface geometry of the model. While this system[4] costs less than €500 to reproduce it is somewhat limited by preventing the use of materials other than sand to represent the landscape. This method is also less accurate than the laser scanner implementation.

[1] For an indepth description see [5].
[2] http://www.minolta.com
[3] Specialized glass beads of 0.5mm diameter.
[4] Curently on display at the Ars Electronic Center, Linz, Austria until Sept., 2003.

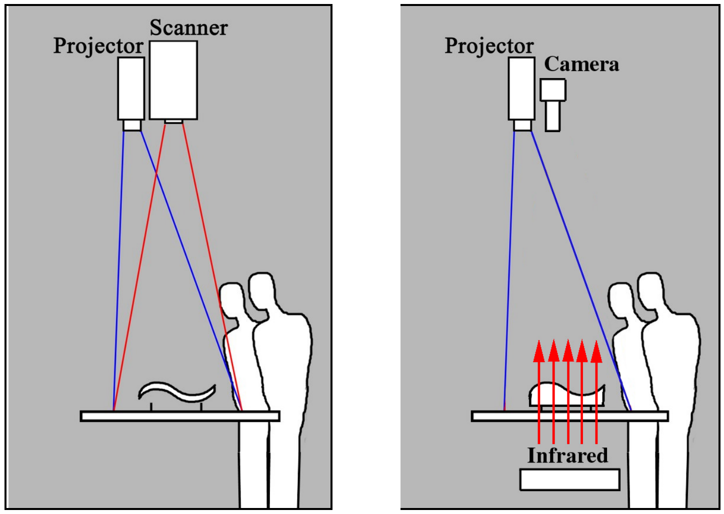

Figure 2: Alternative sensing technologies;
Laser scanner (left), infrared and camera (right).

A library of analysis functions are displayed as thumbnails around the edges of the central model. When a user clicks on one of these thumbnails it is displayed at full size on the surface of the model. A 3D viewing window also allows users to view the landscape and analysis functions from any point within the model.

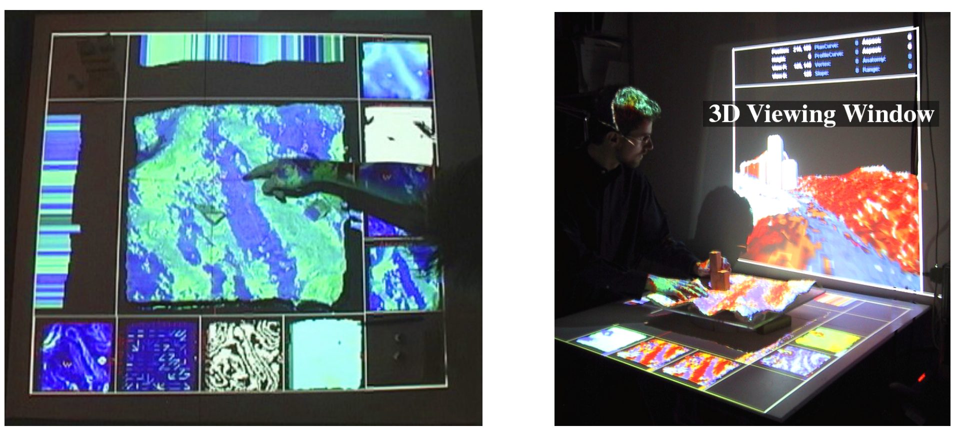

Figure 3: *Illuminating Clay* from above (left), 3D viewing window (right).

A Combined Intuitive and Quantitative Interface

This interface has the advantage over the conventional screen, keyboard and mouse in providing users with both intuitive and quantitative understanding of the landscape. Users can quickly construct physical models of the terrain[5] and understand spatial relationships with greater ease than navigating a graphically reresented landscape model. In addition the projected analsys functions allow the physical model to be understood in highly quantitaive terms, providing a means to query any point on the physical model for numeric properties such as elevation or slope value.

[5] To understand how this can be achieved with some accuracy please see [5] and [6].

4 The Potential Use of GRASS Applications

We have currently implemented a range of standard GIS functions shown in the table below. While these analysis functions have proved useful in the context of a landscape design workshop[6], this simple library does not allow for an understanding of more complex factors in the landscape such as water erosion, pollution, vegetation and human population to mention but a few.

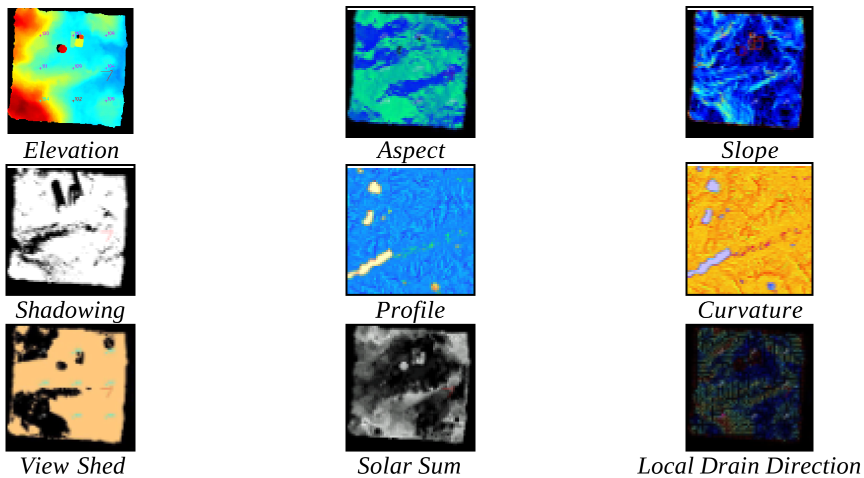

Figure 4: Analysis functions currently implemented in *Illuminating Clay*[7].

We feel that our system could provide a very useful platform for the development of new and more sophisticated analysis functions since it is based around the standard DEM structure. The fact that it allows for instantaneous modifications of the landscape and corresponding DEM model means that it is highly suited for testing such new software developments. In addition having been built in a C++ environment the platform is highly compatible with the existing GRASS software.

Our aim in building *Illuminating Clay* was not only to provide an intuitive platform for GIS analysis to be utilised by students, academics and professionals but also to provide a platform with which GIS software engineers could trail and experiment with their own software and for this reason we would like to invite members of the GRASS community to collaborate in improving the current system.

Figure 5: *Illuminating Clay* in use in a landscape design workshop.

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[6] Conducted at the MIT *Department of Urban Studies and Planning*, spring 2002.
[7] Many of these functions are adapted from [7].

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