"SandScape" is a tactile interface that utilizes various different computer simulations to facilitate the understanding of the origination of topographical landscapes. The projected landscape can be modified interactively through the manipulation of a real sand model. The results are analyzed and generated via computer in the simulation and projected back in real time onto the sand surface. This project is part of a series of research undertakings to come up with new computer interfaces—"tangible user interfaces." It takes advantage of our natural understanding of physical forms in order to make it easier to work with computer models and do digital simulations.

"SandScape" is a tangible interface for designing and understanding the landscape through a variety of computational simulations. Users view these simulations as they are projected on the surface of a sand model that represents the terrain. The users can choose from a variety of different simulations that highlight either the height, slope, contours, shadows, drainage or aspect of the landscape model.

The users can alter the form of the landscape model by manipulating sand while seeing the resultant effects of computational analysis generated and projected on the surface of the sand in-real time. This project demonstrates an alternative form of computer interface (a Tangible User Interface) that takes advantage of our natural ability to understand and manipulate physical forms while harnessing the power of computational simulation.

The system works by capturing the surface geometry of the sand model. The model is lit from underneath with a powerful source of infra-red (invisible) light. A monochrome infra-red camera mounted above the model records the intensity of light passing through the model. From the image of the sand model captured by the infra-red camera it is possible to determine the surface geometry of the model. This image is then used as the input to a variety of image analyses functions that are used to calculate the height, slope, contours, shadows, drainage and aspect of the model. This analysis is projected back onto the surface of the sand.

History of origins

"SandScape" was developed in the summer of 2002 in the Tangible Media Group at the MIT Media Lab. It was based on the approach of a number of previous research projects including the "Urban Planning Workbench", "CADcast", and most significantly "Illuminating Clay".

The "Urban Planning Workbench" (Underkoffler and Ishii, published CHI 99) took a similar approach in using physical objects as the primary means of interacting with computational simulations of the urban landscape. However, this approach was limited by not allowing changes in the form of physical objects to be detected by the system.

The concept of "CADcast" was developed (Piper and Ishii, 01, unpublished) in order to allow changes in physical form to be detected but it was not until a laser scanner was used in "Illuminating Clay" (Piper, Ratti and Ishii, published CHI 02) that this approach led to a working interface.

"Illuminating Clay" allows the physical geometry of any form to be captured for the...
interfaces around more qualitative criteria by reinvesting the richness of the physical quality of daily practice. "SandScape" is a step towards the goal of designing computer While this has brought many quantifiable riches to society it has reduced the experiential allow portions of society to exist merely through the manipulation of information. through and manipulate the physical world is being superseded by technologies that which humans biologically evolved. The role of the body in allowing people to move workforce operates in an environment that is in complete contrast to the environment in increased efficiency and production in the short term, over a longer period it is clear that back lit infra-red was developed for "SandScape".

Concept

The aim of "SandScape" is to combine the power of computational simulation with the tangible immediacy of physical models. "SandScape" integrates many of the advantages of physical and digital representation.

The physical sand model conveys spatial relationships in the landscape and makes use of the designer’s inherent abilities to create and manipulate forms by hand. This approach allows users to quickly create and understand highly complex topographies that would be time consuming and require an inappropriate degree of precision if produced using conventional CAD tools.

The projected graphics give the user a real-time insight into how geometric changes in the landscape influence complex systems such as drainage, sun lighting and slope conditions. While other projects have taken a similar approach in combining physical and digital representation, "SandScape" offers a new contribution by using the surface geometry of the model itself to act as the input and output juncture.

Computational Materiality

A landscape designer has an intuitive understanding of earth, water, wind, sunlight and other natural systems that is built up over a lifetime of experience interacting with the physical world. However, assumptions that are made about the behavior of a particular element are based on interactions that occur on a human experiential scale. It remains extremely difficult to intuitively predict the behavior of the same elements at the scale of the landscape.

It is far more effective to represent these non-human scales systems mathematically and to apply analyses functions to these mathematical models. These functions are generally controlled through a set of given variables that can be adjusted in numerical terms. While this approach has the benefits of accuracy and quantitative control, it does limit the value of mathematical models in the process of design.

"SandScape" supports an intuitive interaction with mathematically modeled elements of the landscape by allowing the designer to observe the results of a direct manipulation on physical landscape models. Through a material experience of mathematical models that react in real-time to tangible manipulation, the user can build up an intuitive understanding of non-human scale systems that are impossible to experience in the physical world.

Social Interaction

Owing to the scale of operation landscape design requires the collaboration of a great number of experts. These include specialists in earth engineering, water management, agrarian management, land economy, legal policy and transport infrastructure to name just a few. "SandScape" provides a platform for collaboration centered on the table workspace. Numerous form of representation can be combined in a single design environment offering the potential for greater cohesion between the large numbers of specialists working on a given landscape design problem.

In addition "SandScape" offers a means for non-experts to have meaningful role in the design process. Landscape interventions inevitably affect large numbers of people living perhaps on or near a particular site. Owing to the simplicity and immediacy of the physical landscape models used in "SandScape", non-experts can directly collaborate with landscape designers in community based participatory planning exercises.

The Contemporary Workplace

The computer has been widely adopted as design aid in practically every area of physical design. The forces that have led to this widespread adoption are as related to the advantages of being digital as they are to the disadvantages of not ‘being digital’. If physical designers do not follow their competitors in adopting the latest technologies then they are likely to be replaced by those that do. This is regardless of the quality of design of the wishes of individual designers, since market-forces, efficiencies and economic saving are currently the main proponents of technological development.

It is now common for the contemporary designer to spend almost the entire productive day operating a computer via a screen, keyboard and mouse. While this has led to increased efficiency and production in the short term, over a longer period it is clear that computer-aided design has simply raised the level of expectation to the point where designers must now work, faster, harder and more efficiently than ever before. The physical effects on the body, not to mention the less quantifiable effects on the mind are unnerving.

The rate of change in the work environment is related to the rate of change of technology, which has been shown to be exponential. Today much of the western workforce operates in an environment that is in complete contrast to the environment in which humans biologically evolved. The role of the body in allowing people to move through and manipulate the physical world is being superceded by technologies that allow portions of society to exist merely through the manipulation of information.

While this has brought many quantifiable riches to society it has reduced the experiential quality of daily practice. "SandScape" is a step towards the goal of designing computer
interfaces around more qualitative criteria by reinvesting the richness of the physical world into the computer interface. It aims to address the specific requirements of one user group - landscape designers - by increasing productivity and efficiency while still meeting the wider aim of providing a tool that is designed around the needs of its human users and provides a level of satisfaction in its use.

Additional Analysis Functions

"SandScape" demonstrates just a few landscape analysis functions that are publicly available. This particular set was chosen to demonstrate the potential of "SandScape" as a method for real-time interaction with computational analysis and as such we have used greatly simplified functions.

Analyses such as Local Drain Direction are highly inaccurate and at present are only useful as a rough visualization of how water might flow through a landscape. A future system architecture, incorporating a faster analysis process, would allow a greater degree of precision and more complex functions for simulating more challenging systems such as tidal flow, erosion or deforestation patterns. Research into the visualization of human activity in the landscape could also be incorporated.

Other Application Domains

"SandScape" was built in response to the needs of the landscape designer to project dynamic topography based simulations onto the surface of physical models. However, there are three significant ways in which the system could be refined to open up possibilities for other applications.

First, the current analysis functions only use the geometry of the physical landscape model as an input yet there is a vast array of information relating to the material of the landscape itself. It may be possible in the future to input values for these material qualities such as the water absorbency of different rock types, the known depth of water tables or even the influence of man made artifacts that can have significant impact on landscape systems.

Second, it would be possible to produce a hybrid system that used some form of tagging to describe object properties to different forms in the landscape. The current system makes no distinction between the landscape terrain and any object that is placed into it. There would be many advantages of combining the continuous, laser scanning based interface with the power of discreet object based recognition. For example a ‘school’ or ‘factory’ object could be associated with a particular level of energy consumption or a ‘forest’ object could exhibit properties that affected water tables, soil chemistry and other simulated factors.

Finally, an interface could be developed for the exploration of digitally represented volumes. Users could operate within an environment similar to "SandScape" in order to explore 3-dimensional representations of geological surveys, complex industrial design elements or the human anatomy.

By tackling the problems of how to represent materials, objects and volumes with in the "SandScape", the system could be extended to provide a far greater range of potential uses.

Details on the artists/the institution

Ben Piper

Ben Piper gained his MA in architecture at the University of Cambridge and recently completed his MSc at the Massachusetts Institute of Technology. He has been involved in a number of design and interactive projects and is currently working as an architectural consultant in Turin.

Carlo Ratti

An architect and civil engineer by education, Dr. Carlo Carlo Ratti graduated from the Ecole Nationale des Ponts et Chaussees in Paris and the University of Cambridge. Having completed a post-doc at MIT, he has recently started his architectural practice in Turin.

Assaf Biderman

Assaf Biderman is currently an undergradate at the Massachusetts Institute of Technology. He has been a sound engineer for a number of largescale public performances and is currently involved in a number of interior design projects in the Boston area.

Yao Wang

Yao Wang has studied architecture at the Massachusetts Institute of Technology and received M.S. degree in 2002. He continues his research on tangible user interface for landscape design in the Department of Urban Studies and Planning at MIT.

The Tangible Media Group

The Tangible Media Group is concerned with the development of human computer interfaces that take full advantage of our natural ability to understand and manipulate physical objects. The group has been responsible for the development of over forty interface prototypes and has published widely with in the HCI community.