COMPUTER VISUALIZATION OF THE SANTA BARBARA CHANNEL

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ABSTRACT

In Santa Barbara in 1998, a partnership was formed composed of The Santa Barbara Museum of Natural History, Alias|Wavefront-makers of the three-dimensional (3-D) software "Maya," the University of California at Santa Barbara (UCSB) Graduate School of Education, and the Santa Barbara County Arts Commission. The primary goal was to conduct an experiment in project-based education under the auspices of a community partnership. The work was hosted by Alias|Wavefront at a computer lab in their Santa Barbara location. Over the course of 20 weeks, nine high school students, artist Doug Hechter, and mapping consultant Joshua Graae used Digital Elevation Models (DEMs) compiled at UCSB to build a 3-D digital visualization of the portion of the California coast known as the Santa Barbara Channel. The model has been used to express changes in the shape of the channel resulting from fluctuations of sea level over the past 25,000 years. This visualization explores the dynamic aspects of 3D/animation software which permits the user to assign attributes of the physical world to objects within the scene being modeled in the computer. This capability suggests the viability of 'virtual experiments' and 'virtual laboratories'. Mockups and studies of dynamic principles used in the construction of this visualization offer further perspective regarding the present capabilities of 3-D computer modeling.

Keywords: Santa Barbara Channel, computer simulation, science and art, science and art education using new technology, terrain modeling.

INTRODUCTION

The Santa Barbara Channel Mapping Project was conducted over the course of twenty weeks to involve high school students in a science-based computer visualization project. It was conducted in response to a need to determine the appropriate integration of new technology into public education at the high school level. In support of this project, a partnership formed consisting of the Santa Barbara Museum of Natural History, Alias|Wavefront, the University of California at Santa Barbara (UCSB) Graduate School of Education, and the Santa Barbara County Arts Commission. Artists, educators, and nine teenage students met after school at an Alias|Wavefront computer lab. Their goal was to build a three-dimensional (3-D) digital model of the channel, islands and mainland that makeup the Santa Barbara/Ventura coastline.

The highly-visual electronic environment that is now the normal experience for young persons challenges notions of literacy as it has been traditionally defined. In presenting students with a 'hands-on' experiment, we set out to define some new possibilities in learning. Computer technology presents conditions that were previously unavailable through the traditional written word. Subtle relationships of natural phenomena occur across multiple subjects using hypertext linkage; the dendritic structure of computer information allows constructive digression to occur in several directions from any point in a journey through a given document. The spatial-visual component enabled by imaging software allows an author to express an idea simultaneously as both picture and text. The capacity to animate opens many possibilities for expressing time and sequence in a document using simple, accessible tools. Our project was designed to explore these new conditions and determine how they might impact the learning of art and science in the next century.

SOME THOUGHTS ON THE RELATIONSHIP OF ART AND SCIENCE

"The greatest enterprise of the mind always has been and always will be the attempt to link the sciences and the humanities." [1]

Computers have a chameleon-like quality that produces an overlap of processes over widely divergent fields. The same computer that can layout a story for publication can also make 3-D art, perform advanced calculations in mathematics, express a relational database, build music, and uphold a conversation across continents. New opportunities for collaboration are apparent. Artists and scientists have always shared a great deal in common. Both activities

[1]Edward O. Wilson. 1998. Back from Chaos. Atlantic Monthly, March 1998.

inherently challenge the edges of the known world. Both must deal with failure as a possible outcome in the act of creativity and exploration. Additionally, they must remain flexible since an idea can develop in unexpected directions. Now, as we consider the 'digital factor,' the possibilities for joint ventures between scientists and artists have never been more favorable.

Although often associated with ornamentation, art in its highest form facilitates understanding. Art can prepare us to learn something for which we have no point of reference. There is an example from a few years back of an attempt to revive an endangered population of giant clams in the South Pacific. Breeding adults were collected by researchers and placed in a bed near the shore of a small island where they could be monitored. The local villagers were accustomed to eating these clams as part of their normal diet and could not be persuaded to leave this close and abundant food source alone. Due to this pressure, the animals were not able to breed and the desperate scientists had to come up with a solution or give up any attempts at repopulation. Then someone had the idea of arranging the giant clams into a pattern that spelled 'parents.' Suddenly, by connecting two subtle ideas with a metaphor bridge, a profound understanding arose among the villagers. These resourceful scientists won the full cooperation of the culture in which they were operating and the clams flourished. To use metaphors and examples is to use cross-lateral thinking and reminds people to consider ideas outside of their normal patterns. This is one of the most important benefits that the artist brings to a society. If a tantalizing idea cannot muster the evidence required by science, it can still be art until a scaffolding of proof rises to confirm or refute it.

In approaching the channel model, the artists' first impulse was to turn the geographic survey files into rich visual environments. Other members of the group were more concerned with the spatial accuracy of shorelines, stream channels and other features. In this project, the synthesis of art and science has produced an attractive and reasonably accurate product as well as provided a cross-disciplinary educational experience that has allowed students (and educators) the freedom to think creatively and critically.

THE PROJECT

Our intent has been to build a model of the Santa Barbara Channel as a digital apparatus using the 3-D program "Maya." The United States Geological Survey (USGS) digital elevation model (DEM) data was converted to a Maya-compatible format to serve as the source of topographical data. Building on this topographical base, textures were added to simulate various environmental surfaces such as soil, water and vegetation (see Appendix A). Lighting and a "diorama dome" were added to provide a simulated atmosphere and kinetic sketches were made with Maya to simulate water flow and particle movement (see Appendix B). Cultural landmarks such as Stearn's Wharf and the Santa Barbara Mission were constructed and added to the model to aid in orienting the viewer. In addition to the work performed in the laboratory, the students and instructors visited Santa Cruz Island to gain firsthand experiences with the environment they were modeling (see Appendix C).

To create an accurate topographical and bathymetrical surface of the study region, data were converted from DEM format to Wavefront Object format and imported into Maya to produce a polygonal wireframe. The DEM data were originally processed and compiled by Professor Leal Mertes and her students at the Department of Geography at the University of California, Santa Barbara. The computationally-intensive DEM to wireframe data conversion was performed on a Silicon Graphics Onyx computer, using PolyTrans, a data conversion program made by Okino Graphics Software. The conversion was performed iteratively to produce a series of 3-D models of varying resolutions (see Appendix D and E).

RESULTS

The result of our efforts is an electronic instrument which functions both as a kinetic sculpture and a laboratory made entirely of data - a neutral stage on which it will be possible to demonstrate a variety of effects. Fluctuations in sea level have occurred over the past 25,000 years. During the glacial age which occurred late in the Pleistocene epoch, significant percentages of the planet's water were held in suspension at the polar ice caps. Estimates vary, but many agree that sea levels were approximately 100 meters lower than present conditions, defining a very different coastline for the prehistoric residents of Santa Barbara. The first task of this model has been to illustrate this fluctuation. Its accuracy is uncertain but it does help to pose some questions based on the new conditions that appear within the simulation. We can speculate how indigenous peoples of that time may have used the revealed terrain as village sites, food sources and travel routes. By adding sonar data available (but not used in the present simulation), it may be possible to plot the harder rock structures beneath the soft marine substrata and aid in further speculation on the ancient coastline, river mouths and wetland locations within the time of human occupation. Someone has asked where the Rincon surf break might have been 25,000 years ago; artists' conceptions of this and other forgotten landscapes are possible. The virtual terrain we have generated may be tumbled and examined from any point of view looking up canyons or down from vistas.

MODELS PRODUCED AND RESOLUTION

The project has produced a library of models representing the entire channel at a variety of resolutions. Also produced were several subset models of the major watersheds of the Santa Barbara area at higher resolution. The highest resolution files contained 110 megabytes of vector information, while lower resolution files were on the order of 100 kilobytes. Due to the large size of the high resolution data sets and the constraints of equipment currently available, processing limitations were encountered. By moving incrementally downward in resolution, a library of compromise files was collected in order to match the weight of the data files to the equipment available for daily use.

PROBLEMS

We encountered some technical limitations in conducting this experiment. Real-time interactive navigation in our virtual environment at a high level of detail was prohibitive. Files at the highest resolutions were slow to update when changed. Adding new information or shifting the viewer's position in the scene was accompanied by an unacceptable delay in screen refresh. Files in the upper ranges of our library crashed the super computer when they were manipulated with the surface information turned on and visible. We have 'rendered' or processed these largest of files into animation clips but they are only records of a programmed sequence and not truly interactive. We have attained interactivity on the lower resolution files but the data is still unmanageable for all but the simplest of reactions between objects in real-time. These problems notwithstanding, we now have the files converted to a current standard format and will be able to take advantage of the next performance boost of computer processors.

DIFFERENTIATING ART FROM SCIENCE WITHIN THE MODEL

Science demands unexaggerated empirical data. Artists have a tendency to press beyond that which is proven. The computer visualization can provide for artistic license without compromising the central core of hard data. Postulated material, where inserted, can be identified by switching the surface information which drapes the wireframes to an alternate legend/schematic display. This would be a bit like having a map or a model which changes 'channels' like a television. These 'channels' would have different visual clues such as color and texture change. This "artist's-conception layer" can be activated by a 'switch' with a scientific disclaimer attending it's viewing. Since "layers" within computer image documents may be made visible and active or invisible and inactive, the unverified data can be turned on or off leaving the basic data set without permanent changes.

FOR THE FUTURE

Copies of the digital files generated by this project will be distributed freely to encourage the development of the model into the spring of 1999 and beyond. In the near future, we hope our virtual landscape will be used to attempt demonstrations of geological movements, human impact and growth projections, botanical conditions, zoological migrations, pollution transport, sand-drift, and other phenomena. The possible topics to enact within the model's environment are myriad.

Presently the size of this data body prohibits its use over the Internet. This is likely to change, however, in the near future. Large entertainment companies such as Disney or Dreamworks plan to control their own intellectual property and manage the direct distribution of large video files to end-users. This restructuring of distribution which will require a data "tunnel" large enough to handle video-on-demand will incidentally provide the means to manage large files such as this simulation in real-time over the internet. In the interim, the channel model will not be a 'shared-file' in any sense that permits simultaneous interactivity by multiple users.

Perhaps, as we await the arrival of broad bandwidth, a less ambitious web-based presentation will provide public access to the model. This web site may serve as a digital crossroads for related scientific resources. A rendered animation loop of the channel, taken from the main model, might function as a 'cover page' or a bookplate illustration, analogous to a kinetic sculpture in the entryway of a library. The entrant may pause for a moment of reflection in the 'lobby' before continuing on toward links, publications, collections and on-line discussions with other institutions and web sites.

CONCLUSION

In the past, planners have gone to great lengths to create spatial environments to reenact natural processes. When the U.S. Army Corps of Engineers set out to study the San Francisco Bay and associated waterways in 1956, they built a scale model in a large warehouse in Sausalito. The Bay Model is a three-dimensional representation of San Francisco Bay and the lower Sacramento and San Joaquin rivers capable of simulating tides, currents, river inflow, and other variables affecting water quality and the movement of water in the estuary. The model spreads over 1.5 acres and is built out of 286 five-ton concrete slabs. This model continues to operate but its maintenance is a constant challenge in a zone as geologically active at the San Francisco Bay. Our digital counterpart suggests a more practical alternative to study these kinds of complex interactions.

Graphic visualization has usually been understood in terms of ornament and illustration but a suggestion of something more profound is coming into view. As computer technology provides us with more powerful hardware, a 3-D world of increasing detail will emerge. The computer will become a container of virtual objects functioning as a type of 'reef' upon which information may be positioned as inter-related layers. Artists will waste no time building ether-worlds where the lines of illusion and reality are undiscernible. They will have us wander in our own literature as co-actors and co-objects. Science will be challenged to maintain objectivity and accuracy regarding their incursions in this new type of environment. Nevertheless, the virtual world as an emersive mnemonic device will provide a new and adaptable kind of organizational structure for information as it expands in the years to come.

The students who have participated in building this model have acquired experience in applied research, a sense of proportion regarding the temporal and digital worlds, and a direct role in raising the collective consciousness about the ocean and other ecosystems. They are proud of their virtual landscape. It is a contribution to the ever-expanding corporate body of scientific work and it will continue to be developed in tandem with the capabilities of the software. Each of these students may now own the thrill of fitting another small piece into the great puzzle.

Much of what we suspected regarding the use of the computer to link the pursuit of art and science has been validated by the fact that enthusiastic learning occurred within our framework. Some of the group, identified in other school settings as underachievers, became deeply vested in the process by their ability to use their visual and tactile senses to break the 'surface tension' of the ideas presented to them.. Additionally, they have acquired a sense of the specialized functions and professional cooperation that help a team accomplish a technical task. We have shown that we are able to gain the attention of the students and challenge them using 3-D technology. As more teaching professionals become involved in projects of this kind, curricula which links the computer activity to all of the other vital disciplines covered in a secondary education will fill in many of the deeper background principles not included in our exercise. The subtle time-honored tools of traditional learning are not replaced but rather augmented by the 'juice' which accompanies the operation of computer tools. The goal will be to help young people obtain an overview of large, important issues both inside and outside the phosphorus screen so that they may concur knowingly with Howard Rheingold, online pioneer, when he declares, "the tool is not the task."

ACKNOWLEDGMENTS

The author would like to acknowledge the following persons and organizations: Mark Sylvester, Alias|Wavefront; Dr. Leal Mertes, Department of Geography, UCSB; Debra Jane and Sean McCurdy, Silicon Graphics; Joshua Graae, Worldview Consulting; Craig Bernstein, Project Network Administrator; Jamie Silva, Project Web Master; Patrick Davis, Santa Barbara County Arts Commission; Jules Zimmer and Mary Anna Rae, the Graduate School of Education at UCSB; John Iwerks, Artist; Brian Rapp, Sheila Cushman, and Krissie Steward, Santa Barbara Museum of Natural History; Donna Moore, U.C. Natural Reserve System; Lyndal Laughrin and Briand\Guerrero, U.C. Field Station at Santa Cruz Island; Richard Armstrong Color Printing; Occidental Petroleum; Compaq Computer Corporation; Hewlett-Packard; and Ted Adams, Wildland Residents Association. Also thanks to the following students: Vincent Argentine, Joseph Belton, Sean Belway, Jacob Goena, Andrew Hager, Derek Main, Francisca, Santibanez, William Rice, and Antony Whyte.

APPENDIX A-TEXTURES

After the wireframe was developed, a 'skin' was draped over the bare geometry. This skin is defined by elements called 'shaders.' Shaders contain information about shadow, color and texture. Shaders may be built using mathematical procedures within the program. Shaders may also consist of photos or illustrations from sources outside of Maya. Textures, like all elements within the Maya environment, may be animated to change or update over time. We used a Thematic Mapper satellite image of the channel as a shader on some files. Studies were produced using shaders to simulate rock and foliage surfaces on others.

APPENDIX B-DYNAMICS

'Kinetic' devices were built to test water flow and camera motions. Students built low-resolution test terrains into which they simulated water coursing down a graded cleft. The wireframe elements in a scene are known as 'objects.' Mountains, trees, and water are 'objects.' They become 'actors' in a digital diorama. Simulations of physical qualities may be assigned to an object that cause it to behave and react like its counterparts in the natural world. These artificial behaviors are called dynamics. Water, clouds, sand, and lava are all represented by 'particle' objects. Particles can be made to behave as fluid, to inherit motion from other objects they encounter. For example, 'water' may become a pliable object that can be assigned to flow in a given direction and bounce off something to which the dynamics of hard stone have been assigned. 'Gravity' can be added to the particles to make them settle. Soft objects attributed as 'cloth' can be made to react to invisible objects 'generating wind.' Skillful use of dynamics is present in motion-picture special effects. Many of them are largely stagecraft. Some of them, however, may be used to set up simulations such as pollution transport in a variety of states, sediment movement or the collisions of tectonic plates. Particle objects can be assigned to a 'motion path' which constrains or allows motion based on current drift, gravity, inversion layers, or forces of strain.

APPENDIX C-THE TRIP TO SANTA CRUZ ISLAND

In keeping with our commitment to include an 'unplugged' component to the student experience, we went outside for a look at the actual site. Nine students and six adults traveled by boat to Santa Cruz Island where we were the guests of UCSB and the Island Reserve at their field station. Over the course of three days, we studied the landscape from a variety of angles. We sketched and photographed the channel from the heights of Diablo Peak. John Iwerks, a landscape painter and member of the Oak Group offered his valuable insights on the qualities of light and atmosphere. Much commentary on local flora and fauna occurred from the back of a pick-up truck. Chris Krissie Steward from the Natural History Museum brought her telescopes along with her wonderful perspective on the firmament by night. At the field station, we enjoyed the company of the scientists who live and study on the island. The students found the experience enlightening, and their commitment to our subject matter was deeply enhanced.

APPENDIX D-TECHNICAL

Creating an accurate representation of surface topography and channel bathymetry for this project required converting data from formats used by geographic information systems (GIS) to formats recognizable by Maya. The primary source for surface data are digital elevation models (DEMs), a product available from the USGS. DEMs represent terrain relief in a digital format by recording location and elevation in a two-dimensional raster or grid, in the same manner that digital images are stored. DEMs are not recognized by Maya, however, and their data structure must be altered before they can be used in Maya. Using GIS software, DEMs were converted from raster (grid, or image type) format to vector (line type, or polygon) format in the early attempts to generate a wireframe for this project. Triangulated irregular networks (TINs) are vector files that can be generated from DEMs and are analogous to the wireframes that Maya uses to represent three-dimensional surfaces; they look somewhat like a fishnet draped over the topography. A TIN for Santa Barbara County and the Channel Islands was generated from DEMs using ARC/INFO, a GIS software package. The TIN's topology (the mathematical description of its shape) was then used to attempt the generation of a wireframe that would accurately depict local terrain using the animation software. After several failed attempts to generate a wireframe from TIN topology, a software package was located that created Wavefront Object files from original DEM data.

PolyTrans (Okino Graphics), a data conversion software package, was used to successfully convert DEM files into Wavefront Object files of varying resolutions. The original DEM resolution of sixty meters was too data intensive to be processed as polygons by the hardware available, so data points were omitted in the conversion to produce smaller files of lower resolution. Omitted data points were systematically chosen by PolyTrans using the "skip factor" option. A skip factor of one preserved the original resolution, while a skip factor of two would omit every other data point, resulting in a resolution of half the original. Therefore a 60 meter (m) resolution data set converted using a skip factor of two would produce a new data set with a resolution of 120 m and a 60 m resolution data set converted using a skip factor of 3 would produce a new data set with a resolution of 180 m. For this project, several object files (terrain models) were produced using skip factors that varied from two to twenty-five. These files were then imported to Maya, which converted them to polygonal wireframes. These wireframes provided the 3-D skeleton of the Channel Model at a series of resolutions.

APPENDIX E

These data sets were compiled and created at the Department of Geography, University of California under the supervision of Dr. Leal A.K. Mertes with Ben Waltenberger, John Dvorsky, Ethan Inlander, Melodee Hickman, Amy Bortman, and Chuck Ehlschlaeger. See the metadata text or Word document for details of the development of these data sets. An appropriate citation for the data set is:

Mertes, L.A.K., M. Hickman, B. Waltemberger, A. L. Bortman, E. Inlander, C. McKenzie, and J. Dvorsky. 1998. Synoptic views of sediment plumes and coastal geography of the Santa Barbara Basin, California. Hydrological Processes 12:967-979.

Funding to support development of these data sets was provided by the University of California, Channel Islands National Marine Sanctuary, Minerals Management Service, and the Channel Islands National Park.