A Digital Drafting Board for Design

Historically, architectural design, particularly the conceptual part, starts with doodles, sketches, simple models, and ideas etched on the back of an envelope. Pencils and tracing paper, drafting boards and T-squares, French curves and splines, were the tools of the trade. Today, with the availability of immense computer processing power and now economic large color screen displays, “Can we not create an environment that has all of the benefits of today’s computer technology but all the feel and ambiance of the creative environments of the past?” asked Professor Donald P. Greenberg, Direction of the Program of Computer Graphics.

To achieve this general goal, Microsoft has funded the development of design software for a Digital Drafting Board, one which could possibly become the standard drafting table of the future.

Graduate architecture students Nicholas Cassab-Gheta and Andrés Gutiérrez working on the software development for the next generation digital drafting board.

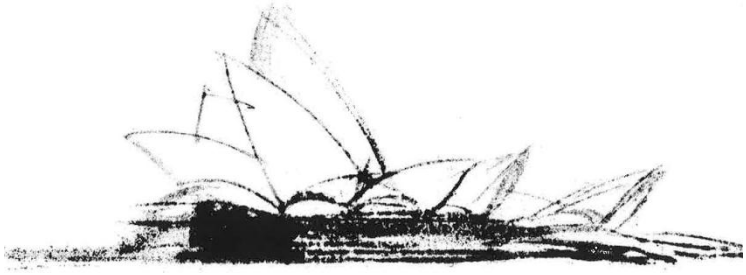
The design process (not necessarily restricted to architecture) usually starts with doodles, sketches, and back-of-the-envelope diagrams to create solutions which depend on not just engineering calculations but also the aesthetic and humanistic aspects of the built environment. It is not unusual for architects to place layer upon layer of tracing paper drawings on top of each other, modifying and combining portions of each layer to derive a preliminary design. Frequently, to help with the creative processes, models of clay, cardboard, or paper are made. Unfortunately, at this stage of the design the most important decisions are made without having the answers to the questions that a designer would like to ask since they are too difficult to obtain rapidly and require too much specificity to obtain the correct solutions.

The difficult technical challenges is how to convert a sketch into a model, one that can ultimately be used for analysis and parametric studies, but in an environment similar to pencil and paper.

Use of multiple sketches on trace during preliminary design.

Crude physical models frequently are used at early design stage. Shown here: Frank Gehry's working model for Abu Dhabi's Guggenheim Museum in 2007.

Historical labor intensive drafting using splines to creates smoothly varying curves.



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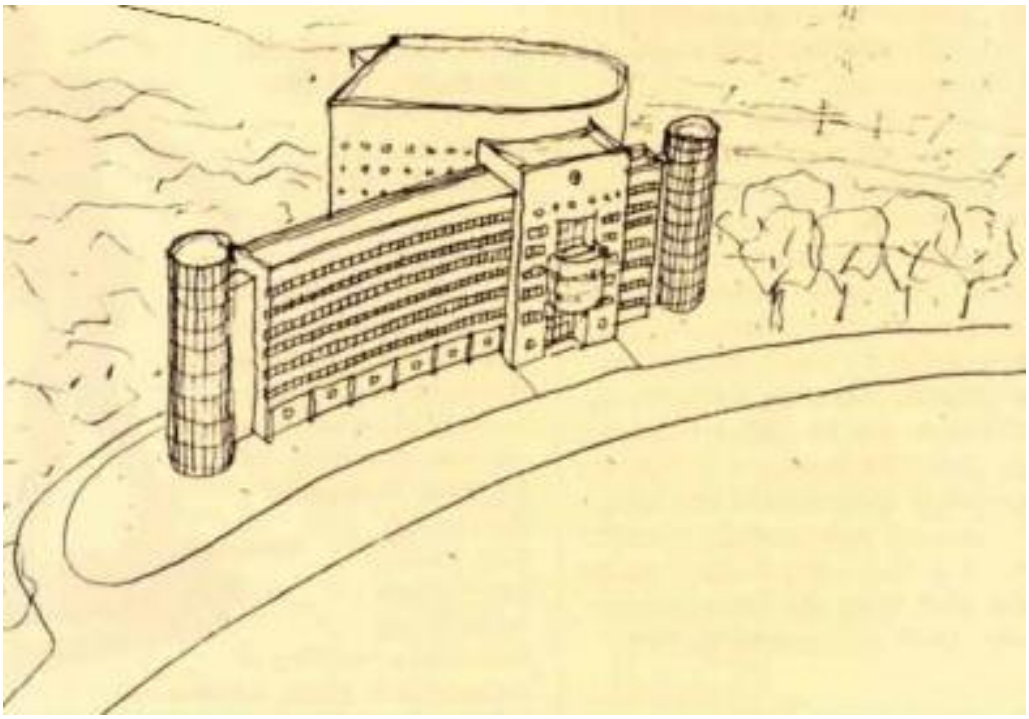

c

Early design sketches have remarkable similarity to final designs as shown by the three examples above.

a) Sketch and photo of the Sidney Opera House by Jorn Utzon
b) Sketch and photo of Walt Disney Concert Hall by Frank Gehry
c) Rhodes Hall on the Cornell University campus by Michael Graves

Consistent with the early stage design process, in our laboratory we are creating software to mimic the sketching metaphor. Routines are being developed to enable free-hand, pen-based sketching routines, on multiple layers of virtual tracing paper. Although drawing is most efficiently enabled on a large, flat, horizontal or near-horizontal tilted surface, the actual "virtual tracing paper" can be rotated to enable sketching in three dimensions. In fact, using canonical solids, or even spline surfaces, the sketching need not be restricted to planar surfaces. Combining virtual layers enables the merging of components from various sketches.

Automatic conversion routines will translate the sketches to mathematical spline definitions without loss of accuracy. We have already perfected these routines and successfully utilized these techniques in a wide variety of applications ranging from the design of ship hulls and automobile surfaces (Wu et al. 1977), to creating models for ornithology (Robertson 2010) and the fabrication of aortic stents for intravascular surgery (Goel et al. 2008) Once the initial spline and/or prismatic geometry has been transformed, it is then easy to manipulate and edit the virtual model using standard CAD software (Greenberg 1977).

Most, if not all designers like to visualize their models using raster graphics rendering software. Computer programs for generating and rendering complex 3D models, including open-source and proprietary software, are readily available (Renderman, V-Ray, Maya, Rhino etc.) and are frequently used in practice. The Program of Computer Graphics is particularly experienced with this type of software, having contributed many advanced global illumination algorithms and having pioneered the use of radiosity methods to allow interactive real-time software for architectural walkthroughs. What is

significant is that the availability of a new high resolution “digital drafting board” will allow the merging of the entire process on one single, easy-to-use, high-resolution device.

Since most important design decisions are made in the early design stages, it is also extremely beneficial to be able to accurately simulate many of the engineering behaviors of the virtual designs during preliminary design. For example, structural analyses and earthquake design, daylighting studies, and energy consumption and efficiency can all be simulated and would improve early design decisions.

Funding for this project was awarded by Microsoft in 2015 and the novel equipment arrived in early 2016 before Cornell’s Spring semester. The project is being developed by two graduate architecture students, Nicholas Cassab-Gheta and Andres Gutierrez, under the direction of Donald P. Greenberg. Both students are studying for their Masters of Science degree in Computer Graphics, but significantly each have won the Charles Goodwin Sands Memorial medal, the highest award for design given in Cornell’s College of Architecture.

We would like to add two more graduate students with computer science backgrounds to augment the research team and help teach future design studios.

Related Publications

- Donald P. Greenberg, “The Coming Breakthrough of Computers as a True Design Tool,” Architectural Record, July 1977.
- Sheng-Chuan Wu, John F. Abel, Donald P. Greenberg. “An Interactive Computer Graphics Approach to Surface Representation,” Communications of the ACM, October 1977.
- Vikash Ravi Goel, Roy K. Greenberg, Donald P. Greenberg. “Automated Vascular Geometric Analysis of Aortic Aneurysms,” IEEE Computer Graphics and Applications, 2008.
- Barbara Robertson. “Taking Flight,” Computer Graphics World, January 2010. Jeff Wang, Donald P. Greenberg research.