2018-10

Simultaneous Worlds: Using Physical Models to Contextualize and Compose Visualizations

Hull, Carmen; Willett, Wesley J.; Carpendale, Sheelagh

Hull, C., Willett, W., & Carpendale, S. (2018). Simultaneous Worlds: Using Physical Models to Contextualize and Compose Visualizations. 1-3.

http://hdl.handle.net/1880/110209

conference poster

Simultaneous Worlds: Using Physical Models to Contextualize and Compose Visualizations

Carmen Hull*
University of Calgary

Wesley Willett*
University of Calgary

Sheelagh Carpendale*
University of Calgary

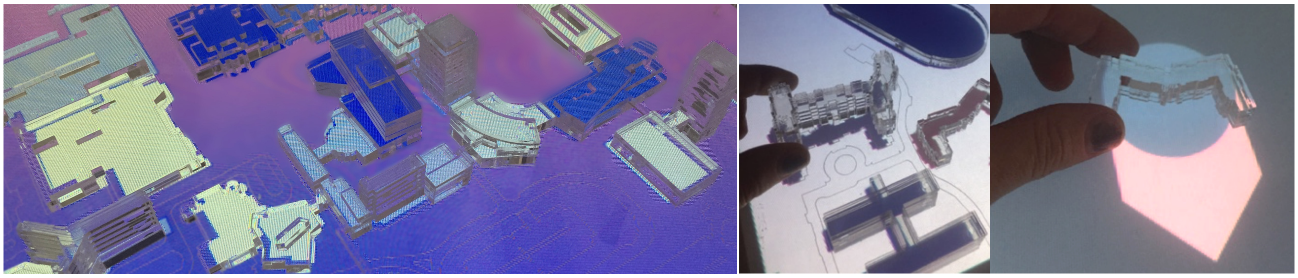

Figure 1. Our augmented tabletop explores how architectural models can serve as a substrate for visualizations. Here, areas inside model buildings (left) show HVAC costs, while outside shows environmental conditions. Models can be physically manipulated (middle) and re-positioned create new visualizations that highlight non-spatial relationships (right).

Abstract

In this poster, we introduce an interactive prototype that integrates site-specific architectural models and tangible displays to compose multiple data representations in the same view. This vision of simultaneous worlds uses physical models as a substrate upon which visualizations of multiple data streams can be dynamically integrated. To explore the potential of this concept, we built a tangible tabletop system that uses scale models of a campus to visualize energy use and climate data. We believe that the metaphor of simultaneous worlds has the ability to unpack novel connections between datasets, supporting embodied exploration, critical thinking, and collaboration.

Keywords: Physical Models, Tangible Surfaces, Fluid Interaction, Embodied Interaction, Data Physicalization.

1 Introduction

Although datasets are often examined in isolation, they are rarely generated that way. Rather, every piece of data represents one small element in a larger picture, and captures only one of many perspectives of the places, people, and phenomena it seeks to characterize. Overlaying, comparing, or integrating visualizations of multiple, complementary datasets in the same physical space is often challenging [1], given the unique constraints of various data types and the limited design space of possible visual encodings. Moreover, for datasets that reference the physical world, much of the surrounding context remains unrecorded, and can be appreciated only by visualizing the data in-situ, where physical and temporal scales can make observation difficult.

Our work examines how physical architectural models can provide context for and support transitions between multiple data visualizations. To explore the potential of this concept, we built a tangible table-top system using scale models of a university campus. Our prototype juxtaposes operational[1] data such as heating and cooling costs alongside ambient and contextual datasets including environmental conditions, occupancy rates, and historical aerial photos. In doing so, the tool surfaces data that is often hidden within institutional silos, and not typically visualized at the same time.

Illuminated surfaces have been used in collaboration with tangible architectural forms in URP [2] or projections onto generic blocks [3]. Our system uses translucent models with distinct and recognizable architectural characteristics that act as proxies for the are real buildings within the visualization, reducing both spatial indirection, decoupling of the data and referent, and occlusion [4]. Each individual model is also a recognizable token that can be used elsewhere on the table to perform more detailed analyses.

2 Concept

By reducing spatial indirection and directly linking the data representation and the model in the same space, we aim to enhance cognition and insight into the complex issues of building energy usage. While most of these datasets can be plotted spatially, simply overlaying them one on top of the other quickly reduces their legibility. In response, physical models can provide a substrate ("a substance or layer that underlies something, or on which some process occurs.") for simultaneously displaying multiple

[1] carmen.hull@ucalgary.ca

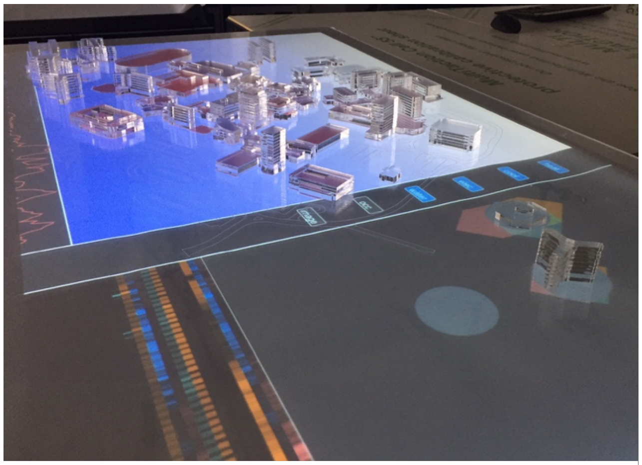

Figure 2. Our augmented table-top prototype

visualizations and facilitating transitions between them using the shared context of the model.

2.1 Implementation

Our system (Figures 1, 2) uses an acrylic model placed on an illuminated table-top which can display a variety of different spatial visualizations. The augmented model is back projected, with the visualizations visible through and around the translucent model. Due to the translucent nature of the acrylic, the visualizations displayed on the surface reflect up through the building mass, filling the volume with encoded acrylic base plate, indicating the footprints of the buildings, as well as roads, parking lots, and other landmarks.

We built the scale model using a mix of digital fabrication and hand-building techniques. The unique outline of every floor of each of the buildings was laser cut from a 1/8" acrylic sheet (which at this scale, was roughly equivalent to the height of one floor). The layers were then assembled by hand with a clear adhesive and placed on top of the base map.

We built the touch surface using Diffuse Surface Illumination (DSI) combined with custom shape detection software for both finger touches and fiducials, which are tracked by a Kinect v2. The hardware consists of a bottom projected illuminated surface supported by a t-slotted aluminum frame. The projection surface is vellum paper sandwiched between the DSI layer with infrared lighting and an acrylic surface. Two infrared cameras mounted below the table surface register touch interactions.

2.2 Benefits of Visualization on Physical Models

Our initial explorations highlight several potential benefits of integrating visualizations with physical building models:

Situating the Visualization. Architectural models can preserve important details about their original referents (including the buildings' size, height, orientation, and layout) which can make it easier to reason about data from them. As such, situating visualizations within and on top of these models can help analysts retain many of the benefits of examining data in the original setting. Moreover, scale models can permit situated analysis and observations from scales and perspectives that are impossible to access in the physical world.

Composite Visualizations. Using models as a substrate or stencil also allows designers to create composite visualizations that encode more diverse combinations of data. For example, the shapes of the model buildings in Figure 1 (left) create both interior and exterior spaces which can be used to visualize different data. Here, the interiors of each of the buildings visualize data about their individual heating and cooling, while the area outside the buildings visualizes overall environmental conditions. These two *simultaneous worlds* co-exist within the same visualization and support more complex analysis and interpretation.

Tangible Manipulation and Authoring. If the pieces of a model are modular, this can also create opportunities for the individual pieces to serve as the building blocks of new visualizations. Viewers can move, manipulate, and examine models independently, and can even use them to compose new visualizations. Figure 2 (right) illustrates one such interaction, in which viewers can reposition individual buildings into an area alongside the original map to create new visualizations. Because the models maintain the geometric form of the original building, they remain easy to identify and reason about even when removed from their original geospatial locations.

3 Preliminary Investigations

As part of our initial exploration, we have piloted several versions of our prototype with campus administrators and students. We also exhibited the system as part of a local science festival. Initial feedback from administrators, operations managers and students demonstrates the broad appeal and practical applications of our system. The model prompted ideas about using the model as a 'control center' for visualizing a diverse set of operational data types that could be used by all departments and for interdepartmental meetings. The students quickly produced an astute range of observations about the energy use of specific buildings, grounded in their own experiences on campus. Going forward, we will conduct a quantitative study to examine the impact of physical interactions for creating new insights.

4 Conclusion

Our project highlights where architectural models can be used to situate and composite multiple visualizations, helping viewers examine complex interrelated data sets. We introduce the idea of simultaneous worlds – using physical models to support compositing and transitions between multiple geospatial datasets. The layering of heterogeneous data representations within the same physical model creates new opportunities for situated data analysis which we are actively exploring in our continuing research.

Acknowledgements

This research was supported in part by Alberta Innovates – Technology Futures (AITF); the Natural Sciences and Engineering Research Council of Canada (NSERC); and SMART Technologies.

References

[1] W. Javed and N. Elmqvist, "Exploring the Design Space of Composite Visualization," *Vis. Symp. (PacificVis)*, p. 1–8, 2012. doi.org/10.1109/PacificVis.2012.6183556

[2] J. Underkoffler and H. Ishii, "Urp: A luminous-tangible workbench for urban planning and design," *Proc. SIGCHI Conf. Hum. Factors Comput. Syst.*, p. 386–393, 1999. doi.acm.org/10.1145/302979.303114

[3] P. Dalsgaard and K. Halskov, "Tangible 3D Tabletops: Combining Tangible Tabletop Interaction and 3D Projection," *Proc. 7th Nord. Conf. Human-Computer Interact.*, p. 109, 2012. doi.org/10.1145/2399016.2399033

[4] Y. Jansen, P. Dragicevic, P. Isenberg, J. Alexander, A. Karnik, J. Kildal, S. Subramanian, and K. Hornbaek, "Opportunities and Challenges for

Data Physicalization," *Proc. SIGCHI Conf. Hum. Factors Comput. Syst.*, p. 3227–3236, 2015. doi.org/10.1145/2702123.2702180