Architectural Interactive Glass, Layering Devices and Collaboration

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Abstract— Desktops can be replaced with collaborative environments utilizing a combination of large scale screens for overviews, collaborative analysis and presentation; mobile devices for focused interactions and local exploration; and combinations of devices for layered visual composition.

Index Terms—Visualization walls, Collaborative visualization, Layered devices.

INTRODUCTION

Non-desktop visualizations already exist all around us; and for a wide variety of different tasks. Enhancement of these systems and better integration of tasks across systems will enable new modes of working with information.

1 BACKGROUND

Non-desktop visualization already broadly exists ranging from visualizations on large scale wall-based displays down to interactive mobile devices, and the author has been involved in the design and implementation on information visualizations including tablet, phone, collaboration rooms, digital signs, large scale multi-CPU screens.

Usage of these displays varies by tasks. Small mobile screens are used for status updates, monitoring, or searching and finding summarizations. Large screens may be used in collaborative settings so that all participants can see and interact with the same visualization - although in some scenarios a single facilitator may interact with the software, while some multi-touch large-scale screens permit multiple simultaneous users. Large screen information visualizations are also used in applications for monitoring (e.g. everyone on the trading floor sees the same macro-market data, or electrical grid or transport system) and in story-telling (e.g. everyone passing through a common area can see and interact with the latest findings by the research group). Heads up displays, VR displays and immersive environments represent other classes of already existing non-desktop rich interactive environments.

Given the breadth of these *existing* visualizations - what ideas are further out?

2 NOVEL DISPLAY ENVIRONMENTS

The approach here is to extrapolate a few current hardware trends and consider how those may benefit infovis. Improved interactive workflows across devices will also benefit users.

2.1 Any glass is visualization ready

Consider combining these two technology threads:
a. **Large scale displays** are approaching architectural scales. For example, Mitsubishi has a 155” flat panel display [1] and the author is aware of at least one infovis installation of such a display.
b. **Transparent displays** can be manufactured by removing the backlight from the video display. Silicon Graphics in the 1990’s created a flat screen display (called Presenter [2]) with a detachable backlight, creating a transparent color display that could be set on an overhead projector, used to project the video image onto large screens. Similarly, some laptops have experimented with transparent displays (e.g. Samsung [3]).

Combining and extrapolating these two could result in buildings where any glass surface, e.g. external windows, walls between conference rooms, desks or tables, is visualization ready. Applications go beyond visualization, for example, initial applications may simply to control the passage of natural light to act like a curtain, similar to Jean Nouvel’s electro-mechanical devices reacting to sun and cloud on the Arab World Institute in Paris. (figure 1). However, the glass can be extended to be data driven and all glass in the building has the potential to be an ambient display of data, possibly for marketing purposes (external facing) or monitoring, analysis and communication purposes (internal windows).

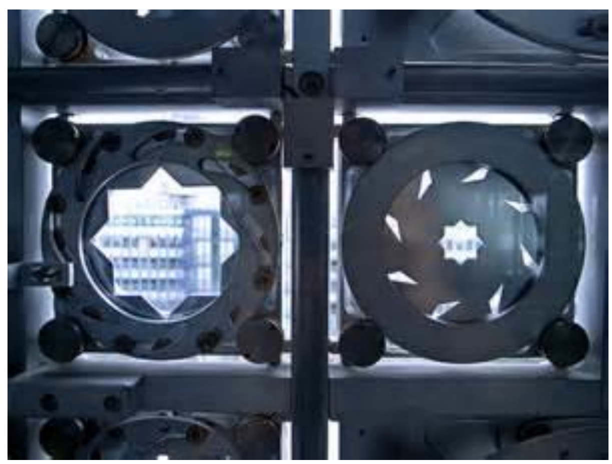

Fig. 1. A multi-storey electromechanical glass wall adjusting its display based on external light conditions.

When every glass surface becomes visualization ready, old windowing paradigms become less relevant - i.e. toggling between application windows. Instead, one can imagine surfaces more like a design studio (figure 2), where walls have many images pinned to them representing various incremental iterations and branches through an exploratory and analytical process - much like the branching processes involved in hypothesis formulation and investigation in data science or intelligence analysis [4,5]. These walls slowly evolve over days and weeks and months during the project. Items can be unpinned and taken away on local devices or reposted. The walls also can act as a CAVE immersive environment, e.g. in a cubicle or conference room.

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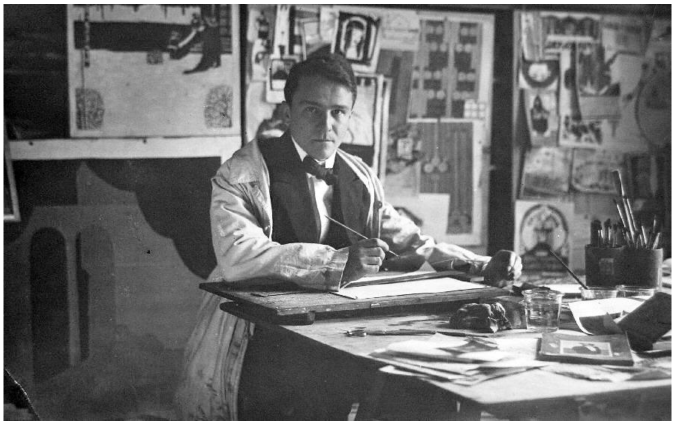

Fig. 2. A design studio. Note the variety of images pinned to walls and stacked on desk (Emil Pirchan, via Wikimedia [6]).

Collaboration with these longitudinal visualization project walls changes. One can approach a particular visualization and create a new branch: modifying state, filters, etc and creating new findings. One could post new hypotheses or post new datasets.

Increasing resolution enables depiction of fine detail. A current trend in both mobile devices (marketed by Apple as "retina displays") and other screens (e.g. 4K TVs), increases pixel densities significantly - moving from 72 or 96 pixels-per-inch common in 2013 on the desktop; to displays with 300 or 400 pixels-per-inch. These higher resolutions enable new visualization possibilities, displaying very dense node-and-link graphs (i.e. graph drawing); use of texture to encode data in visualizations (e.g. [7]); use of multi-attribute icons and shapes (e.g. [8,9]); use of a wide variety of fonts, including font-based encodings (e.g. [10]).

Touch interaction, when added makes any of these surfaces become an analytic and collaborative environment, although the room purpose, shape and furnishings will now be more important to how one may interact with these large scale surfaces.

Other sensors, also change the capabilities of these surfaces. At a simple level, detecting a non-moving person standing in front of the surface may be used to indicate potential interest and automatically start some form of analytic playback / story-telling. More advanced detection, e.g. personal identification, such as employee ID or visitor could be used to highlight certain types of data; or automatically anonymize data, or simply redact confidential portions

2.2 Large Portable Displays

Cell phones, tablets and newspapers are often used to read on public transit - but the former are much smaller than newspapers. Newspapers are typically range in size from 17" x 22" (opened tabloid format) to 29" x 46" (opened broadsheet format) - e.g. the broadsheet is 25x larger than a current iPad. These sizes could be effective sizes for lightweight portable displays enabling far more visible information than current tablet displays. Perhaps this display is rollable (e.g. [11]) or foldable (e.g. [12]) or ingeniously hinged like a Jacob's ladder toy or Rubik's Magic, to facilitate portability and flexible viewing size. The device can also be transparent, similar to the display glass discussed previously.

2.3 Innovation on Small Devices

Small displays will evolve as well. As costs drop, the availability and ubiquity of these devices will proliferate. With a larger ecosystem, these devices will be able to better work together in real-time among themselves (e.g. li Sifteo Cubes) and with other devices. Eventually, credit card sized devices will be given away e.g. as a promotional item, as a ticket, as ID.

For some classes of visualization, e.g. large scale visualizations, new interaction patterns can enable easy movement through the space, for example using a button or gesture on the device as a clutch for panning and zooming. The information space may be one that the user is already familiar with, e.g. a geographic map, a mind map, a map of the Internet (e.g. [13]) or a large data-dense infovis (e.g. [14,15]). The ability to navigate these large spatial visualizations leverages end user's visual memory once they've acquired familiarity with the representations: e.g. Google maps does not provide an overview: just zoom out to return to the overview, or pan based on local knowledge. Some users establish fixed layouts of screens on desktops and use visual memory to quickly navigate to relevant areas, e.g. financial monitoring and analysis applications.

2.4 New Interaction Patterns

Do architectural scale displays, large portable devices and new small devices enable new interaction patterns?

For same time, same place interactions, multiple simultaneous users can interact with large displays either by directly interacting with the display (e.g. touch) or via a mobile device acting as a remote control or viewport onto the larger scene. For users interacting with the same scene from a remote place, similar use of mobile devices opening viewports onto the scene can be used, or telepresence techniques to embed the remote user not only into a window but directly into the display [16]. Or, using ideas borrowed from gaming or VR, avatars could interact directly in a shared space, whether 2D or 3D.

Shared collaborative visualization environments create other opportunities, challenges and issues:

- *Layering* of transparent displays provides a means to compose visualizations made of multiple transparent layers, each with separate data elements but sharing the same coordinate system. Data can remain safely within a particular screen but calibrated with other displays to provide multiple layers of context. This physical analog to turning layers on/off on a map today. This calibration also means that a small scale device, such as a credit-card sized display, can be swept over a larger display, acting like a Magic Lens (see [17]).
- *Ownership* and edit rights may need to be locked to a particular user and/or display device. Similarly visibility to specific details or data points may be restricted: I may get a different tooltip than you get.
- *Filters, layouts and representations* may be simultaneously modified by multiple users impacting the global display. Users will need to be able to create branches and instances for their own exploratory investigation then be able to merge their settings back to the global model. Users may want to toggle between various different configurations and adapt into a new merged global model.
- *Take away* is a key requirement: users may want/need to do local exploration that may take time and may want to investigate multiple hypotheses without visibility or criticism from their peers. Ideally, privacy and security rules can be applied dynamically when visualizations are dragged to and from personal devices to shared workspaces. Bringing a visualization back to a shared environment also raises additional issues, for example, how the data was handled, updated and otherwise modified.
- *Story-telling* becomes interesting. Unlike NY Times narrative visualizations, there may be multiple story threads, some sharing elements. Weaving together, maintaining and updating annotation elements and larger narratives is an issue.

3 A Scenario

Investment Banker Buck and Research Analyst Ivy working on a pitch to Mr. Big Client X.

Buck is in an autonomous vehicle reviewing a broadsheet visualization of a proposed M&A scenario. He can see the entire visualization - a large mental model visualization comprised of data, models and story-telling elements. In his review, he gets worried about some of the assumptions in the model, since Client X put out a news release about a new aggressive product this morning. Social media visualization elements in his visualization indicate strong positive sentiment and potential strong consumer demand. He tags the items visually and immediately alerts Ivy.

Ivy is on a crowded ferry half way around the world, standing room only. Ivy's watch receives the alert and automatically zooms in to the portion of the display that has been tagged along with a verbal note that Buck has added and converted into a scrolling text message. Ivy can do pinch/zoom interactions and track graph drawing connections across her model, change a few input parameters and highlight those for Buck. Buck can see these changes in real-time although he is modifying content in another portion of the screen.

At Mr. Big's office, Buck uses a swipe gesture to transfer the display of his model on Mr. Big's office wall as a full size display. Mr. Big's CFO Fin questions some of the assumptions and Ivy walks in visually appearing on the opposite side of the visualization as though behind the wall via telepresence and then via direct touch interaction proceeds to walk through some of the assumptions. (e.g. see Hiroshi Ishii Clearboard 1992 [16]).

Fin drags an instance of model over to the next pane of glass, along with Ivy, while Big and Buck walk through the story. Big questions Buck regarding some of assumptions in Buck's black-box model. The model is proprietary to the bank, but Buck pulls out his broadsheet, currently folded to tablet size, and pans it slowly over portion of the wall. The tablet layer superimposes calculation linkages for the underlying cells revealing that portion of the model to Big's satisfaction.

In the visualization model, one component is a choropleth map indicating sales growth figures that Buck and Ivy had created. Fin circles the north-east which he posts to his VP Sales, Sally. Sally is currently on vacation at a ski slope with her family. Sally is on chair lift with her augmented reality (ski) goggles when she receives a notification from Fin. She discusses with Fin the need for the latest numbers, executes a voice search, retrieving all the detailed records for sales in progress in the north-east. Fin can see Sally's view and confirm that this is the version he is looking for. Sally authorizes Fin's access and gets back to vacation as fast as possible.

Fin has the latest highly-confidential forecast numbers from Sally. Fin pulls out his own broadsheet and overlays it against the glass wall. With a couple taps, Fin has a calibrated his broadsheet map over top Ivy's map. Fin can zoom in/out and both maps remain calibrated. Ivy, on the opposite side, only sees her version and a redacted version of Fin's map.

Fin has a group of stores in the NYC area of interest and now has the benefit of seeing his data (internal sales projections per customer address as a massive tile-based visual analytic) overlaid on Ivy's detailed choropleth (perhaps block-level census age and income data) [15] from which Fin gains some new insights about his product's popularity in Brooklyn by different demographics. Fin removes the broadsheet and allows Ivy to continue with her explanation. Ivy adds a few annotations to the north-east for future reference. These also appear in Buck's presentation, but they adjust location automatically with appropriate leader lines and layouts, deferring to Buck's presentation so he does not lose the primary elements of his story.

As a final leave-behind, Buck leaves Fin and Mr. Big with two credit card sized saved versions of the visualization for further local exploration.

4 Conclusion

Elements of this future may already be here but it would be much more exciting if there were easier ways to explore these hardware technologies and interaction patterns. There is much future work that can be done currently, working with existing off the shelf devices and creating techniques for some of these newer types of workflows.

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