Progress towards Site Visits by Situated Visualization

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Abstract
We describe our experience and lessons learned from conducting a CS course final project to explore urban design site visits using augmented reality.

Keywords
Augmented reality, site visit, situated visualization

ACM Classification Keywords
H.5.1. [Information interfaces and presentation] Multimedia Information Interfaces—*Artificial, augmented, and virtual realities*; H.5.2 [Information Interfaces and Presentation] User Interfaces—*Theory and methods*; J.5 [Arts and humanities] *Architecture*.

Introduction
At Columbia University, we are investigating how mobile computing can support the site visits that architects and urban designers make as they begin a design activity. We base our primary tools and methodologies on more than a decade of mobile augmented reality research by Columbia University's Computer Graphics and User Interfaces Lab [1]. These practices and technologies were further developed in Spring 2007 through a Computer Science course on 3D user interface design [5], taught in collaboration with faculty and students from the Graduate School of Architecture, Planning, and Preservation.

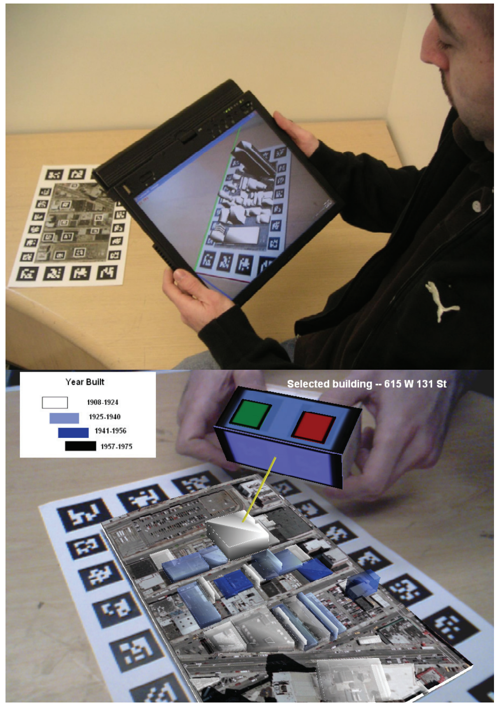

figure 1. (a) Tablet PC with video camera attached to back overlaying a virtual model on the site map. (b) Example of selecting building in virtual model associated with site plan (Courtesy of Mike Sorvillo, Levi Lister, Taran Singh, and Sasha Stoeva).

The prototypes we have been developing augment 2D paper site plans (figure 1), and actual 3D physical sites (figure 2). Our primary platform is a laptop computer with an attached camera that records the physical scene. Computer vision algorithms recognize and track printed paper markers in the scene in real time, making it possible to overlay relevant information interactively on top of what the camera sees. This lets us create live "situated visualizations", described later, that depict otherwise invisible characteristics of a site and its surroundings. During the Spring 2007 semester, students addressed the site of Columbia's proposed Manhattanville expansion using curated data collected specifically for the project, as well as GIS data.

Site Visit

With more than half of the world's populations living in urban environments, the expectations for future development in our cities require greater degrees of redundancy across infrastructural, cultural and environmental systems. Hybrid programming of densely urban sites, such as mixed-use transit hubs, renewable energy producing parks, and live-work waterfronts, has surged in the last decade. Design fields are expanding disciplinary interaction in order to coordinate this complex enterprise of scales, stakeholders and resources. Vital to this effort is the ability to maintain evenly balanced exposure to each system's design variables, regardless of its immediate visibility or presence.

In architecture and urban design, the concept of *site* is fluid. The most straightforward definition considers a site to be an entity defined by "boundaries that delimit it from the surroundings," where boundaries are typically considered to be spatial. In a more expansive view, the site can be understood as the superposition of all aspects of the entity, beginning with the specific place but including spatial and temporal surroundings, multiple histories, and physical, social, political, environmental and cultural characteristics—that is, all things that influence or are influenced by the site.

Our research endorses the designer's ability to dynamically visualize a site—to study, map, document, tag and interact with a site in multiple scales, contexts, timelines and agendas.

The Site

Our research activities focus on a 17-acre industrial district of New York City known as Manhattanville, where rezoning efforts are raising disputes over land use, economic development, socio-cultural diversity and environmental stewardship. This area has been proposed as the site for Columbia University's campus expansion, for which preliminary design propositions have been publicized using various visualization strategies.

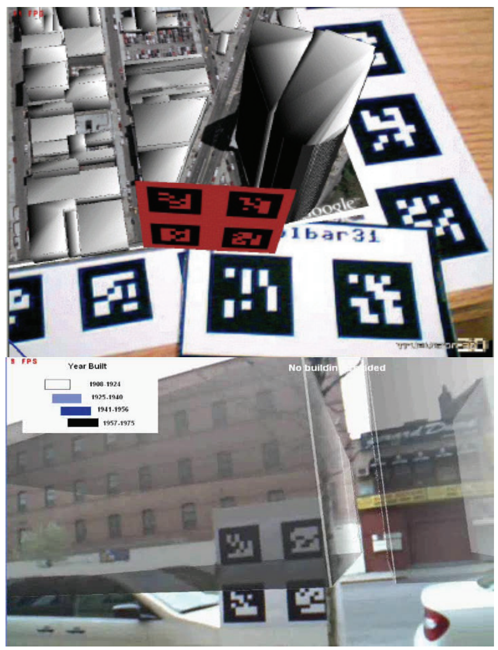

figure 2. (a) Positioning a virtual fiducial in the site plan virtual model to correspond with the location of a physical fiducial in the real world (Courtesy of Varun Maithel, Armando Ramirez, Michael Wasserman, and William Yin). (b) Related virtual information overlaid on real buildings, registered with full-size fiducial (Courtesy of Mike Sorvillo, Levi Lister, Taran Singh, and Sasha Stoeva).

3D User Interface Class Project

As part of our investigation, the team final project in a class on 3D user interface design asked students to explore different scales of user interface and interaction in the urban environment. We asked the students to design and develop a prototype visualization tool that could help architects and urban designers better understand a site prior to or during a design activity by visualizing unseen or invisible aspects of the site. The project had two stages: augmenting a flat 2D site plan (figure 1) and augmenting a portion of the 3D physical site (figure 2). Students curated their own data and developed situated visualizations of selected invisible aspects of the site, along with techniques and new affordances [3] for interacting with those aspects.

Situated Visualizations. Typically, visualizations are shown on a stand-alone display, whether desktop, hand-held, or head-worn. In the figure-ground relationship, the physical environment that serves as the ground in which the visualization is presented has no meaningful relationship to it. In contrast, we use the term *situated visualization* to describe a visualization that is related to its environment; for example, by being specific to the surrounding spatial context. Situated visualizations gain meaning through the combination of the visualization and the relationship between the visualization and environment. In the context of site visits, the visualizations become part of the site.

Platform. We provided students a platform [4] built on top of an existing 3D engine [6] extended with augmented reality capabilities including live video capture, 6DOF fiducial marker tracking [2], and the ability to combine live video with 3D graphics. This made it possible for students to, for example, display virtual objects registered with optical markers overlaid on the real environment, captured with an inexpensive web camera.

Data Curation. We provided students with a 2D image of the site plan with fiducial markers and a 3D digital model of the site generated from GIS data. Students were asked to gather their own additional data about the site. Two problems arose in our data curation. Models from GIS were inaccurate and improperly represented slope and elevation differences. In addition, students had to generate their own spatial data because the granularity of much of the data found was only at the block or building level, which does not take advantage of the richness found in environmental augmented reality.

Presentation and Interaction. Projects explored a variety of presentation and interaction techniques. Of particularly interest was veridicality of visualizations, connecting techniques at multiple scales and between egocentric and exocentric interaction, and display-fixed versus world-fixed representations. For instance, figure 2a shows a technique for associating a marker in the physical world with a location in the 3D model. Figure 2b shows a display-fixed legend and world-fixed highlighting of buildings based on age. The same highlighting model is used in the site plan in figure 1b.

Situated visualizations provide an enhanced way of interacting with urban environments, but many questions arise here. Are the visualizations now part of the urban environment? How do they change perception of the space? What authorship and provenance representations are required? What conceptual model and metaphor should be presented? Is there a canonical language of presentation and interaction? How are the flows of people, culture, and concerns best represented and reflected? Relative to design activities, do visually situated site conditions accelerate or optimize the entire design process? Does the site have authority in its transformation?

Future Directions

To address these questions, we are investigating how to localize and register visualizations without global models. We will pair this with participatory localized authoring and shared curation of spatial data, along with common presentation and interaction techniques to develop a framework for situated visualization.

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