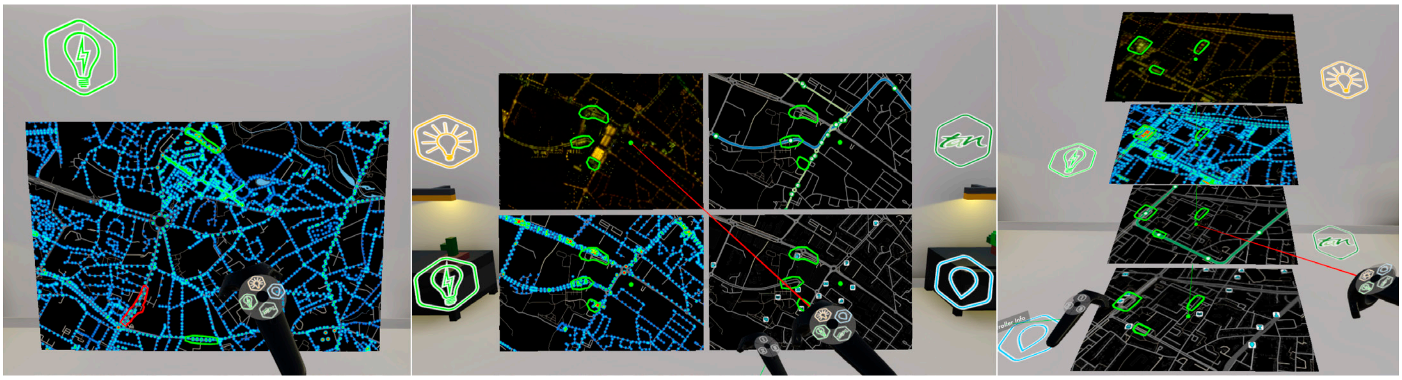

Figure 1: Three map juxtaposition systems experimentally compared: Blitting (switching), a grid, and a stack of layers.

Maxim Spur[1] (maxim.spur@ec-nantes.fr) and Vincent Tourre[1] (vincent.tourre@ec-nantes.fr)
[1]AAU Crenau, Centrale Nantes

LENSSTACKVR: EXPLORING MULTILAYERED URBAN DATA IN VIRTUAL REALITY

Keywords: Urban Data Visualization, Virtual Reality, Multiple and Coordinated Views, Focus + Context, Immersive Analytics

1. RESEARCH PURPOSE

We first investigated different methods of visualizing multiple heterogeneous layers of geospatial data to aid decision-making in urban planning. For a simulated citizen participation task, we developed three prototypes that utilize the advantages virtual reality (VR) provides to different degrees (Fig. 1). Based on favorable findings from a formal experiment and expert feedback, we now extend the capabilities of one of those systems to suit explorative tasks.

2. BACKGROUND

Faced with the multitude of heterogeneous geospatial data available for cities, it is often necessary to take more layers of information into account than can easily be merged into one map during analysis or exploration. Literature exists on evaluating methods of presenting two layers [3], and proposals for vertically stacking layers of geospatial data [1]. We extend that research into multiple layers, focus on the urban environment in particular, and take advantage of VR systems.

3. APPROACH, DESIGN, METHODOLOGY

Working with researchers in urbanism and considering the work of Gleicher [2] on visual comparisons, we developed a task that asked participants to select areas in a city that are in need of improvement in terms of public lighting. This was chosen as an example that requires understanding and balancing the information presented in multiple spatial layers, in this case: light pollution, energy consumption of street lights, transportation networks, and points of interest. Because of the overlapping nature of these data, juxtaposition and simple switching (blitting) of these layers were chosen as practical approaches, and we implemented three prototypes to compare (c.f. Fig. 1).

Test participants (naïve, N=26) rated the stack system highly in terms of ease of use and visual design, and measurements (system interactions and oculometry) showed faster task completion times as well as a larger number of comparisons (changes of gaze from one data layer to another) than with the other two systems (a grid or blitting). The closeness of the layers and the vertical arrangement which presents a high coherence between layers apparent-

ly invited users to linger less and make larger and quicker saccades to compare the layers.
While we kept the functionalities of the three systems on equal footing for a fair comparison, with the confirmation of the stack's validity we could then extends its capabilities beyond what would be feasible with the other systems.
The common interactions were *panning* and *zooming* of the map via 3D controller gestures, and placing markers that were linked with lines across the layers.
With exploration in mind, we propose to add a *base layer*, with 3D buildings on the ground below the stack to create a *Focus + Context* view (Fig. 2).

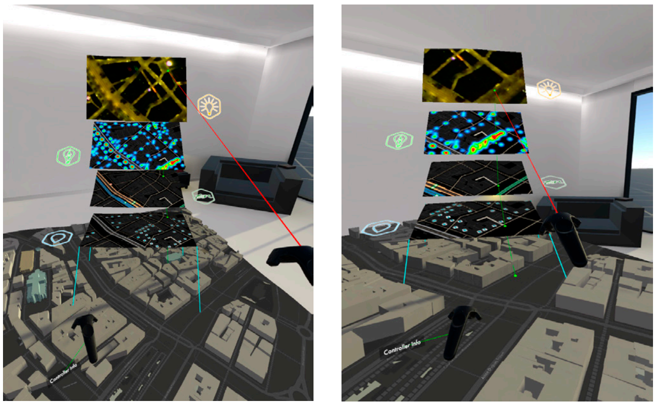

Figure 2: A standing and sitting view of the multilayer lens stack over a city.

The user is not restricted to a seated position anymore, and instead free to move around a room with a large area of the city on the floor. As before, the map can be panned and zoomed, but the stack, which now acts as a multilayered *lens* can be positioned as needed, and its orientation follows the viewer (billboarding). We also enabled users to rearrange the layout of the "lens stack" to fit their needs: enlarge or shrink the windows, change the vertical distances between them, change their order, and adjust their tilt. It is also possible to elevate the base layer to desk height, or scale it up so far as to be immersed in the urban geometry. The lens' scale can be increased to zoom into an area while keeping the base map on a small scale. Finally, we can stereographically project one selected data layer or the base map on a sphere or other non-planar surface surrounding the viewer, further aiding the focus + context paradigm by extending the extent of the map that can be seen.

4. ORIGINALITY

The originality stems from our research into visualizing more than two data layers of the same geospatial region at a time. While a low number of layers is still quite navigable with blitting or a regular grid, the stack is poised to most easily accomodate a larger number of layers that would quickly render a switching system too cumbersome to navigate, and a grid too small to read. We also utilize the intuitiveness of 3D control for map navigation and the immersiveness of VR.

5. PRACTICAL IMPLICATIONS

Using Mapbox as a platform for managing urban data and its API for integration with Unity 3D, our system can quickly be adapted to any location and data. Using eye tracking and other measurements stemming from a VR implementation, we can continue to refine visualization parameters and explain and adapt to user behavior.

6. IMPACT

We extended research into comparative visualization of multiple geospatial data layers. The task design for the experiment set up to evaluate the proposed system was also directly useful for research in urbanism. Directly incorporating feedback from participants and urbanists into the layer stack system, we hope to create a useful tool for immersively exploring multilayered urban environments.

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