Engineering Interactive Geospatial Visualizations for Cluster-Driven Ultra-high-resolution Wall Displays

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ABSTRACT

Ultra-high-resolution wall-sized displays feature a very high pixel density over a large physical surface, typically covering a few square meters. They provide effective support for collaborative work sessions that involve the visualization of large, heterogeneous datasets. But the development of interactive visualizations for ultra-high-resolution wall displays raises significant challenges. These range from the design of input techniques adapted to such surfaces, to the design of visualizations that effectively leverage their extreme display capacity. Challenges lie not only in the design but in the technical realization of these visualizations as well, as they run on computer clusters and thus require dedicated software frameworks for the distribution and synchronization of data and graphics. In this talk, I will essentially focus on challenges that relate to the engineering of interactive visualizations for cluster-driven wall displays, discussing different approaches that we explored over the last fourteen years to create geospatial visualizations and the associated multi-scale interaction techniques.

1 INTRODUCTION

Ultra-high-resolution wall displays have two key features, as their name suggests: a large display area, combined with a very high pixel density. On the most recent platforms, this density is getting close to human visual acuity when standing near (within arms' reach of) the display. For instance, the WILD-512K wall display depicted in Figure 1-a has a pixel density of more than 100 pixels/mm^2 for a surface area of more than 9 m^2, amounting to a $61\,440 \times 17\,280$ pixel resolution in total.

Taking geospatial data visualization as an example, this display capacity means that compared to more conventional desktop display setups, the same spatial region can be visualized with a much higher level of detail, which can be of key importance as cartographic representations often feature many small elements and subtle visual cues. Put another way, this increased display capacity means that for a given level of detail, a much larger spatial region can be visualized.

This increased display capacity is not just an opportunity to show a more detailed rendering of one monolithic workspace, though. It also means that small-multiple visualizations, that juxtapose a series of related maps or charts to ease their comparison, can be rendered with a level of detail significantly higher than the typical thumbnail-like renderings shown on desktop displays [3]. It also enables displaying data that do not directly belong to the map [6], such as documents, tables, statistical charts, or node-link diagrams. Those can be juxtaposed with the map, or superimposed on top of it in regions of lesser importance, depending on the application and task at hand. Similarly, multiple locally-bounded interactive magnifications of the geographical region of interest can be displayed over the main map, possibly showing different layers of information (*e.g.*, multispectral images [6]) at different scales. Figure 1-b illustrates such an example: users work with multiple views giving complementary perspectives on the geographical region of interest at different levels of detail. They interact with these views using multitouch gestures performed either directly on the wall or indirectly on a handheld tablet [1].

Geospatial data visualization has been a key application area of our research on wall displays: interaction techniques for high-precision pointing [4], for multi-scale navigation [5], or more recently tangible interaction [2]. But the amount, complexity and heterogeneity of geospatial data have also led us to research questions related to the engineering of interactive geospatial visualization early on, focusing on toolkits to display elaborate 2D multi-scale information spaces [7] as well as input management systems [1].

In this talk, I will essentially focus on challenges that relate to the engineering of interactive geospatial applications designed to run on cluster-driven wall displays. I will discuss different approaches that we explored over the last fourteen years to enable the development of *interactive* geospatial visualizations of *dynamic* data (Figure 1-c), making use of a variety of input devices and sensors: multi-touch frame, motion tracking equipment, tangible objects, handheld devices such as tablets and smartphones, augmented reality eyewear, highlighting some of the many challenges that remain to be addressed.

2 BIOGRAPHY

Emmanuel Pietriga is a Senior Research Scientist at Inria in France, where he leads the ILDA team. He is also Course Instructor at École Polytechnique where he teaches Data Visualization. His research focuses on the design and engineering of techniques for the visual representation and interactive manipulation of complex, heterogeneous data structures. His specific topics include interaction and visualization techniques for novel forms of displays (ultra-walls, AR, pen+touch surfaces), multi-scale user interfaces, visualization techniques for multivariate networks, and HCI aspects of Web browsing. He received his PhD at Institut National Polytechnique de Grenoble (INPG) in 2002. His previous research positions include Xerox Research Centre Europe, the Decentralized Information Group at MIT, where he worked for the World Wide Web Consortium, and Inria's research center in Santiago de Chile, where he worked in close

Figure 1: (a) Visualization of an AIS marine traffic data feed on the WILD-512K ultra-wall. (b) Visualization of multiple data feeds at different scales, including topographic map, ortho-imagery, sea-level rise simulation, population density data, in a crisis management scenario on the WILDER ultra-wall. (c) Visualization of a live railroad traffic feed on the same platform.

collaboration with the ALMA observatory on the design and implementation of user interfaces for telescope operations monitoring and control. He has since then worked in collaboration with other prominent astronomical observatories, including the Cherenkov Telescope Array and the Vera C. Rubin observatory.

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