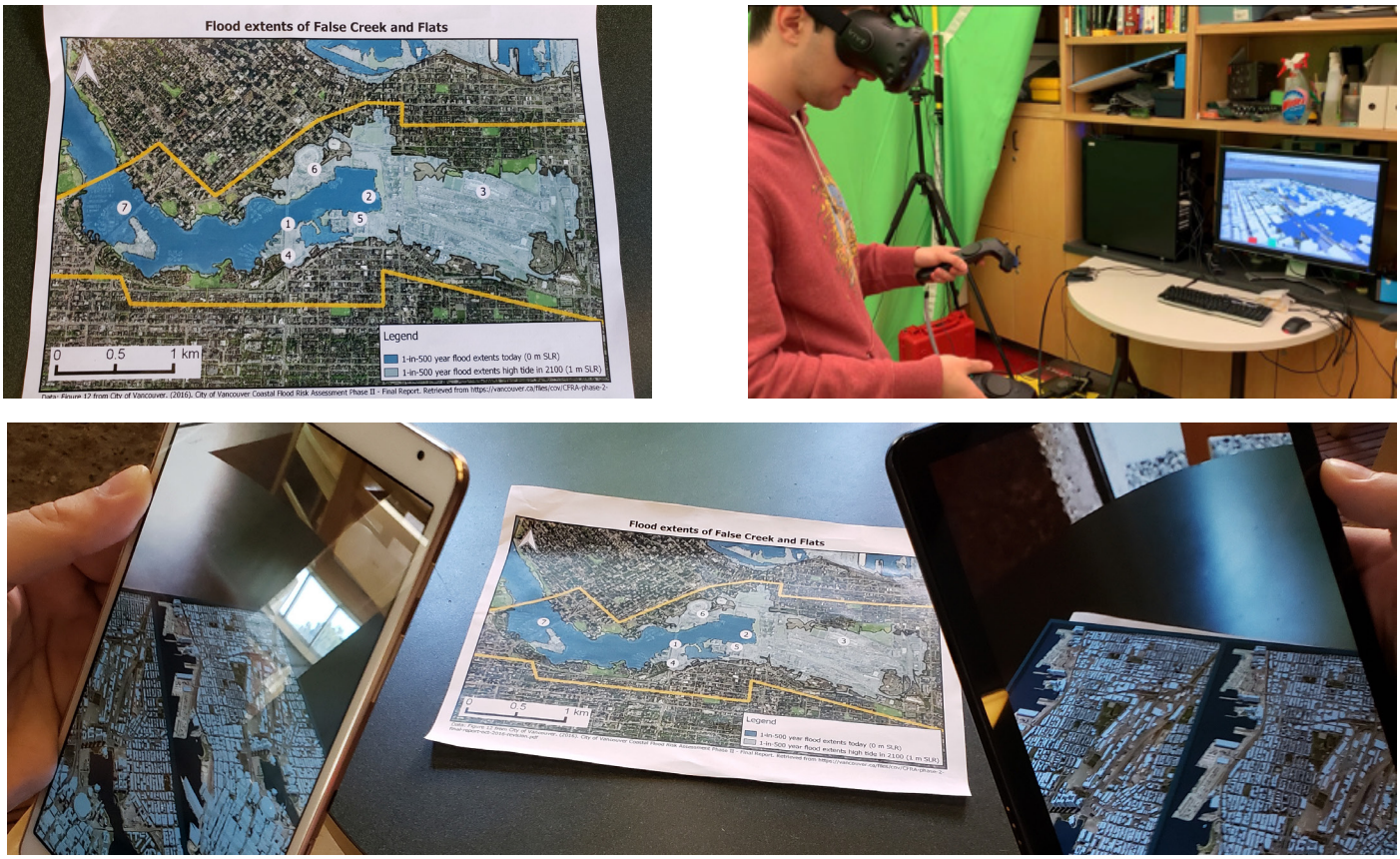

Figure 1: (Top lef) Example of conventional 2D map visualization medium typically used in FRM. (Top right) Example of a flood visualization prototype we built using immersive VR. (Bottom) Example of a collaborative mobile AR application we built, allowing interactive control and display of water levels during storms, comparing current and projected future water levels for scenarios of the same probability.

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EMERGING VISUALIZATION INTERFACES AND THEIR IMPLICATIONS FOR FLOOD RISK PERCEPTION AND MANAGEMENT

Keywords: Flood; Risk Communication; 3D visualization; game engines; mixed reality; virtual environments.

1. INTRODUCTION

Increasing global sea levels, growing risks of fluvial flooding and intense development across the world make understanding and managing risks an integral part of urban development. Most metropolitan areas across Canada are at-risk from coastal, fluvial or flash floods and the magnitude and frequency of events is projected to increase [1]. Amidst growing costs of providing disaster assistance, the responsibility for managing flooding is increasingly being shifted towards at-risk populations [2]. A recent survey illustrates that half of people living in designated floodplains in Canada express no concern at all related to flooding risk and majority also expect flooding to decrease in coming decades [3]. This worrying risk perception among exposed populations is combined with equally concerning

deficits in knowledge availability about flooding risks, where most communities in country have outdated maps that are not suitable for public communication [4]. This context of a need to understand evolving inundation risk and significantly improve public understanding of risks provides opportunities to explore emerging visualizations.

2. PURPOSE OF RESEARCH

In response to a growing interest in implementing interactive 3D visualizations of flood hazards and risk, our work assesses the interplay of conventional versus emerging 3D data characterizations of flood processes in urban risk analysis and communication. We are investigating the potential of emerging 3D interface technologies to support perception, interpretation of flood risk scenarios. We are interested how mixtures of visualization design, and interface affordances support (or impede) creation of knowledge and situational awareness of flood risk scenarios using visual analytical tools. We consider how emerging visualization and interface platforms such as 3D game engines, virtual (VR) and mixed reality (MR) embody visual analytical capabilities different from conventional spatial information platforms. We explore their strengths and limitations, how they may deliver new ways to perceive, interpret, communicate and manage flood risks in urban context.

3. APPROACH

Our work has three components. First - a critical assessment of conventional spatial data and interface use, critical review of potentially disruptive technologies such as 3D game engines, virtual and mixed reality interface platforms applied to flood risk communication and analysis. Second – implementation of 3D engine, VR and mixed reality flood risk visualization prototypes designed based upon observation and engagement with active urban planners, using multiple types of spatial data (LiDAR; inundation models; GIS) across several spatial resolutions and temporal scales. Third – empirical evaluation of the impact of integration and use of these visualization platforms into the Flood Risk Management (FRM) process – focusing on their role in supporting, enhancing, or impeding risk communication and perception, co-construction of situational awareness, and risk management processes.

Through this work, we aim to investigate whether rigorous FRM practice (analysis/communication) is supported, impeded or enhanced by emerging 3D visualization methods. We aim to identify opportunities to add value to FRM practices, through guidance for design and commentary on usefulness and feasibility of integrating emerging interface technologies into routine FRM practice and factors that may impede their uptake.

4. PRELIMINARY FINDINGS

In our work so far, we have investigated the scope and extent of existing examples of visualization methods and interfaces applied to flood risk management (FRM) and governance (FRG). We have critically reviewed trends in visualization of flood hazards; trends and themes in increasing use of 3D geovisualization methods and 3D platforms for FRM and their implications for flood risk perception, communication and practice. We have also designed and built some preliminary flood visualization prototypes using immersive virtual reality (VR) and mobile tangible augmented reality (AR interfaces (see figure 1).

4.1 Visualizations

Traditionally, flooding risks have been communicated through flood maps, illustrating likely extent of flooding of a certain probability, critical infrastructure and residences at risk [4]. Recently, there has been a groundswell in the use of 3D platforms (such as game engines) as new platforms with which to visualize coastal and urban flood risks. This trend is sparked by decreasing complexity and cost (free software) of producing compelling data-driven 3D visualizations of hazards and the existing gaps in visual flood risk communication, where most maps currently available are not suitable for public communication [4]. The 3-dimensional representation of a potential flooding area could be useful for co-creation of risk understanding through the reduced abstraction of the depicted phenomena, which enables diverse set of stakeholders to provide meaningful input [5], [6]. Recent progress in the application of game-engines for visualization of flooding scenarios combined with LiDAR capture of urban landscape provide a promising topologically 3-dimensional alternative for analysis and communication of flood risks [7].

While game-engines possess some compelling visualization capabilities that often feature in media coverage, many have technical capabilities for data integration and processing that might provide significant analytical benefits for hazard awareness and risk management. they have not been explored particularly deeply. While game engines

may capture viewers' attention, it is also imperative that we are not seduced simply by attractive 3D graphics. We must interrogate their representational rigour, and the implications of employing 3D dynamic, interactive interfaces as mediums for critical flood risk management and planning. Since the growth of such attempts in research settings is relatively recent, there is no robust evidence of superiority of 2D or 3D representation of urban hazards for understanding of risks or improved situational awareness. Compelling risk visualizations must be supported with evidence-based visualization design and data science.

4.2 Emerging Interfaces

Researchers speculate that the benefits of complex 3D representations made possible by powerful forms of 3D data (LiDAR; SfM) and models cannot be realized via topologically 2D software, or via conventional flat-screen interface technologies [8]. Some researchers are beginning to use augmented and virtual reality interfaces for risk communication (tsunamis, mass evacuation), and to connect researchers, planners and public to the complexities of flooding risks in cities [9], [10]. Many mixed reality interfaces enable natural user interaction with 3D visualizations as well as provide semi-immersive user experiences that may connect users powerfully to digital representations of hazard scenarios. Such affordances combined with significant reduction in prices of VR and AR displays and interaction platforms make integration of these tools into daily planning practice viable, while also providing a number of promising research venues. New research methodologies are enabled by emerging interface platforms (e.g. HTC Vive Pro Eye; Microsoft Hololens 2). Their native integration of eye-tracking and ability to export that data could provide fruitful substrate to collect empirical data on the usability and usefulness of visualization tools.

5. FUTURE WORK

Our on-going work explores the role that collaborative virtual and mixed reality flood risk visualization systems can play in rigorous Flood Risk Management (FRM) and Governance (FRG). We are working to assemble evidence that informs us whether different combinations of data, 3D visualizations, and emerging interfaces support modify our ability to perceive, comprehend or respond to flood risks; or whether the affordances of these new platforms deliver different information experiences; or support alternate ways to co-create knowledge capital, that may transform our ability to characterize, perceive, and communicate flood risks.

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