FloodWatch: Devising an Autonomous Cyber Physical System for Real Time Flood Intelligence in an Operational Framework

Considerations of Co-Creation in Devising an Autonomous Cyber Physical System for Real Time Flood Intelligence in an Operational Framework - Development and Adoption

A Thesis Prospectus

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By

Abhir Karande

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Department of Computer Science

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Kathryn A. Neeley, Department of Engineering and Society

N. Rich Nguyen, Department of Computer Science

Abstract

I have a personal connection to the technical project through my work with the FloodWatch Research Team. My work there involves developing cyber-physical system infrastructure that leverages various data sources to produce valuable insights, forecasts, and classifications regarding natural disaster events. The work is currently centered in Vietnam as a whole, a country in the South Eastern part of Asia that has had a long history of flooding disasters. This paper will discuss the approach to the end goal of providing smart city support to the Country of Vietnam and the key stakeholders in meeting this goal will be introduced to you, the reader.

My interest in carrying out research on smart city disaster prevention is heavily rooted in personal experience of residing in an area that is nationally known as being most prone to sea level rise and flooding. Having lived in Hampton Roads I have physically seen the infrastructure damage and fear that has been caused as a result of rising water levels in combination with storms. Though I live in Hampton Roads, I have never been directly affected by the rising water levels, and with this there might be gaps in my perception of the depth of the problem. In an effort to stay aware I am actively working in infrastructure planning and development through my involvement with the FloodWatch research group, which aims to make a distributed data and decision making platform that uses data from various municipal, crowd-source, and sensor data sources.

Problematization, Guiding Question, and Projected Outcomes

The main problem of interest that will be discussed is the lack of intelligent infrastructure in place to prepare municipalities for natural disasters including storms, floods, and hurricanes. In particular, Vietnam, a considerably less technologically advanced country as compared to the United States and other counterparts, suffers from several flooding events throughout the whole country, geographically. Not only are rural coastline provinces affected, but also larger urban areas including the capital city of Ho Chi Minh City. The havoc caused by the several annual flooding events wreaks havoc on families, agriculture, infrastructure, and the overall economy.

In carrying out this research, what I hope to gain is an understanding of the various societal, political, and technical factors that go into the rolling out of smart city projects.This research will potentially provide suggestions for adopting the smart city infrastructure that can be used for making informed legislative decisions.

Technical Project Description

To elaborate on the current workings of FloodWatch, the front-facing product that users will see is a web/mobile application that intuitively displays current and future flood severities through rasterizations that are encoded by color. The backend side of the project has several components that provide technological complexity. To start, data from various sensors for measuring precipitation, water level, humidity, tide, and wind are currently placed throughout all of Vietnam and are constantly streaming their respective data to LoRa wide area network routers, which are staged with APIs to send data temporarily to our server. Separately, long short term memory (LSTM) neural network models are prepared to forecast water levels through time series techniques and leverage the elevation to determine flood severity at various locations throughout

the country. These trained models are exported for scheduled use and provide forecasts daily for various flood severities that can be seen on our frontend application. As this is a heavily collaborative project, there are efforts beyond the technical aspects which involve crowdsourcing endeavors for public and municipal encouragement. The crowdsourcing involves users submitting flood reports with accompanying photographs for corroboration efforts. Collaborators for this project are working with the Vietnamese government to potentially offer tax breaks to frequent reporters.

Preliminary Literature Review & Findings

There have been prior critiques and discussions regarding the future of smart city technology in cities. One key critique or challenge that developments of certain technologies in this sector will cause is the inadvertent increase in mobility and accessibility gaps (Ahvenniemi, H., et al., 2017). Publications in the past decade revolve around reviews of existing smart city solutions. Such reviews analyze the disaster management and policy contexts, both of which will potentially be a new facet of the FloodWatch project. From a technical perspective, there are several private initiatives that are undertaken purely for research and development purposes.

STS Project Proposal

STS or Science, Technology, and Society is an interdisciplinary field that studies the interactions between technically related disciplines and socio-cultural and political factors. As FloodWatch and other smart city projects generally operate in the medium of developed civilizations, there certainly is ground for municipal and social involvement

This work will primarily revolve around the societal and political realms of smart city development and as mentioned previously, there have been several relevant reviews and

publications from leading journals including the *Journal of Open Innovation*, *Journal of Urban Technology*, the *International Journal of Disaster Risk Reduction*, and the *Association of Computing Machinery*. From an overall perspective there are provided overviews of the current research on smart city disaster resilience and the interdisciplinary collaboration and involvement of multiple stakeholders in developing resilient smart cities . One common theme that appears often is the importance of considering the social and cultural context of the city in developing smart city projects, a perspective that can be used to analyze the impact of disaster prevention and safety (Nam, T., & Pardo, T. A., 2011). From publications in these journals, different technologies and data sources that enhance disaster response and recovery have also been exposed.

From an epistemological perspective, this research most loosely follows the post-phenomenological framework. Generally speaking, post-phenomenology focuses on understanding the different roles technology plays in the relationships between humans and the world, and this is the perspective from which smart cities will be analyzed (Rosenberger, R., & -P.-P. Verbeek, 2015). More specifically, post-phenomenology provides a way for the critical examination of the role of smart city technology in impacting human experiences, including issues related to sustainability and legislation. Post-phenomenology can help co-produce research that aligns with the STS principles discussed above because similar to how STS is concerned with understanding the complex interplay between technological and societal systems, and how these systems mutually shape one another, post-phenomenology also conveys that technologies are not neutral but shaped by human values, social norms, and cultural contexts (Voordijk, A., et al., 2019).

Post-phenomenological investigations of smart city roll-out and adoption can be related to Value-Sensitive Design, an approach to designing technology that takes into account human needs and characteristics. By adopting a post-phenomenological perspective, designers can identify the ways in which smart city technologies are shaping human experiences and values, and use this knowledge to design technologies that align with various community principles. This approach's methods can be used to assess how smart city technologies are designed in a way that is sensitive to human values such as privacy, autonomy, and social justice, ultimately leading to more ethical and socially responsible smart city developments (Helbing, D., et al., 2021). Relative to FloodWatch, an overarching theme is making value-sensitive decisions in implementations for various aspects of the project that in any way interact with users and citizens.

Limitations of this Work

Due to various financial and time related constraints this research certainly is not free of gaps in knowledge, a limitation of this work. Furthermore, due to my limited experience exploring post-phenomenology and making use of Value-Sensitive Design, it should be known that this information for now should be held separately from any official publications or documents related to professional work on smart cities and any academic or professional analysis of smart cities from any of the above mentioned perspectives.

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