Detection and Estimation of Inundation and Associated Risks using Traffic Monitoring Cameras and High-resolution Flood Maps under Extreme Flooding Conditions

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19SAUTA04

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$55,000

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Tran-SET
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$110,000

Developing an inundation detection and evaluation framework using images from traffic monitoring cameras and high-resolution flood maps under extreme precipitation conditions

During extreme flooding such as Hurricane Harvey, photo images from traffic monitoring cameras provide critical information, sometimes as the only reliable source, to identify whether or not a road is flooded. The advent of new image processing and filtering technologies has enabled us to extract extent of inundation from low-resolution photos with reasonable accuracy. Despite the high potential, however, the images from traffic monitoring systems have yet to be investigated to extract more accurate flood information using objective and automatic ways. The main objective of this project is to develop an inundation detection and evaluation framework using images from traffic monitoring cameras and high-resolution flood maps under extreme precipitation conditions. A new Bayesian filtering method will be devised to detect occurrence of flooding and extract inundation extent from low-resolution images taken by the existing traffic monitoring cameras during the extreme events. High-resolution urban flood modeling will produce street-resolving flood maps based on multiple extreme precipitation frequencies. Capability of the filtering algorithm and the flood model will be demonstrated for the past extreme event (e.g. Hurricane Harvey) at a city scale (e.g. the Downtown Houston areas).

Problem Statement

During extreme flooding such as Hurricane Harvey, photo images from traffic monitoring cameras (Fig. 1) provide critical information, sometimes as the only reliable source, to identify whether or not a road is flooded. The advent of new image processing and filtering technologies has enabled us to extract extent of inundation from low-resolution photos with reasonable accuracy. Despite the high potential, however, the images from traffic monitoring systems have yet to be investigated to extract more accurate flood information using objective and automatic ways. Once flooding is detected on the roads, it is crucial to estimate the spatial impact of local flooding to highways and roads in the vicinity to establish a traffic control plan and find the best route for the first responders. There is also high potential for high-resolution urban flood modeling to provide the street-resolving flooding information for the larger area by combining point-scale flooding information detected by traffic monitoring systems with pre-simulated flood maps.

Figure 1. Example images taken by road traffic monitoring cameras during Hurricane Harvey.

Objectives

The main objective of this project is to develop an inundation detection and evaluation framework using images from traffic monitoring cameras and high-resolution flood maps under extreme precipitation conditions. As shown in the schematic of the framework (Fig. 2), a new Bayesian filtering method will be devised and applied to detect occurrence of flooding and extract inundation extent from low-resolution images taken by the existing traffic monitoring cameras during the extreme events. High-resolution urban flood modeling produces street resolving flood maps based on multiple extreme precipitation frequencies. Capability of developed filtering algorithm and flood model will be demonstrated for the past extreme event (e.g. Hurricane Harvey) at a city scale (e.g. the Downtown Houston areas). The developed tools will be potentially applicable in real-time to all sites monitored by road traffic cameras.

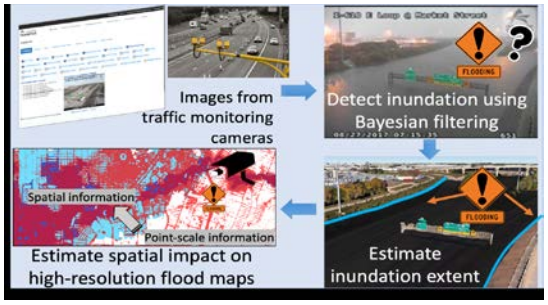

Figure 2. An overview of the inundation detection and evaluation framework.

Intended Implementation of Research

Education and Workforce Development: Findings will support curriculum improvements at UTA. The research team will develop educational modules to discuss this project to undergraduate and graduate students in UTA. The image analysis technique and high-resolution flood maps produced in this project will be used as class materials to show real-world applications in Region 6 area in the multiple courses in UTA such as 'GIS and Hydrologic & Hydraulic modeling', 'Hydraulic Design', and 'Advanced Hydraulics'. The team will support one PhD student in UTA under this project. Students from underrepresented populations will be considered in high priority.

• The approach will help traffic engineers easily detect inundation with reasonable accuracy using existing traffic monitoring cameras.

• An integrated information from the extracted inundation and high-resolution flood maps will improve operations and decisions by traffic engineers under extreme conditions.

• Online-learning material will be developed to assist current practitioners for realistic workforce development (YouTube videos and webinar).

Outreach Activities: The implementation phase of the project will consist of outreach activities, including to:

• Elaborate a short document aimed at DOT and practicing engineers detailing research findings,

• Present research results from the project in technical meetings,

• Improve engineering curriculum at the University of Texas at Arlington (UTA),

• Build partnerships with city planners and engineers,

• Provide online-learning material to assist current practitioners.

Anticipated Impacts/Benefits of Implementation

This project will have a positive impact for the communities of Region 6 where traffic monitoring cameras area are in operations and images from cameras are publicly available for estimating inundation. High-resolution two-dimensional flood modeling will provide street-resolving inundation maps under extreme rainfall conditions. Combining the inundation detected at the monitored locations with high-resolution flood maps will provide high-fidelity inundation information and associated flooding risk for a wide range of areas around critical roadways.

Web links

- TranSET's website (https://transet.lsu.edu/research-in-progress/)
- TRB's Research in Progress (RIP) database (https://rip.trb.org/View/1644426)

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Mr. Christopher Melson (Tran-SET Program Manager) directly at transet@lsu.edu.