Real-Time Early Detection and Monitoring of Flooding Using Low-Cost Highly Sensitivity Ultrasonic Sensing of Water Level

Development and implementation of a real-time highly sensitive and highly efficient solar-powered water level detection units on critical corridors for both short-term and long-term monitoring

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$58,000

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$116,000

Flooding poses safety hazards to motorists, emergency and maintenance crews and may cause costly damage to transportation infrastructure and its operation. Water level detection units are commonly designed for riverine flooding rather than flash flooding. Moreover, installation and maintenance of traditional water level sensing systems are expensive. The current cutting-edge water level detection techniques, on the other hand, have significant limitations: noise and erroneous signals from sensors, unstable power management, and slow data transmitting. Unmanned aerial vehicles (UAV) may also be used to sense flash floods in real time. The UAVs, however, have their limitations in that they only provide snap shots of flood information in the short period time they operate. As a promising solution, this study will evaluate a low-cost real-time ultrasound water-level measuring unit at critical corridors in Region 6, to develop integrated-sensing of the low-cost, highly sensitive ultrasonic water level detection (UWLD) unit to increase its reliability and resolution and to integrate it with a highly efficient solar power system and a reliable cellular network. The flood stage information will be transmitted using a cellular module in the UWLD unit to the Region 6 Flood Control District or sent directly to emergency command centers for early warning so that they may take timely action such as citizen/driver evacuation, route/ramp closures, and signal timing modification.

Problem Statement

Flooding poses safety hazards to motorists, emergency and maintenance crews and may cause costly damage to transportation infrastructure and its operation. Flash flooding, in particular, causes the most flood-related deaths. According to NOAA, in 2017 alone, flash flooding also caused $60.7 billion worth of economic damage. Low-water crossings are among the first places where deaths and significant damages to vehicles occur during flooding. With flash flooding, when a critical corridor is blocked by high level of water, it affects the safety of the general public.

To keep the critical corridors open as long as possible and to minimize losses from flooding, accurate early detection of the rising water level is essential. The flood level detection system has to have flood stage maps (i.e., normal or extreme water elevation) in the geographic information system (GIS), for the street-, roadway-, and critical-freight corridors. This area encompasses public roads in urbanized areas which provide access and connection

to the primary roads for ports, public transportation or other transportation facilities. The traffic will exhibit both commuter and freight congestion. The critical corridors are high priority the in Texas Freight Mobility Plan 2017. Water level detection units are commonly designed for riverine flooding rather than flash flooding. Moreover, installation and maintenance of traditional water level sensing systems are expensive (> $ 75,000). The current cutting-edge water level detection techniques, on the other hand, have significant limitations: noise and erroneous signals from sensors, unstable power management, and slow data transmitting. Unmanned aerial vehicles (UAV) may also be used to sense flash floods in real time. The UAVs, however, have their limitations in that they only provide snap shots of flood information in the short period time they operate.

Objectives

The proposed study will evaluate and improve a low-cost (under $200) high-sensitivity (< 1 mm) real-time high-water detection unit based on advanced ultrasonic distance sensing which may be used for detection and monitoring of water levels on roadways as well as in and around other transportation infrastructure (Figure 1). The ultrasound water-level measuring unit will be evaluated at critical corridors in Region 6. An integrated-sensing of the UWLD unit to increase reliability and resolution will be developed. A highly efficient solar power system and a reliable cellular network will be integrated to the detection unit.

The objectives of this study is to do the following: (a) Evaluate a low-cost real-time ultrasonic water level detection (UWLD) unit at critical corridors in Region 6; (b) develop integrated-sensing of the UWLD unit to increase its reliability and resolution; and (c) integrate the unit with a highly efficient solar power system and a reliable cellular network.

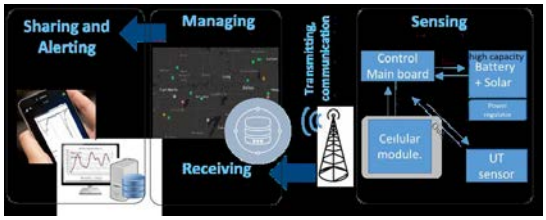

Figure 1. UTA low-cost, highly sensitive ultrasonic water level detection (UWLD) system.

Intended Implementation of Research

Education and Workforce Development: The PI will incorporate and integrate research findings into two courses that will teach at UTA: CE5300-2, "Real-Time Wireless System," and CE5352 "Sensing for Civil Infrastructure." The PI will incorporate and integrate specific aspects of the research (sensing and monitoring) into a planned graduate level course: "Advanced physical acoustics." The team plans to support total of two PhD students and one Master's student in UTA under this project. At least two underrepresented populations will be involved in this project, including a faculty member. The students in Transportation Group will have opportunity to synthesize literature and current practice in sensor utilization, and to develop the evaluation tool. The student in Structure Group will learn sensor design and development for implementation. All the students will engage with city planners and stakeholders to get feedbacks and technical advice on decision making process, and to arrange field implementation. 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.

Outreach Activities: The team will invite leaders from companion programs to UTA for seminars. Other information will be disseminated at conferences and papers dedicated to this topic. He will also consult with Region 6 DOT concerning the best way to contact state leaders who are open to meetings with those who could best use this technology. The research team will also work to build partnerships with city planners and engineers, providing information and support to ensure that our research findings and strategies can be maximized in a decision-making process for transportation planning.

Anticipated Impacts/Benefits of Implementation

It will be potentially a valuable water level detecting unit for Region 6, allowing flood stage information to reach critical corridors using a cellular module in the UWLD system to communicate with Region 6 traffic command centers. Information can also be directly sent to Texas emergency operation centers or other local/regional centers. The accurate and rapid flood information will transfer to a district operation center to potentially reduce damage and accidents as well help in the preservation of the transportation network from damage caused by flash floods alerting them more quickly about flooding situations. This project will address a direct need to improve the ability to assess and reduce the impacts of severe weather events on the transportation infrastructure and travelers' safety.

Web links

- TranSET's website (https://transet.lsu.edu/research-in-progress/)
- TRB's Research in Progress (RIP) database (https://rip.trb.org/View/1644425)

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.