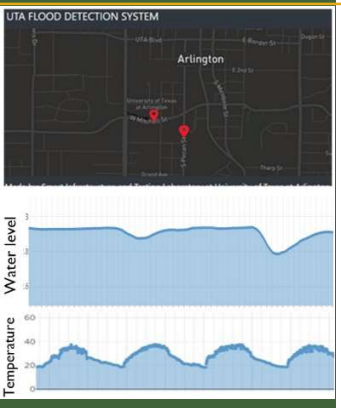
Real-Time Early Detection and Monitoring of Flooding Using Low-Cost Highly Sensitivity Ultrasound Sensing of Water Level



Monitoring the water level change measured by the low-cast and high-sensitive ultrasonic water level detection (UWLD) system.

Floods are one of the most frequent natural disasters, not only causing costly damage to infrastructure and property but also causing injuries or fatalities. In some cases, flash floods cannot be drained in time, causing urban inundation and stream overflow. Hence, the ultrasonic water level detection (UWLD) system is developed to monitor the water level in real-time. The power management and minimized power consumption of the unit are essential in order to ensure a long-term stable operation. In addition, flood monitoring for both urban inundation and stream overflow is significant. 1) The proposed dual microcontroller was used to obtain the minimized power consumption unit, and 2) the proposed dual ultrasonic sensor was installed to monitor both pavement and streamside water level change.

Highlight | Dec. 2020

Project No. 19ASUTA03

PI: Dr. Suyun Ham (UTA)

Dr. Dong-Jun Seo (UTA)

Dr. Seong Jin Noh (UTA)

POP: Aug. 2019 – Jan 2021

Background

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 a 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.

Project Summary

The main goal of this project is to develop cost-effective and high efficient solar-powered water level detection units and implement real-time water level monitoring for water both pavement and river stream. The project was performed with three objectives: to develop the low cost reliable real-time data of the ultrasound water level detection system, increasing its data reliability and resolution; 2) to improve an energy-saving processing system; and to deploy the ultrasound water level detection system and real-time monitoring system for water both pavement and river stream for safety measures. The obtained results and findings imply the developed monitoring system can present reliable water level data with efficient power and data transmission system.

Status Update

In order to ensure a long-term stable operation, a low power consumption design of the UWLD unit is proposed by controlling the unit with the dual microcontroller (MCU). Dual MCU is adopted to improve this inefficiency of the sleep mode by installing the additional MCU and solid-state relay (SSR), which has lesser power consumption. It would be anticipated that the total power consumption will have dwindled when the additional MCU is used as the alarm of the main MCU, which performs the main task, including measurement, calculation, and data transfer. The additional MCU is named as switch MCU because it exists only for turning on/off the main MCU (Figure 1).

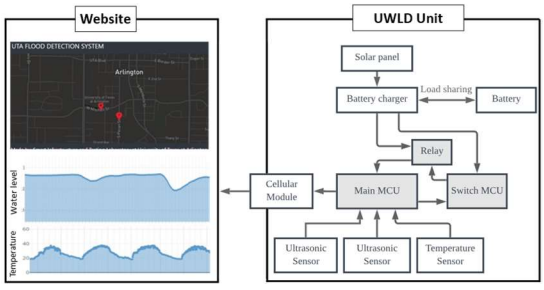


Figure 1. System representation of UWLD.

The battery power efficiency was improved for the stable operation of the UWLD system deploying the dual MCU unit, which is composed of the additional MCU (switch MCU) and SSR for controlling the main MCU. The dual MCU system reduced the power consumption from 165 mA to 110 mA of the averaged current consumption (Figure 2). It is significant for power saving during

solar power charging, which is affected by the external environment.

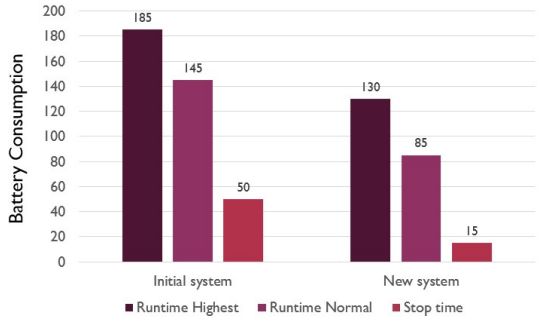


Figure 2. Battery consumption of the single (initial system) and dual MCU (New system) units

Ultrasound sensors are deployed to calculate the distance between the sensor and the water surface. Water on the pavement could not only threaten the life of people but also damage the pavement surface when a flood occurs. So, it is highly important to sense both the water level on the streamside and on the pavement (Figure 3).

Figure 3. Installed UWLD systems on the pavement side and streamside

Impacts

Overall, this is a cost-effective solution to give information on rising water levels in flash flooding. The system is based on a low-cost high-energy efficient distance sensing unit using a high signal-to-noise ratio ultrasound transducer and reliable cellular data transmission. To increase accuracy, the low-cost highly-sensitive ultrasonic water level detection (UWLD) system with energy-efficient dual MCU and dual targets to pavement and streamsides. The potential other applications for this project includes the followings: providing researchers with a good amount of detailed research data, which will in-turn help researchers to incorporate into future research and possibly expand its features and applications; resulting in the development of an affordable module or unit to offer precise sensing data in real-time; being capable of operating in a wide array of environments, from extreme summers to extreme winters with water-resistant helping people in foreign lands, where there are very few measures and devices to predict flash flooding events.

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 Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.