Multi-Level Adaptive Remote Sensing Package for Bridge Scour Health Management
Arizona State University

Executive Summary

Over the past few decades, various fixed scour monitoring instruments such as sonar, manual sliding collar, tilt sensors, and sounding rods have been installed on bridge structures for measuring bridge scour depth. Typical issues reported of unmanned detection techniques are either vulnerability or survivability of the device under harsh conditions.

In this project for the U.S. Department of Transportation (DOT), our overarching objective was to develop an integrated means for reliable monitoring, inspection, detection, and prediction of local scour for bridge structures. Our Multi-level, Adaptive, Remote Sensing System (MARSS) integrates remote sensing and wireless technology with adaptive information processing, Gaussian process and particle filtering for prognosis, and a decision support system to assess different modes of scour (i.e., clear-water vs. live-bed scour) as well as their extent in terms of depth and volume near bridge structures.

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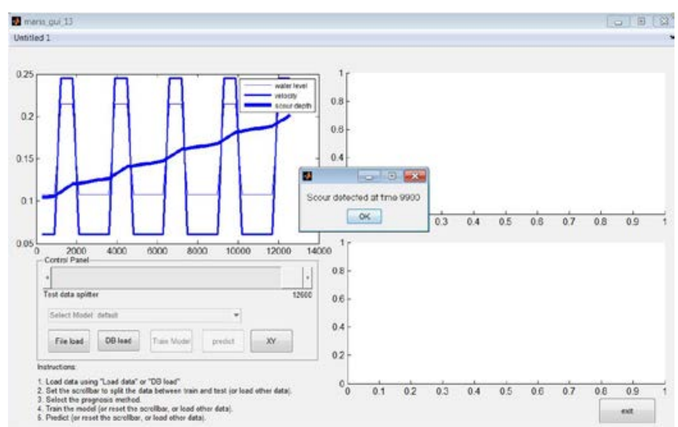
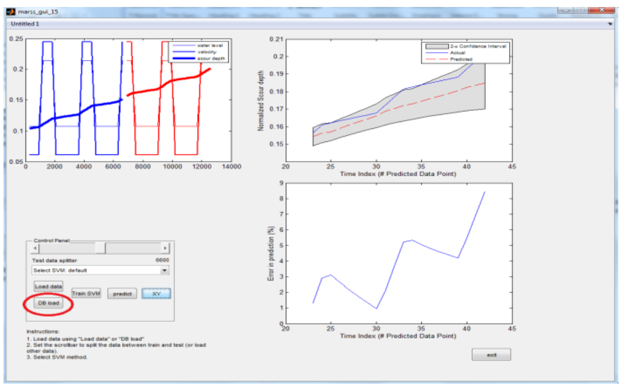
Findings and Output

Radio Frequency ID (RFID) was developed for online detection of local scour around bridge piers during scour critical events. The key component of the RFID system is the reader. The reader not only emits the initial radio signal to activate the RFID transponders, but also receives and processes the return signal from the transponders. Three readers for the RFID systems were constructed by assembling the various electronic components, which included the circuit boards, attached wires, and connection ports for the computer and RFID antenna. RFID detection software PAPTSAK was developed. This software was needed for the integration of the RFID system into the MARSS package. The software calculates the inclination angle of the RFID sensor with respect to the excitation antenna.

One of the critical components of detection in MARSS is the critical scour depth. A scour estimation equation was developed based on the available filed data as a threshold scour depth. Detection in MARSS has two components. (i) Detection during data collection: a data examination procedure has been added into the data-gathering software of the gateway. If scour is detected then an alert procedure is activated. The alert procedure can perform actions according to the preferences of the operator, e.g. can make an audible signal at the gateway, initiate more frequent data sampling, or send in a notification to a control room if connectivity to it is available. (ii) During the loading of data from the database, the MARSS software reviews the values and runs a scour detection technique, which in the simplest form is a value comparison to a preconfigured threshold. Once scour above threshold is detected, then a message dialog box pops up and warns the user of the detection



The evolution of scour is highly stochastic in nature. Therefore, in order to capture this uncertainty, probabilistic prognostic methods were developed to predict scour depth. A Gaussian process based prognosis model was developed to predict temporal scour using laboratory and field data sets. A stochastic filtering approach (particle-filtering) was developed and integrated with the Gaussian process prognosis model to (i) include the uncertainty in measurement data from the RFID sensors and (ii) to predict the scour depth using training data. A Decision Support System (DSS) with a robust database, which covers bridges and piers information along with the RFIDs attached to each pier and their dependents like transmitters and their activities was designed for MARSS. In MARSS, we have managed to bring multiple uses into one, easy-to-use interface.



Products & Outcomes

RFID and MARSS system was implemented in two sites in Iowa and Arizona. In Iowa, a geodetic survey was conducted using a Total Station of a 350-m long reach of Clear Creek near Camp Cardinal in Johnson County, IA where the RFIDs were installed. A series of four RFID transponders were placed at 2, 4, 8, and 12 ft. depths below the bed surface at the Clear Creek site. They were secured to a chain that ran along the stream bed and up the bank to a ground anchor. A field test was also conducted at N Bush Highway Bridge at Blue Point picnic area in Arizona. We were able to get a detection distance of 24 ft. with at least 50% success rate or higher and 32 ft. with 37% success rate. The prognosis software can predict scour depth with a minimum of 90% accuracy.

Post Project Initiatives (Future Projects)

In future projects, a few minor improvements can be done before vast implementation of MARSS for scour detection and prediction. (i) the bridges located at places with very poor connectivity should be studied; (ii) the source of power to be used to charge the device to which the base station is connected needs to be studied. Solar energy stands as an option to charge the device for many states in the country; (iii) at the current status, the sensor network for data collection must be entirely under the bridge as it was observed that the bridge concrete top deck had a fast fading effect on the signal and hence reduced the signal strength by a great extent. Effect of concrete and metallic structures on the performance of MARSS needs to be studied.

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