Microsoft Research

Wireless Sensor Network Provides Early Flood Detection for Underserved Countries

Devastation caused by flooding is often more severe in the developing world, where sophisticated flood detection technologies are neither affordable nor practical. To address this urgent problem, a team of researchers at the Massachusetts Institute of Technology is designing a low-cost, wireless flood detection system that meets the needs of communities with limited resources and rudimentary communications infrastructure.

The Aguán River in northeastern Honduras, whose basin and riverbanks are home to 35,000 people, floods each year during the rainy season. Every five to 10 years, a catastrophic flood occurs—such as in 1998, when Hurricane Mitch caused the river to breach its banks in numerous places and wash away the entire village of Santa Rosa de Aguán, killing several people.

Such destruction and loss of life from natural disasters is a challenge worldwide. But it is most acute in the developing world, where weather monitoring technology and emergency warning systems are almost entirely nonexistent. The Indian Ocean tsunami of 2004 was the most dramatic recent example—hundreds of thousands of people were swept into the ocean without any warning of the impending disaster.

The flood warning systems used in the developed world are expensive and rely on expert hydrologists who monitor real-time data 24 hours a day and run sophisticated computational models at a centralized location. These kinds of resources are both unaffordable and impractical for poorer countries.

To address this glaring disparity, a team of researchers at the Massachusetts Institute of Technology (MIT) in Cambridge is designing an affordable automated flood warning

MIT researchers tested some of their sensor prototypes at this location on the Aguán River in northeastern Honduras.

Fast Facts

Project: Early Warning Flood Systems Based on Sensor Networks

Project Principals:

Dr. Daniela Rus and **Elizabeth Basha**, Massachusetts Institute of Technology

Partner:

Fundacíon San Alonso Rodríguez (FSAR)

Web Site:

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Profile:

MIT researchers have designed a low-cost, wireless flood detection system for developing countries that relies on automated sensor networks. The prototype technologies and computational algorithms are being field tested in Honduras.

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system that takes into account an array of challenges in the developing world: lack of resources and trained personnel, harsh physical conditions, large physical areas to monitor and a partly illiterate population.

Led by Professor Daniela Rus of MIT's Computer Science and Artificial Intelligence Laboratory and Ph.D. student Elizabeth Basha, the team is field testing a prototype system on the Aguán River in collaboration with Fundacíon San Alonso Rodríguez (FSAR), a Honduran nonprofit organization dedicated to providing communities with technical assistance in such areas as agriculture and sanitation. The MIT system consists of an automated sensor network running prediction software that measures and computes in real time in order to address changing conditions during a flood.

The project began in 2004 and received research funding and technology resources from the Microsoft Research Digital Inclusion Program in 2006. The MIT researchers have worked on developing the technology, while FSAR has worked with the Honduran government on a complementary effort to create a flood alert process and evacuation plans for the local population, which depends on fishing and farming for a living.

A key part of the project has been examining the tradeoffs between controlling costs and increasing sensing accuracy, computational power and redundancy in the system.

The system developed by the MIT researchers uses a combination of 900 MHz and 144 MHz radio frequencies for data transmission, which means that sensor clusters in the network can be as far apart as 34.2 miles (55 kilometers). Radio antenna towers built to withstand hurricane-force winds support this long-range communication. Some sensor locations are designated as "government office nodes" and have an office with a laptop computer where data is collected and stored, some predictive computation is done and alert notifications are displayed. Solar-powered backup systems are in place at these sites in case the power grid fails.

The procedure for alerting the community about an impending flood is still being formulated. It might involve having the predictive software trigger a flashing-light signal in the homes of certain city officials, who can then use centralized radio megaphones to alert the community and initiate evacuation.

Because accurate geographical models and historical data on flooding of the Aguán River are not available, the researchers have relied on the memories of community members to chart where the river has previously flooded and how high the water has risen. Based on this information, they have written software designed to predict an impending flood and the likely flood zones.

Among the many technical challenges faced by the researchers has been finding the optimal approach to water measurement. After trying many different approaches, they settled on measuring water pressure to gauge the river level. Sensor boxes for taking these measurements can be installed on a bridge or in the middle of the river, in the latter case attached to a cement-filled tire and chained to the shore.

Theft and vandalism have also presented a challenge, so the team has had to devise solutions such as surrounding antenna towers with fencing and barbed wire, camouflaging sensor equipment and running cable within PVC pipes.

FSAR, which has deep roots in the community and initiated the partnership, has funded its own part of the work and participated in every facet of the project, from securing land for antenna towers to finding local suppliers of raw materials. "They initiated the project because of community feedback, which guarantees the support of the community in implementing and maintaining the system," says Basha, whose doctoral dissertation will be based on this project.

Rus says that a key part of the project has been examining the tradeoffs between controlling costs—and thereby ensuring a more feasible, scalable solution—and increasing sensing accuracy, computational power and redundancy in the system. The prototype sensors have cost about US$200 apiece to build, but with economies of scale, the cost could be reduced to $50 or even $10 per unit, says Rus.

"What I find exciting about Elizabeth's work is that she's been able to map the computation-intensive prediction to a much leaner system," says Rus. "It's a very exciting research project, not just because it solves a specific problem for the developing world but because Elizabeth's approach opens the door to new ways of doing model-driven computation in sensor networks. Hopefully it will extend beyond helping people with weather issues." Rus cites agricultural field monitoring, hospital patient systems, traffic congestion relief systems and other types of natural disaster monitoring as examples of possible future applications.

Adds Rus: "This project is turning into one with both social and scientific impact. We're really thrilled to be able to get it off the ground—and we wouldn't have been able to do it without the help from Microsoft Research."