

Real-time Displacement Monitoring Based on Wireless Sensor Networks for Landslide-prone Areas

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Background



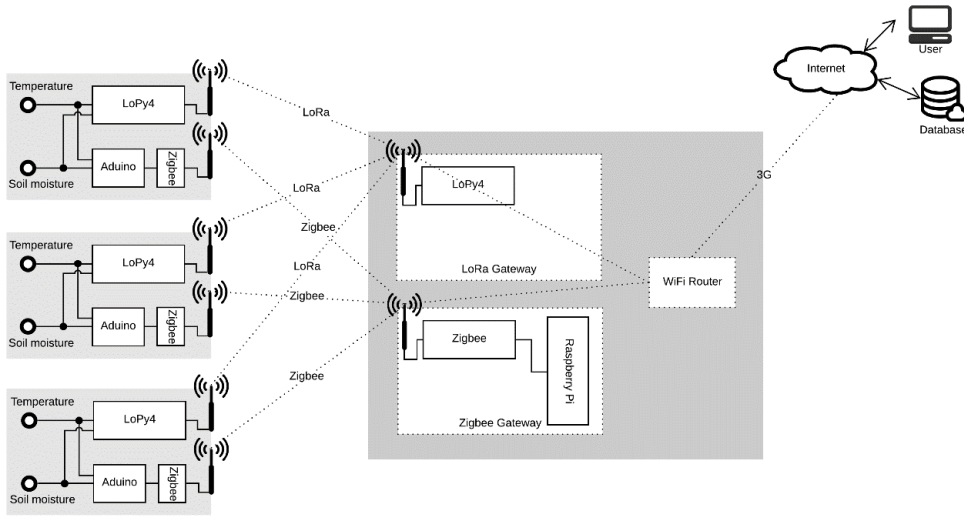
Industrial park at Shenzhen, Guangdong Province, China (Dec 20, 2015)

- 33 destroyed industrial buildings buried under 20 feet
- More than 90 people missing during the landslide.

Source: <https://www.nbcnews.com/slideshow/massive-landslide-destroyed-buildings-shenzhen-least-27-unaccounted-n483401>

To encounter the risk, ICT-based system has been developed to predict, mitigate, prevent and manage the disaster situation.

ICT-based system using wireless sensor networks (WSN) for monitoring the landslide-prone areas



[Ongoing projected] Structure of the based on WSN being tested and installed at the test site in Chiang Mai, Thailand.

This project are the collaboration between Japan, Vietnam, Philippines, and Laos under the support from ASEAN COSTI and e-Asia JRP.

Important parameters to monitor the landslide-prone areas:

- Soil moisture
- Temperature
- Precipitation
- **Surface displacement**

Geotechnical expertise is needed for installing the extensometer equipment !!

Purpose

- To develop and implement a new method:
 - *Improve the accuracy of the surface displacement.*
 - *Suitable for landslide monitoring applications.*

Objectives

- To investigate how to apply the current distance measurement techniques for the WSN to landslide monitoring applications.
 - *The challenge lies in the fact that the distance resolution of WSN-based measurement is relatively high; hence, it might not be suitable for landslide applications.*
- To apply data fusion techniques, such as Kalman filtering and Dempster-Shafer theory, in distance measurement accuracy improvement.
- To collect displacement data for analysis.

Distance Estimations in WSNs

Global Positioning System (GPS)

- Navigation system that provides geolocation and time information to a GPS receiver.
- High accuracy & low cost.
- Limited under indoor, high building compact or obstructed geological areas.

Inertial Navigation System (INS)

- Navigation device that the estimated displacement by continuously calculating the position, the orientation, and the velocity of a moving object without the need for external references.
- Not suitable for long term tracking applications and practical application due to accumulative errors and drifting problem.

Time of Arrival (TOA)

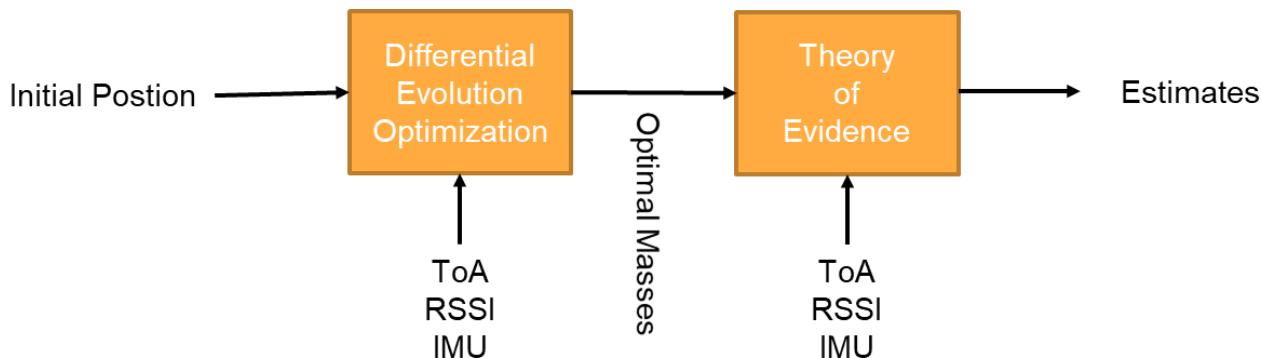
- The estimated displacement can be done by recording the absolute time instant when the transmission signal from base station reach the receiver.
- Limited under non-line-of-sight (NLOS) environments.

Received Signal Strength (RSSI)

- The estimated displacement can be done by measuring the signal's power and translates it to distance using the path loss model.
- Limited under non-line-of-sight (NLOS) environments.

Research Gap & Challenges

- To apply the multi-sensor fusion approaches to improve the precision of distance measurement in landslide monitoring applications.
 - The output from INS, ToA-based method, and RSSI-based method are fused by multi-sensor data fusion techniques.
 - To select the optimized parameters used in data fusion techniques, any optimization algorithm can be applied.



[Example of the proposed framework] The data to be fused is obtained from ToA, RSSI, and IMU. The fusion technique is based on the theory of evidence (or DST). The parameters used in DST, such masses, can be determined by the differential evolution algorithm.

Plan for connected projects

- The period of the proposed project is planned for 12 months. The links between the proposed project and other related projects can be summarized in the table below.

Project	Period	Partner	Funding Source	Relation/Integration
Real-time Monitoring Based on Wireless Sensor Networks for Landslide-prone Areas	2018-2021	PHL, LAO	ASEAN COSTI	The proposed research project can be implemented on the wireless sensor networks developed and deployed in these two projects. Thus, it upgrades the capability of the existing networks.
Establishment of a Landslide Monitoring and Prediction System	2019-2021	JPN, VNM	e-Asia JRP	
Relay Station Network Based on Low-power Wide-area Network (LPWAN) Technologies	2019-2021	JPN, BRN, PHL, LAO, MMR	ASEAN IVO	The relay station network can be used to forward data (including surface displacement) collected from the WSN installed in a no-3G/4G-signal area to a server.