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The Implementation of Debris Flow Seismic Detector With Raspberry Shake

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Abstract

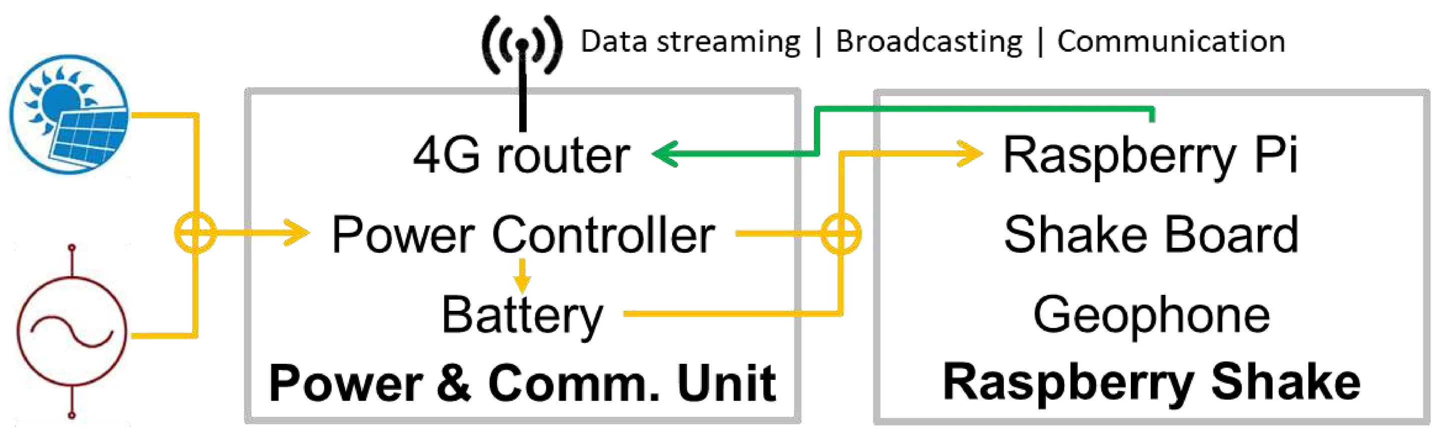
Seismology is a convincing approach to monitor debris flow in the past decade. Some literatures showed that debris flow could generate seismic waves with specific time and spectral behaviors different from earthquake. The unique characteristics of debris flow seismic signal show the possibility to create a detector to identify event occurrence. This work tried to implement this idea with an IoT-based seismic sensor Raspberry Shake to monitor debris flow process in a natural creek. Two Raspberry Shakes were deployed in the study area along the natural creek which was gradually formed by landslides during 2015 - 2016 in Wulai, New Taipei City, Taiwan. The measurement started from April 2017 to the end of year in order to monitor the debris flow process and river sediment process and to evaluate the performance of the devices. Meanwhile, the archive data, including due to three real debris flows, recorded by the other seismometer network in different field were used to examine the event detection algorithm constructed by traditional STA/LTA method. Although there was no debris flow detected by Raspberry Shakes during the study period, several earthquakes were clearly recognized in seismic recording, and river process due to heavy rainfall by Typhoon Maria also well corresponds with local rain gauge data and water level measured at down-stream. The results showed the potential of monitoring other geomorphic processes, including debris flow. Moreover, the built-in operation system of Raspberry Shake would be a suitable platform to install the detection algorithm for in-situ operation purpose, and that will be examined in the next phase.

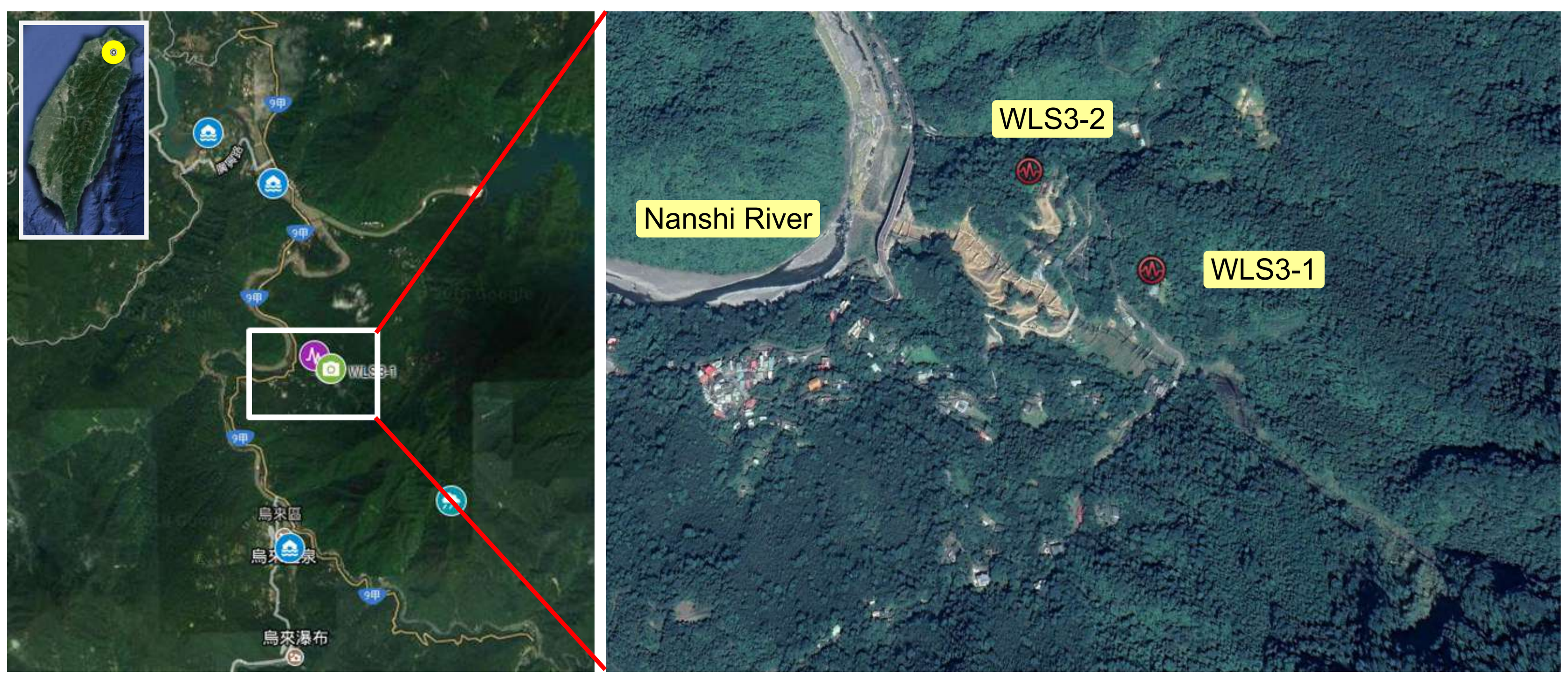
I. Introduction

Seismology was increasingly used for monitoring geomorphic processes, such as debris flow, during the last two decades. Some case studies in literature showed that debris flow could generate seismic wave with the similar features of spindle shape in time series and triangular shape in spectrogram [1, 2]. These features are helpful to identify debris flow signal from the continuous seismic recording. Thanks to the IoT instrument technology, the seismic sensor and computation unit could be integrated as a single device, which is beneficial for low cost, low power consumption and convenient network construction. This work tried to use an IoT-based seismic device, Raspberry Shake (RS), to monitor debris flow in a natural creek. Originally, RS seismometer is designed for different purposes, i.e. home usage, amateur exploring and education need. Therefore, the performance of the device for installing outside and monitoring the specific geomorphic process needs to be evaluated, especially in severe environmental condition. In this work, RS was fixed in waterproof case, integrated with power controller and 4G internet router, and deployed near a natural creek in north of Taiwan. Meanwhile, three debris flows from other site in 2013 and 2014 were used to calibrate the Debris Flow Detector (DFD) algorithm, which will work inside the RS in the future plan.

II. Deployment of Seismometer

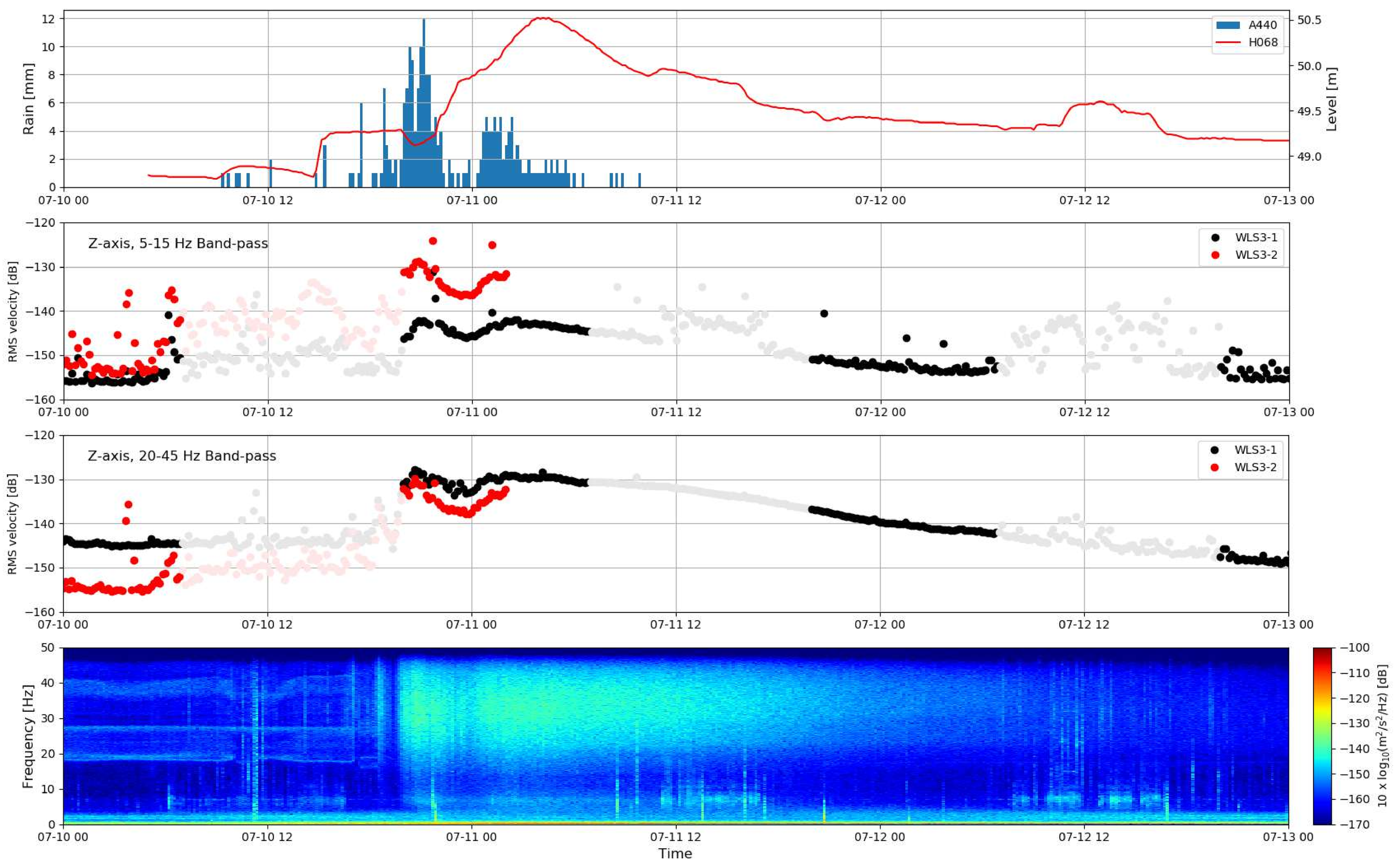
Two RS seismometers, WLS3-1 and WLS3-2, were deployed along the landslide-formed creek near Nanshi River in Wulai, New Taipei City, Taiwan. Before installation, this work partially modified the structure of RS to improve the system stability. In detail, a power controller was used to get AC or solar power input and supply DC output to RS and rechargeable batteries as the backup power. 4G router served as a link for several purposes, i.e. streaming data to designated server, broadcasting message to end-users, and two-way communication. This study also created the waterproof case to embed RS inside and integrate the power, I/O and internet lines in single cable. In field, this work buried the seismometer under ground to avoid noise as much as possible. This study dug a pit about 60-80 cm, fixed a tank by concrete to form an empty space under ground, and placed RS inside of the tank. The batteries, power controller and 4G router were placed in the other case. After installation, the whole system was covered by sand to attenuate the noise by rain drop above.



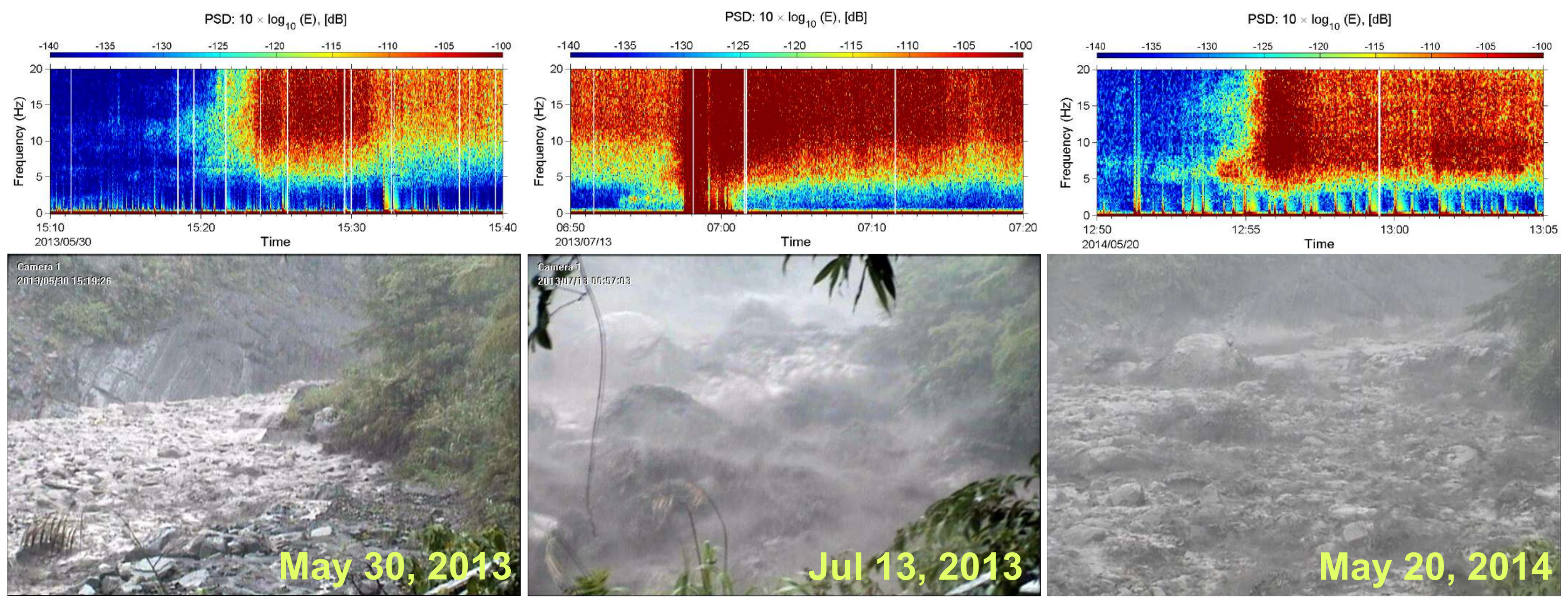


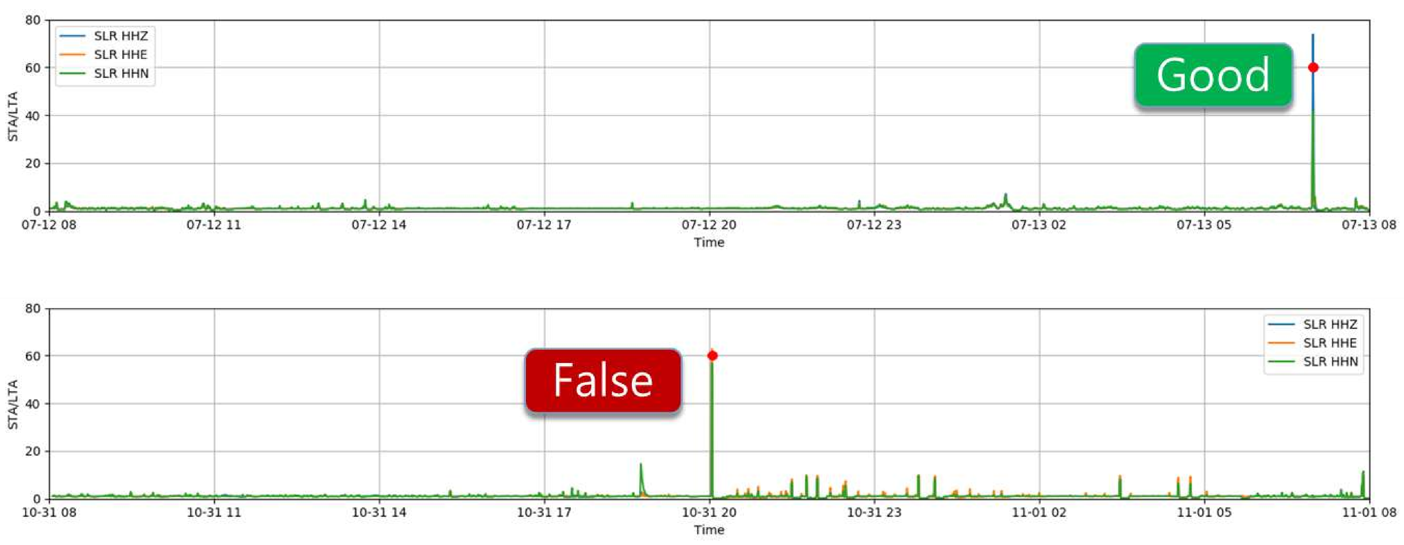
III. Data Analysis

The data recovery during test period of nine months was more than 98%, which meant the system worked reliably. Even though there was no debris flow took place in the period, some signals due to typhoon could be used to examine the performance of RS. The fluctuation of seismic energy below 1 Hz due to ocean wave was correspondent with typhoon strength and path. Above 1 Hz, this work focus on 5-15 Hz and 20-45 Hz bands. Sediment transportation in Nanshi River could generate 5-15 Hz seismic wave, and the received energy at WLS3-2 was higher than WLS3-1 because of the attenuation by different range to Nanshi River. In 20-45 Hz, the received energy at both stations were in similar level, considering that the seismic contribution was from local surface water effect.



The DFD algorithm was developed from traditional STA/LTA method considering about the low computation requirement. For identifying the difference of debris flow and earthquake, two bandpass filters worked with STA/LTA calculation. The off-line test of DFD (v.3) was estimated by using the 1-year long data recorded from other site, and three debris flows could be detected successfully with one false alarm by local earthquake.





IV. Conclusion

This work used RS seismometer and developed a stable platform to work as an in-situ debris flow alarm system. The performance of RS are reliable and the sensitivity is high enough to sense local sediment transportation in the river. Although there was no debris flow event in the test period, the RS is affordable to monitor such geomorphic process for sure based on the results in this work. The test of the on-line operation version of DFD and RS will be carried out in our future plan.

Acknowledgement

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[3] *Source*: 24º53’7.31” N and 121º33’24.88” E. Google Earth. October 29th, 2018.