FLOOD DETECTION AND FORECAST BY IOT TECHNOLOGY

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Introduction

Under the influence of climate change, the scale and impact of flood disasters have become more and more severe in Taiwan due to the increase in rainfall intensity and urbanization. To strengthen the technology of flood detection and forecast in urban areas, an IoT (Internet of Things) based flood sensor (named flood box) and a flood prediction model based on ML (machine learning) technology were developed in this study. The flood boxes have been installed at several low-lying locations in Tainan, Taiwan and functioned normally under outdoor rainy weather conditions. The ML model was used to predict the inundation depth at the locations where flood sensors are absent or malfunctioned. Satisfactory agreements between prediction and observation are found.

Study Subjects

The Tainan City in Taiwan is selected as the study area. In this area, 13 flood sensors out of the sensors installed by WRA are selected for analysis as shown in Figure 1. The historical flood event occurred on Aug. 13 in 2019 is selected for case study, which has brought 188 mm of rainfall in 3 hours.

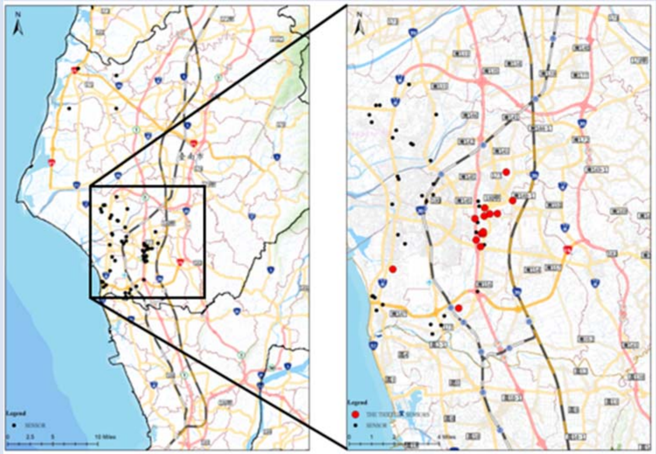


Figure 1. The locations of flood sensors in this study

Methodologies

Flood box

- Contains five components, including an ultrasonic sensor, an Arduino circuit board (with LoRa module function), an analog signal display, a power supply battery, and a circuit board connected to an antenna.
- The measured water levels are wirelessly transmitted to a Raspyberry Pi via LoRa and upload to a cloud server in a period of 10 mins.
- The device is small in size, low in power consumption, and using open source language to reduce cost.

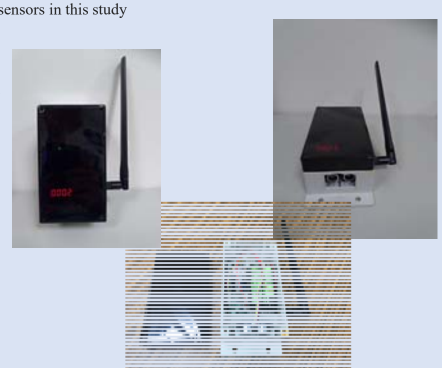


Figure 2. Flood sensor

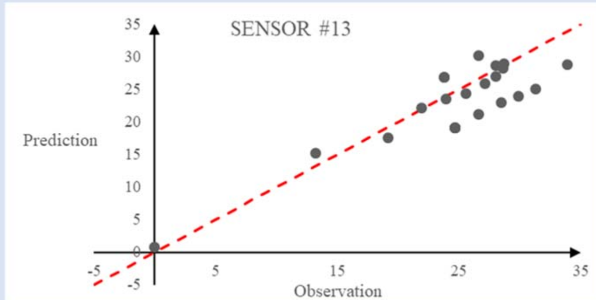
ML Model

- In this study, the inundation depths measured by the 13 flood sensors during the study event are served as the database for the ML model using the SVR (Support Vector Regression) algorithm.
- For each sensor, there are a total of 59 inundation depths recorded every 10 minutes from 3:00 a.m. to 12:40 p.m. in 13 Aug., 2019, which are divided into two groups with a ratio of 6: 4 for training and test, respectively.
- By assuming there is a sensor failed once a time, the data of the rest 12 sensors are used to predict the inundation depths for the failed sensor. The regression function can be express by the following equation in which f(x) is the inundation depth of sensor i, $\dot{x}$ is the inundation depths of the remaining 12 sensors, $\dot{\omega}$ is the vector of weights; b is the bias.

$$f_i(x) = \dot{\omega} \cdot \dot{x} + b$$

Conclusions

- Figure 3 shows the comparisons between the observed and predicted inundation depths when Station #13 and Station #5 are assumed to be failed.
- The predictions are slightly underestimated and overestimated for Sensor #13 and Sensor #5, respectively. Overall, the predictions given by the SVR are satisfactory with RMSE of 5.73 cm.
- In the future, the ML model can be improved when more data are recorded by the sensors and the results can be open to the public for disaster prevention uses.



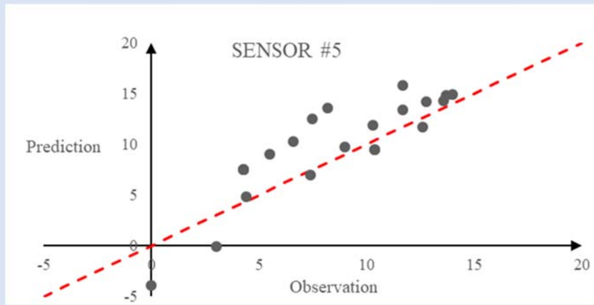


Figure 3. Comparison between observed and predicted inundation depths for Sensor #13 and Sensor #5.

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