An Affordable Smart Sensor Network for Water Level Management in a Catchment

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Introduction

Accurately monitoring water levels at high special and temporal scale is the key element in every catchment or flood risk management system. Building, evaluating and testing hydrological models typically require years of high frequency datasets. Current water level monitoring systems are expensive and usually deployed sparsely throughout a catchment. This may not provide sufficient information to simulate the hydrological variations of a catchment. In this paper, we evaluate the Kingspan Sonic SignalMan ultra-sonic sensor that is designed for monitoring liquid, such as diesel, AdBlue, lubricants additives etc., level autonomously over years. The cost of this sensor is relatively low, which enables the deploying of a water level monitoring system at a much larger spatial scale at an affordable cost. A smart sensor network for catchment management is proposed based on the use of the Kingspan sensor.

Methods

Sensing: To measure river level accurately, eleven ultra-sonic sensor units have been deployed along a number of catchments in south Dublin. Four of these units were installed beside the state-of-the-art Dublin City Council (DCC) existing river level monitoring stations, which were used as the references for the evaluation. The sensors transmit water level measurements to the Kingspan sensor data center via built in 3G/GPRS modules at pre-define schedule or in real time if a pre-defined threshold is breached. The data can be accessed via watchman mobile app, at the watchman website or streamed via SOAP API. Within the scope of this project, the sampling interval is set to 15 min, which matches the sampling rate of the reference stations. Figure 1 shows an example of the installed sensor unit and the mobile app for accessing sensor measurements. To compare the performance, Pearson's Correlation is used to measure the linear correlation between Kingspan sensor and DCC station readings.

Figure 1: Kingspan ultra-sonic in-situ sensor (top left), mobile app for remote data access (middle and bottom left) and one of the installed units.

Smart Sensor Network: In order to manage catchment more effectively, a smart sensor network system is designed. The system

diagram is shown in Figure 2. The initial layer of the system is a network of in-situ water level sensors that operate autonomously. On top of this physical layer is the data processing layer, which extracts abnormal sensor readings from the data stream. To detect the outliers, MoBPAS anomaly detection method is applied (Zhang, 2015).

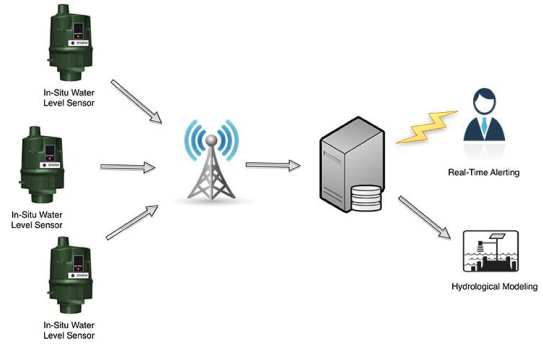

Figure 2: The architecture of the smart sensor network system for catchment management.

Results

To evaluate the performance of the sensor, the data is compared with existing DCC water level stations.

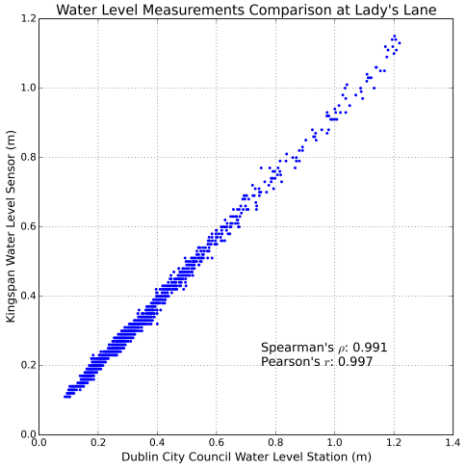

Figure 3: A comparison of DCC data vs. Kingspan in-situ sensor. The result shows that the correlation between these two datasets is very high. This indicates that the Kingspan sensor performs as well as the state-of-the-art water level monitoring stations.

As shown in Figure 3, the correlation between the two systems is very high, which indicates that the Kingspan sensor can provide accurate water level information with a much lower cost. Figure 4 shows an example of the anomaly detection results from a sensor data stream. An alert can be sent to the operators when unusual water level is detected.

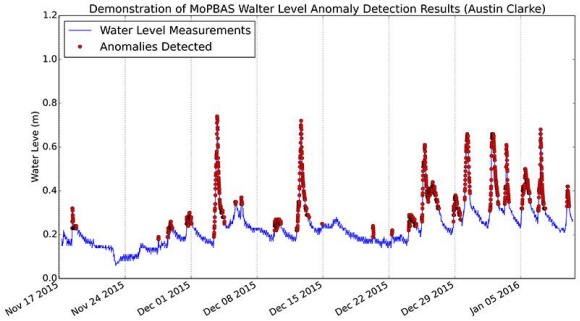

Figure 4: Anomaly detection results using MoPBAS.

Discussion and Conclusions

In this work, the performance of low-cost Kingspan ultra-sonic in-situ water level sensor was evaluated. Results show that the Kingspan sensor can provide comparable water level information with a much lower cost. This can significantly reduce the cost of deploying a large-scale water level monitoring system in any catchment. In addition, a smart sensor network system is proposed for catchment monitoring. The system can detect anomalies and notify operators. The system can also provide high spatial and temporal datasets for further hydrological modeling.

References

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Disclosures

The authors have nothing to disclose.