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Fast Detection of Anomalies in A Model Earth Dam Based on A Distributed Temperature Sensing Data Integrated with Artificial Intelligence

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Abstract

The dam safety evaluation method based on the temperature profile of earth dams has evolved into various forms during the last one-half centennial. One recently developed fiber optics-based method called Discrete Temperature Sensing (DTS) can typically measure the temperature at every one-meter sensing resolution. An innovatively wound DTS can provide even the centimeter range sensing resolution and miles long measurement range. Combining this high-resolution temperature data measured during the prolonged time duration and the seepage analysis may reveal the location of critical cracks in earthen dams.

However, DTS is a newly emerged sensing technique, and most applications are on existing dams. Analysis of DTS data has to be conducted with no or little prior data, which is a challenging task. Techniques such as Principal Component Analysis, Independent Component Analysis, and Impulse Response Function Analysis are developed to mitigate the aforementioned technical difficulties. However, these techniques still require several weeks to several months worth of initial data.

This research elaborated a real-time anomaly detection method for DTS data based on the spatial autocorrelation technique, an artificial intelligence (AI) system seeking spatial relationships within the measured temperature data themselves without resorting to the temperature-time history. The proposed method is based on the notion that temperature anomalies due to a defect or different thermal source will be spatially localized, forming clusters of outlier temperatures in the DTS data at a given measurement time based on the local Moran's index. This method predicted the accurate location of the defect in a laboratory dam from the very first set of the measured temperature data.