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Evidence Theory Enabled Quickest Change Detection Using Big Time-Series Data from Internet of Things

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Abstract : Traditionally in sensor networks and recently in the Internet of Things, numerous heterogeneous sensors are deployed in distributed manner to monitor a phenomenon that often can be model by an underlying stochastic process. The big time-series data collected by the sensors must be analyzed to detect change in the stochastic process as quickly as possible with tolerable false alarm rate. However, sensors may have different accuracy and sensitivity range, and they decay along time. As a result, the big time-series data collected by the sensors will contain uncertainties and sometimes they are conflicting. In this study, we present a framework to take advantage of Evidence Theory (a.k.a. Dempster-Shafer and Dezert-Smarandache Theories) capabilities of representing and managing uncertainty and conflict to fast change detection and effectively deal with complementary hypotheses. Specifically, Kullback-Leibler divergence is used as the similarity metric to calculate the distances between the estimated current distribution with the pre- and post-change distributions. Then mass functions are calculated and related combination rules are applied to combine the mass values among all sensors. Furthermore, we applied the method to estimate the minimum number of sensors needed to combine, so computational efficiency could be improved. Cumulative sum test is then applied on the ratio of pignistic probability to detect and declare the change for decision making purpose. Simulation results using both synthetic data and real data from experimental setup demonstrate the effectiveness of the presented schemes.

Keywords : CUSUM, evidence theory, kl divergence, quickest change detection, time series data
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