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Diffusing Event Monitoring in Sensor Networks
基于传感器网络的扩散型事件监测技术研究

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Abstract

The research is motivated with the background of an increasingly pervasive sensing world today. Being the key role in the applications of pervasive computing, sensor networks have made ubiquitous sensing, ad-hoc networking, automatic computing and strategic communication possible and effective. The term, *diffusing event*, summarizes the common characteristic of a series of environmental problems such as fire, typhoon, flood and fume diffusion. Being a flexible reactive network, the sensor network serves as the best choice of monitoring diffusing events and sketching the diffusion trend in the real time. Therefore, the diffusing-event monitoring problem is researched based on sensor networks. The major contributions are as follows:

Firstly, the data processing architecture is designed and a data discrimination framework is presented. Specifically, in the node scope, the data processing architecture is designed to support dynamic correlation discovery and adaptive data sampling. The experiments on real-world datasets have proved the energy consistency and data accuracy of the architecture. In the network scope, in order to reduce the influence of sensor data uncertainty, a systematic discrimination framework is presented to partition the raw data set into event, error and ordinary subsets through node-level temporal processing, neighbor-level spatial processing, cluster-level ranking and network-level decision fusion. The experiment has increased the distinction ratio to as high as 97% with the error occurrence rate up to 50% in the network. Compared with traditional event/anomaly detection, the proposed framework can considerably reduce false-alarm rate and keep miss-hit rate at an acceptable low level.

Secondly, diffusing events are modeled. A *TSEC* conceptual model is presented to completely express the temporal, spatial and event-related correlations. Based on *TSEC* model and the domain knowledge of diffusing events, association modeling is presented, including the establishment of homogeneous/heterogeneous data correlation models, the event-abstraction model and their associations. This work is the first to integrate the temporal, spatial and event relations into the same conceptual model, and the first to apply such a conceptual model into the diffusing-event monitoring in sensor networks.

Thirdly, the general process of diffusing-event monitoring is analyzed, the corresponding algorithms are presented for efficient monitoring, and both theoretical analysis and case studies are proposed. Based on the *TSEC* model, the general monitoring process is analyzed and the available solutions are proposed for the key points in the general process. Following the general process, a series of window-based in-network cooperation algorithms are presented for diffusing-event monitoring, involving the linear regression on sensor nodes, the intra-/inter-cluster information exchanging for event-boundary detection and the judgment of diffusion trend. The experiments on real-world datasets have demonstrated the energy efficiency, report reliability and scalability of the proposed algorithms. The theoretical analyses on the comparison of single-source vs. multi-source diffusion and pure diffusion vs. mixed diffusion have indicated that the basic diffusing-event monitoring strategies can be easily extended to monitoring the two types of complex diffusing events. In addition, the scenario-based case studies have been conducted to investigate the wind effect and geographical influence on diffusing-event monitoring. For the wind-constrained diffusing-event monitoring, a heterogeneous method is proposed to cooperate wind nodes (for diffusion-trend determination) and concentration nodes (for event-boundary detection). The experimental results have shown the event coverage rate at 80%~95% with the heterogeneous method, while 60%~25% without such a method. For the geography-constrained diffusing-event monitoring, GA-deployment is presented to enhance the event detection probability. A Voronoi diagram is generated from the layout of geographical obstacles and the network area are allocated with different node densities according to the edge set of the Voronoi diagram. The typical network tessellations have been extended based on the idea of GA-deployment, and such extension has considerably saved energy, with low miss-hit rate, high fault tolerance and strong report reliability.

In summary, the major contributions of this work involve the design of data processing architecture for dynamic correlation discovery, the data discrimination framework to improve data accuracy, the modeling for diffusion-event monitoring, the presentation of a series of diffusing-event monitoring algorithms with theoretical analysis and case studies on typical applications. The ideas, models and approaches presented in this thesis can also be extended and applied to the related domains.

Key Words: diffusing-event monitoring, sensor network, major diffusion trend.

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