

An Online Outlier Detection Technique for Wireless Sensor Networks

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Abstract. We propose an online and local outlier detection technique with low resource consumption based on an unsupervised centered quarter-sphere support vector machine for wireless sensor networks. Using synthetic data, we demonstrate that our technique achieves better mining performance in terms of parameter selection using difference kernel functions compared to an earlier offline outlier detection technique.

1 Introduction

Many applications of wireless sensor networks (WSNs) require outlier detection techniques to be performed locally in the network and in real-time to identify errors, potential events and malicious attacks occurred in the network. The main challenge faced by outlier detection techniques designed for WSNs is achieving high detection rate and low false alarm rate while maintaining the resource consumption of WSNs to a minimum.

One of the techniques used for outlier detection is one-class sphere-based support vector machine (SVM) [1, 2, 3]. The main idea of the one-class quarter-sphere SVM based outlier detection approaches is that data vectors in the input space are first mapped to a higher dimensional space and centered by means of kernel function, then a quarter-sphere centered at the origin is fitted with a minimal radius to encompass the majority of the data vectors in the higher dimensional space. Those vectors that fall on or inside the quarter-sphere are normal and those falling outside the quarter-sphere indicate anomalous data.

2 An Online and Local Outlier Detection Technique

We extend the offline technique of [3], and propose an online and local outlier detection technique with low resource consumption. The proposed technique is based on a *linear-optimization* centered quarter-sphere SVM of [2] and takes advantage of the high degree of *spatial correlations* that exist among the sensor readings of the adjacent nodes in a densely deployed WSN. The technique enables that each node in the network has sufficient information to identify local outliers in real-time. It has the following steps:

- Each sensor node learns its own radius of the quarter-sphere and sends the radius information to its neighboring nodes.

- Each node then computes the median radius of the neighboring nodes' radii.
- When a new data measurement arrives at a sensor node, the node computes the distance of the new data measurement from the origin.
- The new data measurement is then classified into normal or anomalous if its distance from origin is larger than both the node's radius and the median radius of the node's neighboring nodes.

3 Experiments and Results

We simulate our protocol in Matlab and use 7 spatially neighboring nodes within one-hop neighborhood. The 2-D synthetic data for each node is composed of a mixture of Gaussian distributions with 5% (of the normal data) uniform anomalous data introduced. We have tested three kernel functions, namely, linear, RBF and polynomial. As it is shown in the figure below, simulation results show that our approach achieves 100% detection rate and lower false alarm in all these three kernel functions compared to an offline quarter-sphere SVM based outlier detection approach introduced in [3].

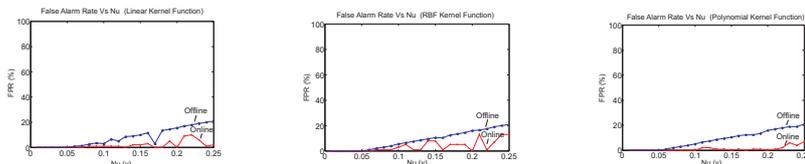


Fig. 1. False alarm rate for linear (left), RBF(middle) and polynomial (right) kernel functions in terms of parameter (ν) selection. Our proposed approach are in red.

4 Conclusions

In this paper, we have proposed an online and local outlier detection technique with low computational complexity and memory usage based on an unsupervised centered quarter-sphere SVM. We compare the performance of our technique with an offline scheme and achieve better false alarm performance.

References

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