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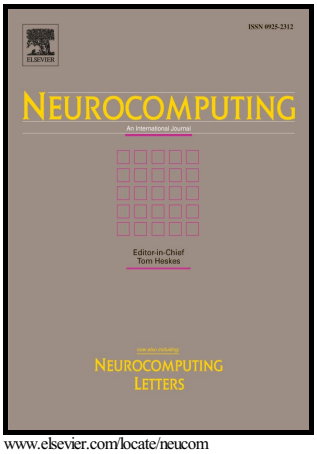


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# Hop-by-Hop Congestion Avoidance in Wireless Sensor Networks Based on Genetic Support Vector Machine

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## Abstract

Congestion in wireless sensor networks causes packet loss, throughput reduction and low energy efficiency. To address this challenge, a transmission rate control method is presented in this article. The strategy calculates buffer occupancy ratio and estimates the congestion degree of the downstream node. Then, it sends this information to the current node. The current node adjusts the transmission rate to tackle the problem of congestion, improving the network throughput by using multi-classification obtained via Support Vector Machines (SVMs). SVM parameters are tuned, using genetic algorithm. Simulations showed that in most cases, the results of the SVM network match the actual data in training and testing phases. Also, simulation results demonstrated that the proposed method not only decreases energy consumption, packet loss and end to end delay in networks, but it also significantly improves throughput and network lifetime under different traffic conditions, especially in heavy traffic areas.

**Keywords:** Wireless Sensor Networks, Congestion control, Transmission rate, Multi-classification, Support Vector Machine, Genetic Algorithm, and Tukey test.



## 1- Introduction

Wireless sensor networks (WSNs) comprise a large number of small and cheap sensor nodes with the restricted data processing and communication capabilities to sense the environment. In event-driven sensor networks, nodes operate under idle or load states. These networks are extensively used in several areas such as military surveillance, habitat monitoring, healthcare, and forest fire detection, to name a few [1,2]. The following are the main areas in which WSNs are applied: sensing the environment, collecting data, and processing them through sensor nodes cooperation and finally transferring the packets to sink nodes.

Congestion occurs when the rates of incoming and outgoing packets in the nodes are not equal [3]. When the network congestion occurs, some packets may be lost due to the limited size of the nodes buffer. This may result in the reduction of the network throughput as well as energy wasting. Therefore, congestion control is a crucial challenge in WSNs. There are several congestion control methods that use transmission rate adjustment [4].

The first study of this kind called Congestion Detection and Avoidance (CODA) was proposed by Wan et al. [5]. CODA consists of three main strategies: Congestion detection based on the received message, hop-by-hop open-loop feedback to the upstream nodes, and closed-loop adjustment of the transmission rate in the source nodes. CODA ensures that the network throughput will be appropriate through adjusting the close-loop rate. In this method, continuous monitoring of the channel causes abundant energy consumption in the involved nodes.

ECODA (Enhanced congestion detection and avoidance) [6] is a good mechanism to detect and avoid the congestion. ECODA uses three strategies in the face of congestion: At first, dual buffer thresholds are used for congestion detection. Then, the Flexible Queue Scheduler is determined for packet scheduling and finally a bottleneck-node-based source sending rate control scheme is presented to prevent the congestion. The ECODA mechanism sets $q_{max}$(maximum queue) to inform neighbor nodes about the occurrence of congestion, asking them to slow down the data sending rate. Two sub-queues in each node are considered, with one of them being used for a locally generated packet of a node and another one for route traffic. On the route traffic queue, packets are grouped by sources. For every source, packets are sorted by their dynamic priority from high to low. When congestion happens, the incoming packets get dropped from the tail. Therefore, the lower priority packets get dropped at first. Thus, using this scheme, a node drops some low priority packets from either of the queues when it receives high priority packets from a neighbor. In a bottleneck-node-based source sending rate control scheme, each node adjusts