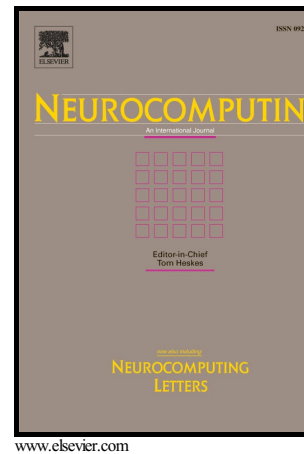


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# MI-ELM: Highly Efficient Multi-Instance Learning Based on Hierarchical Extreme Learning Machine

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## Abstract

Multi-instance learning (MIL) is one of promising paradigms in the supervised learning aiming to handle real world classification problems where a classification target contains several featured sections, e.g., an image typically contains several salient regions. In this paper, we propose a highly efficient learning method for MI classification based on hierarchical extreme learning machine (ELM), called MI-ELM. Specifically, a double-hidden layers feedforward network (DLFN) is designed to serve as the MI classifier. Then, the MI classification is formulated as an optimization problem. Moreover, the output weights of DLFN can be analytically determined by solving the aforementioned optimization problem. The merits of MI-ELM are as follows: (i) MI-ELM extends the single-layer ELM to be a hierarchical one that well fits for training DLFNs in MI classification. (ii) The input and hidden-layer parameters of DLFNs are assigned randomly rather than tuned iteratively, and the output weights of DLFNs can be determined analytically in one step. Therefore, MI-ELM significantly enhances the efficiency of the DLFN without notable loss of the classification accuracy. Experimental results over several real-world data sets demonstrate that the proposed MI-ELM method significantly outperforms existing kernel methods for MI classification in terms of the classification accuracy and the classification time.

**Keywords:** Multi-instance learning, hierarchical extreme learning machine, optimization, double-hidden layers feedforward network

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