

研究论文

基于神经网络简单集成的湖库富营养化综合评价模型

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摘要 根据中国水利部推荐的地表水富营养化控制标准, 以叶绿素a、总磷、总氮、化学需氧量和透明度为评价指标, 采用线性插值方法生成均匀分布的训练样本, 建立了用于湖泊、水库富营养化综合评价的神经网络简单集成模型, 其个体网络采用反向传播网络。通过递增法分别确定个体网络隐含层节点数为3, 集成规模为40。所有个体网络均采用弹性反传训练算法和带动量的梯度下降学习算法。将该模型应用于巢湖富营养化综合评价, 结果表明该模型有效消除了单个反向传播神经网络对初始网络权重的敏感性, 泛化能力得到显著的提高。该模型的评价结果与综合营养状态指数法差异极显著, 而与插值评分法差异不显著; 但相关性较高, 相关系数分别为0.9406和0.8891。通过对比分析, 表明该模型较好地归纳了评价标准中的潜在评价规则, 评价结果客观、可靠。

关键词 [富营养化](#); [综合评价](#); [BP \(back propagation\) 神经网络](#); [神经网络集成](#); [泛化能力](#)

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A model based on simple ensemble of neural networks for comprehensive eutrophication assessment of lake and reservoir

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Abstract Based on Surface Water Eutrophication Control Standard recommended by Ministry of Water Resources of China, a simple neural network ensemble(NNE) model was constructed for comprehensive eutrophication assessment of lake and reservoir. This model adopted Chlorophyll a, Total Phosphorus, Total Nitrogen, Chemical Oxygen Demand and Secchi Depth as inputs, and the output is a continuous variable, which represents the trophic state. 1000 input/output pairs were produced with linear interpolation method according to the above standard. 100 pairs were selected randomly from all data pairs as testing sample, and the rest used as training sample. Back propagation(BP) neural network with same topology structure were applied to all subnets of this ensemble model and were trained using resilient back propagation and gradient descent with momentum as the learning algorithm. The number of hidden nodes of subnet and number of subnets of ensemble are 3 and 40 respectively, determined with the incremental method. All subnets were trained with different initial weights and bias. The results of using this model to assess the trophic state of Chaohu Lake, showed that this model is insensitive to initial weights, and the generalization ability is improved remarkably. With respect to assessment results, there is no apparent difference between this model and the interpolation scoring method, but there is significant difference between this model and the comprehensive trophic level index method. The correlation coefficients of assessment results gained by this model and those by the comprehensive trophic level index method and the interpolation scoring method are 0.9406 and 0.8891, respectively. The results of contrast analysis indicate this model has learned the potential assessment rules from assessment standard, and assessment results of this model are objective and reliable.

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Key words [eutrophication](#) _ [comprehensive assessment](#) _ [back propagation\(BP\)](#) [neural network](#) _ [neural network ensemble\(NNE\)](#) _ [generalization ability](#)

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