World Academy of Science, Engineering and Technology
International Journal of Agricultural and Biosystems Engineering
Vol:18, No:06, 2024

Artificial Neural Network Approach for GIS-Based Soil Macro-Nutrients Mapping

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Abstract : Conventional methods for nutrient soil mapping are based on laboratory tests of samples that are obtained from surveys. The time and cost involved in gathering and analyzing soil samples are the reasons that researchers use Predictive Soil Mapping (PSM). PSM can be defined as the development of a numerical or statistical model of the relationship among environmental variables and soil properties, which is then applied to a geographic database to create a predictive map. Kriging is a group of geostatistical techniques to spatially interpolate point values at an unobserved location from observations of values at nearby locations. The main problem with using kriging as an interpolator is that it is excessively data-dependent and requires a large number of closely spaced data points. Hence, there is a need to minimize the number of data points without sacrificing the accuracy of the results. In this paper, an Artificial Neural Networks (ANN) scheme was used to predict macronutrient values at un-sampled points. ANN has become a popular tool for prediction as it eliminates certain difficulties in soil property prediction, such as non-linear relationships and non-normality. Back-propagation multilayer feed-forward network structures were used to predict nitrogen, phosphorous and potassium values in the soil of the study area. A limited number of samples were used in the training, validation and testing phases of ANN (pattern reconstruction structures) to classify soil properties and the trained network was used for prediction. The soil analysis results of samples collected from the soil survey of block C of Sawah Sempadan, Tanjung Karang rice irrigation project at Selangor of Malaysia were used. Soil maps were produced by the Kriging method using 236 samples (or values) that were a combination of actual values (obtained from real samples) and virtual values (neural network predicted values). For each macronutrient element, three types of maps were generated with 118 actual and 118 virtual values, 59 actual and 177 virtual values, and 30 actual and 206 virtual values, respectively. To evaluate the performance of the proposed method, for each macronutrient element, a base map using 236 actual samples and test maps using 118, 59 and 30 actual samples respectively produced by the Kriging method. A set of parameters was defined to measure the similarity of the maps that were generated with the proposed method, termed the sample reduction method. The results show that the maps that were generated through the sample reduction method were more accurate than the corresponding base maps produced through a smaller number of real samples. For example, nitrogen maps that were produced from 118, 59 and 30 real samples have 78%, 62%, 41% similarity, respectively with the base map (236 samples) and the sample reduction method increased similarity to 87%, 77%, 71%, respectively. Hence, this method can reduce the number of real samples and substitute ANN predictive samples to achieve the specified level of accuracy.

Keywords : artificial neural network, kriging, macro nutrient, pattern recognition, precision farming, soil mapping
Conference Title : ICGISAA 2024 : International Conference on GIS Applications in Agriculture
Conference Location : Toronto, Canada
Conference Dates : June 13-14, 2024