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Using model complexity to select the optimum architecture for artificial neural networks

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Floods are one of the most devastating natural disasters globally and improved streamflow prediction is essential for better flood management. Today, high-resolution real-time datasets for flood-related variables (e.g. streamflow, precipitation) are widely available. These data can be used to create data-driven models, such as artificial neural networks (ANNs) for accurate streamflow predictions. However, these models have uncertainty stemming from a number issues, including the architecture of the model (i.e. number of neurons and hidden layers). Typically, an ad hoc approach has been used to select these parameters, which increases the uncertainty of the model performance. In this research, we propose a novel complexity-based approach to select the optimum (i.e. least complex) network architecture for most reliable model predictions. We create several candidate ANN models to predict streamflow in the Bow River (located in Alberta, Canada). The candidate models increase in complexity: from 1 to 2 hidden layers, with 3 to 30 neuron in each layer, as well as increasing the number of inputs from 1 to 3. For each candidate model, we calculate the Degrees of Freedom (DOF) as a measure of complexity and model comparison. They provide an objective measure of the stability of model inversion given the used training data. Therefore, the data is perturbed in a residual bootstrapping procedure and the sensitivity of inversion towards this alteration is assessed as DOF. Initial results demonstrate the DOF scores are commensurate with model complexity. The DOF score along with model performance criteria (e.g. sum of squared error) can then be used to select the most suitable model, i.e. the level of complexity that provides best performance while still allowing stable inversion. The proposed approach will help reduce the uncertainty in model selection when designing ANN models for streamflow prediction and can easily be extended to other domains.