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Neural Network River Flow Forecasting: The Role of Hidden Neurons in a Regulated Catchment with Arterial Drainage Modifications

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The reported investigation extends previous explorations that have attempted to detect physical process representation inside a neural network rainfall-runoff forecaster. Earlier proof of concept experiments were based on conceptual model outputs and performed in a controlled environment. The observed relationship between individual isolated hidden neuron outputs and the model output was reported and compared to recognised hydrological processes e.g. baseflow and quickflow runoff components. This paper in contrast investigates the processing functions inside a non-linear autoregressive neural network river flow forecasting model that was developed using the observed discharges of the River Brosna in the Republic of Ireland. This is one of several rivers that have experienced extensive remedial schemes to help counteract the effect of poor drainage gradients e.g. embankment construction, river straightening and diversion, increased use of lake storage opportunities, etc. The strongest concentration of effort has been placed on the deepening and widening of channels. This river also flows through one of the biggest areas of bog and active peat harvesting in the land which is a significant catchment factor with respect to both the hydrological response curve and peat silt or sediment buildup. The structure of the neural network river flow forecasting model in this investigation was a feedforward multi-layer-perceptron. The model had three layers and the middle layer had three hidden neurons. Linear regression was found to be a useful tool to investigate the internal relationships that exist between the hidden neuron outputs and the observed discharges. This simple mechanism was able to provide a very good approximation to the sigmoid transfer operation

that was performed inside the output neuron and also provided useful numerical information about the nature of the internal neural network processes and functions. The results were visualized and it was found that the outputs of one of the hidden neurons captured the input-output relationship and provided a very good linear approximation to the observed discharges better than those of the other two hidden neurons. However, the outputs of the other two hidden neurons provided a complex integrated non-linear correction to the linear approximation that had differential impacts at the lower-to-intermediate and upper levels of a flood event. The neural solution was thus able to replicate different hydrological processes that occurred in different periods of a flood event for a wet catchment with a temperate climate in a regulated hydrological environment with arterial drainage modifications.

Keywords: artificial neural network, river flow forecasting, regulated catchment