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Hidden unit specialisation in two neuroevolution rainfall-runoff models

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Neural network hydrological models are treated as black box solutions in which a set of input variables (e.g. discharge, rainfall, soil moisture, etc.) is transformed into a set of required outputs (future discharge). The black box nature of neural networks and our inability to explain their internal functions in terms of recognised physical processes has discouraged widespread use of these tools by hydrological modellers despite continuing evidence in the literature of good model performance and speed of processing. Several attempts have been made to investigate their internal operations both in the hydrological sciences as well as in other domains and disciplines. In most cases the investigation has been restricted to rule extraction or gaining understanding through different forms of 'sensitivity analysis'. However, recent hydrological studies have focussed on examining the behaviour of the hidden units or neurons inside a set of neural network river discharge forecasters. This paper furthers the discussion and investigates the nature of hidden unit specialisation that occurs in two rainfall-runoff models that were developed in a neuroevolution software package that uses cooperative co-evolution to evolve a population of neural network models. JavaSANE tasks each individual neuron to establish connections with other neurons in the population, and the evolution-based mechanisms of mutation, crossover and selection encourage the development of 'different types' or 'specialisations' of hidden unit. The response of the hidden units is extracted and principal components analysis is used to reduce the number of output dimensions such that the development and behaviour of each hidden unit can be viewed in relation to other members of the population on a 2-D surface. The neuroevolution approach is applied to a large river basin in Northern England for lead times of T+6 and T+24.