Prestructuring ANNs via A Priori Knowledge

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The work to be described has as its objective development of a constructive method that uses certain *a priori* information about a problem domain to design the starting structure of an artificial neural network (ANN). For the prestructuring process, there is motivation to move away from homogeneous structures to ones that comprise modules of smaller ANNs. Issues of concern include physical realizability, scalability of training time with large numbers of connections, and successful generalization.

The method explored is based on a general systems theory methodology (here called GSM) that calculates a kind of structural information of the problem domain via analyzing I/O pairs from that domain. This GSM-based information is used for developing a modularized ANN starting structure.

The present work assumes the GSM model for the given problem context has been determined (represented here in the form of Boolean functions of known decompositions). This means that certain information is available about constraint among the system variables, and is used to develop a modularized ANN. The modularized ANN and an equivalent general ANN (full-interconnect, feed-forward) are both trained on the same data. Various predictions were made: 1) The general and the modularized ANNs will both learn the task, but the modularized ANN will learn it faster. 2) If trained on an (appropriate) subset of possible inputs, the modularized ANN will perform better generalization than the general ANN. 3) If trained on a non-decomposable function of the same variables, the general NN will learn the task, but the modularized NN will not.

The notion of performance subset (PS) of an ANN structure is defined to be the collection of all mappings an ANN would be capable of performing as the parameters (e.g., weights) of the starting structure are allowed to sweep through all their possible values. The PS is clearly a subset of the collection of all possible mappings from the ANN's input domain to its output range.

Extensive experiments on 3-input, 1-output Boolean mappings verify the above predictions. In addition, the experiments indicate that the GSM-based modularized-ANN design is 'conservative' in the sense that the PS of the modularized ANN contains at least all the mappings included in the GSM category used to design the ANN. Experiments with 5-input, 1-output Boolean functions provide further support of the conclusions.

In addition, the experiments also suggest the possibility of using a measure of the learning curve of specified ANNs on a series of (in this case Boolean) functions to serve as a proxy measure for the *complexity* of those functions. This proxy measure seems to correlate well with a measure known as Boolean Length. Determining a function's Boolean Length is a non-trivial undertaking; perhaps it will turn out that training an ANN on the function and measuring its learning experience will be a useful measure of function complexity, and easier to determine than the function's Boolean Length.

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