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L.E. Atlas, R.J. Marks II and J.W. Taylor "Network learning modifications for multi-modal classification problems: applications to EKG patterns", Neural Networks, vol.1, sup. 1, p.4 (1988).

NETWORK LEARNING MODIFICATIONS FOR MULTI-MODAL CLASSIFICATION PROBLEMS: APPLICATIONS TO EKG PATTERNS. L. E. Atlas, R. J. Marks II and J. W. Taylor. Department of Electrical Engineering, FT-10, University of Washington, Seattle, WA 98195

Many real-world classification problems can be assumed to have multiple modes or, in some cases, many disjoint regions corresponding to the same class. Two important examples are automatic speech recognition and automatic EKG pattern identification. For this study, we concentrated on an aspect of the EKG problem which is well-handled by human experts yet difficult to automate. This identification task involves detecting the time location of the heartbeat (QRS complex) under various acute disease conditions such as ventricular fibrillation. We made use of a waveform data base which was annotated as to QRS location by a clinical cardiac specialist. The data base, which represented a total of 3,250 cardiac cycles for 20 patients, was preprocessed to find all time peaks. These files of time peaks, with corresponding annotation, were used to train both a backpropagation type network and an alternating projection neural network (APNN) [1]. For both cases it was found that the network performed significantly worse than the conventional real-time techniques [2].

The reason for the failure of both networks was tied to the irregularity of the data. Due to the nature of the problem, time peaks with dramatically different structures represented QRS complexes and were thus members of the same class. For backpropagation, the input-to-hidden layer weights reached a stable yet high error state. For the APNN, the classification shapes were extremely sensitive to output threshold and to input-to-hidden layer weights. In both cases, the network capacity was exceeded.

In order to alleviate the observed problems, a theoretical study was undertaken to reformulate the network learning rules. The first phase of this study is based on the physiological suggestion that certain interconnects among neurons in biological neural networks have values that are not determined by the network's use of the path and are therefore, to a degree, randomly chosen. We show that stochastically chosen interconnects that remain unchanged during the training of an artificial neural network can be effectively used to increase the storage capacity of the network. In viable artificial neural networks, the capacity of the network increases with the number of neurons since the number of degrees of freedom available to the network is increased. Stochastically chosen interconnects to neurons in a hidden layer can be used to artificially increase the number of available degrees of freedom where almost any nonlinear combination of established states effectively increases the working dimension. We propose nonlinearites consisting of a stochastically weighted sums of neural states followed by a fixed monotonic sigmoid type nonlinearities. The networks will theoretically perform quite well for multi-modal classification. Experiments are underway to test this theory on the EKG data base.

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