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Artificial Neural Networks Applications for Plasma Torch Operation and Process Control

Artificial Neural Networks (ANN) is a critical technology which finds applications in Engineering, Science, Business, Medicine, and several other fields. Their capability for classification, pattern recognition, and prediction, using data which appear unintelligible, places them in a unique and versatile position to be used in very imaginative ways. Its ability to deal with nonlinear data is especially useful for interpreting complex situations. The prediction and classification features of ANN have been used to support torch control at DIAL, and other potential applications are being identified. ANN currently has a modular design to use it as a component in a larger intelligent support system.

ANN derives its topology from the interconnections of neurons in the human brain. It learns the characteristics of each process by observation, and adapts its strategy for a particular situation. Neural networks automatically take advantage of process upgrades and compensate for system degradation. Nonlinear and multivariate capabilities of neural networks make it ideal for even direct control. The network's neurons (represented by the filled circles in Figure 1) work together to make decisions based on their individual inputs and weights. The network is trained by sampling thousands of examples of actual data where input patterns were received and correct decisions were made. The network learns to recognize these correct patterns using a neural mathematical model. After being trained to recognize input patterns, the neural network can make good decisions even for new and unfamiliar patterns.

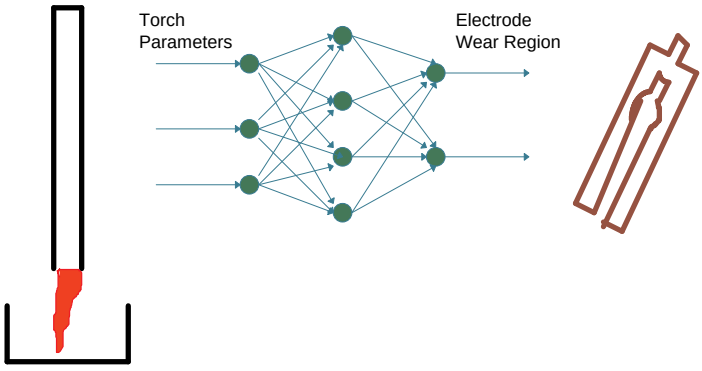

Figure 1. Application of a multilayer neural network.

Neural networks handle time series prediction in a unique way as they are versatile and accommodate nonlinear data with noise. It adjusts its own model based on the behavior of historical data, to predict future behavior fairly accurately. As many of the time series have a significant chaotic component, neural networks do a far better job in handling them than other models of time series prediction.

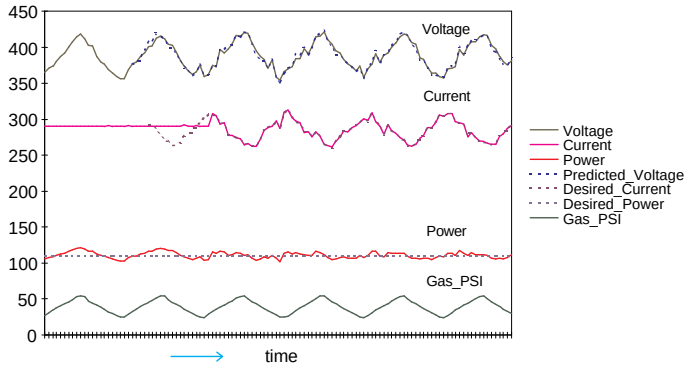

Figure 2. Comparison of power before and after ANN control.

Time series prediction techniques have been applied at DIAL to plasma torch voltages to stabilize output power using the backpropagation model of an artificial neural network. The torch power fluctuation is caused by the variation of gas pressure inside the electrode to move the arc attachment point. Operation with small power fluctuations is not usually detrimental. However, power stabilization allows more freedom for gas pressure variation, and this can be very useful. The application of ANN to solve this problem has eliminated the power variation due to gas pressure for the trained operating conditions. Figure 2 shows the results of using the ANN stabilizer during a typical torch operation.

During classification, a fully trained ANN recognizes a familiar pattern or makes an approximate guess on the unfamiliar patterns. DIAL has also applied ANN to characterize a simulated waste feedstream. Physical properties of waste materials have been used as inputs to ANN to identify the materials. In the present model, a fuzzy ARTMAP network uses four parameters to identify ten materials. The system classified 94% of the test data correctly.

The nonlinear and multivariate capabilities of the neural networks, and their ability to learn and recognize correct patterns, are currently being applied to predict the attachment point and electrode wear from measurements of torch parameters. Initial experiments show potential to obtain a reliable solution to this problem. DIAL has the capability to extend the predictive and classification techniques it uses to efficient implementation of diagnostic and monitoring systems.

Additional information about ANN applications may be obtained by contacting:

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