Failure of Motor Learning and How to Succeed Anyway

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Learning algorithms may become stuck in local minima or may fail to learn at all when used as part of a control system. This can occur even when the algorithm itself has guaranteed convergence. ”Failure of motor learning” is the condition when, after sufficient practice, an adaptive controller has not converged to a solution that would otherwise be representable by the controller. There are at least two causes of failure of motor learning: Type 1 (sensory) failure occurs when the network is unable to observe its own errors. Type 2 (practice) failure occurs when the network's initial performance is sufficiently inaccurate that the performance does not provide good examples for training. In both cases, the theory predicts that learning algorithms will become stuck in local minima, often with very poor performance.

The theory predicts that similar phenomena will occur in humans. Experiments in which humans control a visual display using surface electromyography electrodes show that both type 1 and type 2 failure do indeed occur. Failure of motor learning may explain certain abnormalities of muscle control in disease. For example, persistent muscular co-contraction seen in children with dystonia may be partly explained by failure of motor learning.

However, in the course of these experiments it appeared that certain children and adults were able to solve apparently ”impossible” tasks despite lack of knowledge of the error gradient and the presence of complex and unknown sensory-motor mappings. Careful examination of the human behavior suggested that humans have access to a stochastic learning algorithm that we call ”error-dependent noise” (EDN) learning. This is a new learning algorithm that approximates gradient descent without requiring knowledge of the gradient. When the gradient is (at least approximately) known, both healthy and dystonic children appear to use gradient descent learning. When the gradient is not known, healthy and dystonic children appear to use EDN learning and possibly other stochastic search algorithms. This suggests that machine learning could take advantage of similarly flexible algorithms when faced with control of unknown plants in unknown or time-varying environments.