A Universal Robotic Control System using Reinforcement Learning with Limited Feedback

Executive Summary

Robotic intelligence can be simplified to a black box, with inputs such as sensor data and outputs such as motor control. Most robotic software today operates as "expert systems," using preprogrammed logic to execute a set routine. These implementations are sufficient for the specific purpose and platform that they are designed for but lack the ability to perform other tasks or work on other robots.

The purpose of this project was to develop a universal robot control system that can not only adapt to any robot hardware, but can also be trained in a short amount of time using positive and negative reinforcement. The implementation (nicknamed Fido) is lightweight and resource-efficient, making it a practical solution as a control system for mobile robots. This was achieved by regulating artificial neural networks according to a novel learning algorithm. The algorithm modifies a well-tested reinforcement learning algorithm called Q-learning by fitting a curve to discrete points through a moving least squares interpolator and incorporates a Boltzmann distribution of probability into action selection.

Fido was tested on a simulated robot with a differential drive system (similar to that of a tank), a large sensor array, and some additional outputs. The system performed well doing a variety of tasks, such as learning to drive to a set location and line following. Additionally, results showed that only limited feedback was necessary for learning, allowing Fido to be trained in a reasonable amount of time by a person. Future plans for continuing research include a hardware implementation to test Fido outside of a simulation environment and additional improvements to Fido's software.