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SELECTING INPUT SIGNALS FOR NEURAL NETWORK PILE LOADING CONTROLLERS

Abstract

End-to-end Neural Network (NN) control is a promising new development in robotics, whereby NNs replace traditional control systems for robotic manipulators and mobile robots. Instead of humans programming object recognition and optimal joint trajectories for achieving desired actions, for example, an end-to-end NN controller learns to generate actuator signals directly from sensor data. Instead of writing complex programs, the work of human developers shifts to training NNs, which can be achieved by providing examples of the task.

One application for this technique is autonomous loading of ground material with robotic wheel loaders. This is difficult to automate due to various factors that can affect ground properties, including compaction, rocks of various sizes and moisture. Human operators intuitively deal with these challenges, though coding this intuition into a program may be non-trivial. Training an NN controller by demonstration therefore offers a way to transfer this intuition to a computer. A further benefit of using NNs is that they can interpret the large number of noisy sensor signals which may be available, deciding which are useful, while a human programmer may have a difficult time interpreting this data.

In the mining industry, automated hauling and dumping of material is widely applied, however the loading action is usually controlled by a human, either on board or by remote control. Reliable automation of the loading action therefore offers the possibility of fully automated work cycles, with the benefits of increased safety and productivity. In space applications, this capability could be useful for establishing permanent human settlements on the Moon or Mars. Automated earthmovers could be used to harvest regolith, to obtain water ice for propellant plants, to manufacture bricks for masonry structures, or to bury habitats for radiation shielding.

This paper compares two NN pile loading controllers for a robotic compact wheel loader. One has three input signals: the hydraulic driving pressure, boom angle and bucket angle. The 2nd has the four wheel odometries as additional inputs. Both NNs produce three control signals: the gas command, boom actuator and bucket actuator. Both NNs are able to automatically control bucket filling, but the 2nd, with additional inputs, results in more reliable action that avoids a certain problem behaviour of driving up the slope after extracting the load. Furthermore, pile transfer experiments compare the performance of NN controllers with a traditional heuristic controller and manual human control.