Space Resources (10)
Space Resources (2) (2)

Author: Dr. Eric Halbach
Finland

Prof. Joni Kämäräinen
Finland
Prof. Reza Ghabcheloo
Finland

NEURAL NETWORK CONTROL OF WHEEL LOADER BUCKET FILLING FROM PILE APPROACH TO EXTRACTION

Abstract

End-to-end Neural Network (NN) control is a promising development in robotics, whereby NNs replace traditional control systems by generating actuator signals directly from sensor input. The work of humans thus shifts from programming object recognition and joint actions, for example, to training NNs, which can be achieved by providing examples of the task.

One application for this technique is the loading of ground material with robotic wheel loaders. This is difficult to automate due to 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 an algorithm may be non-trivial. Training an NN controller by demonstration therefore offers a way to transfer this intuition to a computer. A further benefit is that NNs can interpret the large number of noisy sensor signals that may be available, which could be difficult for a human.

This capability could be useful for establishing a permanent human presence on the Moon or Mars. Fully automated robotic earthmoving systems could perform mining and construction activities in the harsh surface environment, increasing the safety and productivity of the crew. Harvested regolith could be used to extract water and other resources, or as a building material for berms, masonry or radiation shielding for habitats.

The authors previously presented NN pile loading controllers for a robotic compact wheel loader, trained with data from 23 manually-controlled scooping actions [ICRA 2019]. The NNs have three input signals (hydraulic driving pressure, boom angle, bucket angle), and produce three control signals (gas command, boom actuation, bucket actuation). This paper presents a 2nd version with the four wheel speeds as additional inputs, which functions more reliably by avoiding an occasional problem behaviour of driving up the slope after load extraction. The NN controllers are tested at an outdoor site with mixed dirt-gravel piles, with varying moisture conditions, and are able to automatically control the full bucket filling action from pile approach to load extraction. This differs from another example in the literature for NN control of part of the filling action [Dadhich et al.]. Pile transfer experiments are also made to compare the performance of the NN controllers with a heuristic algorithm controller and manual human control. Additionally, one benefit for planetary applications is that the NN controllers “feel” the pile’s location via its resistance, and do not require optical sensors which could be obscured by dust.