World Academy of Science, Engineering and Technology
International Journal of Agricultural and Biosystems Engineering
Vol:11, No:04, 2017

Embedded Visual Perception for Autonomous Agricultural Machines Using Lightweight Convolutional Neural Networks

Authors : René A. Sørensen, Søren Skovsen, Peter Christiansen, Henrik Karstoft

Abstract : Autonomous agricultural machines act in stochastic surroundings and therefore, must be able to perceive the surroundings in real time. This perception can be achieved using image sensors combined with advanced machine learning, in particular Deep Learning. Deep convolutional neural networks excel in labeling and perceiving color images and since the cost of high-quality RGB-cameras is low, the hardware cost of good perception depends heavily on memory and computation power. This paper investigates the possibility of designing lightweight convolutional neural networks for semantic segmentation (pixel wise classification) with reduced hardware requirements, to allow for embedded usage in autonomous agricultural machines. Using compression techniques, a lightweight convolutional neural network is designed to perform real-time semantic segmentation on an embedded platform. The network is trained on two large datasets, ImageNet and Pascal Context, to recognize up to 400 individual classes. The 400 classes are remapped into agricultural superclasses (e.g. human, animal, sky, road, field, shelterbelt and obstacle) and the ability to provide accurate real-time perception of agricultural surroundings is studied. The network is applied to the case of autonomous grass mowing using the NVIDIA Tegra X1 embedded platform. Feeding case-specific images to the network results in a fully segmented map of the superclasses in the image. As the network is still being designed and optimized, only a qualitative analysis of the method is complete at the abstract submission deadline. Proceeding this deadline, the finalized design is quantitatively evaluated on 20 annotated grass mowing images. Lightweight convolutional neural networks for semantic segmentation can be implemented on an embedded platform and show competitive performance with regards to accuracy and speed. It is feasible to provide cost-efficient perceptive capabilities related to semantic segmentation for autonomous agricultural machines.

Keywords : autonomous agricultural machines, deep learning, safety, visual perception
Conference Title : ICPA 2017 : International Conference on Precision Agriculture
Conference Location : Kyoto, Japan
Conference Dates : April 27-28, 2017