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Assistance System for an Automatic Loading Process

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EXTENDED ABSTRACT

1. Introduction

One of the biggest challenges forestry contractors face today is high employee fluctuation, resulting in unexperienced operators with minor background in forestry. On the other hand, forwarding shows a huge potential towards automation. An assistance system which semi-automates the loading process during a cut-to-length logging process would increase the productivity significantly, in particular for new operators. Especially for them, positioning the grapple and gripping the log without ground penetration are the most challenging parts of loading phases due to a high number of simultaneous control tasks. The presented assistance system is able to execute these phases completely automatically. The assistance system consists of two essential components, a log detection algorithm and a control system for driving the forestry crane.

2. Log detection

The log detection is based on machine vision methods and uses rgb-images and point cloud data from a depth camera mounted on the forwarder. The neural network YOLACT++ as CNN-based single-stage instance segmentation architecture was trained via transfer learning to determine which pixels in an image belong to a log, achieving a high mean accuracy of 56.65 mAP. Combining this 2D-based object detection with the point cloud data of the depth camera results in a semantically segmented point cloud of the environment. The very points belonging to a log are further processed to estimate the log features like diameter, length and position, compare figure 1. The log position and accordingly its gripping point is transferred to the machine control of the forwarder.

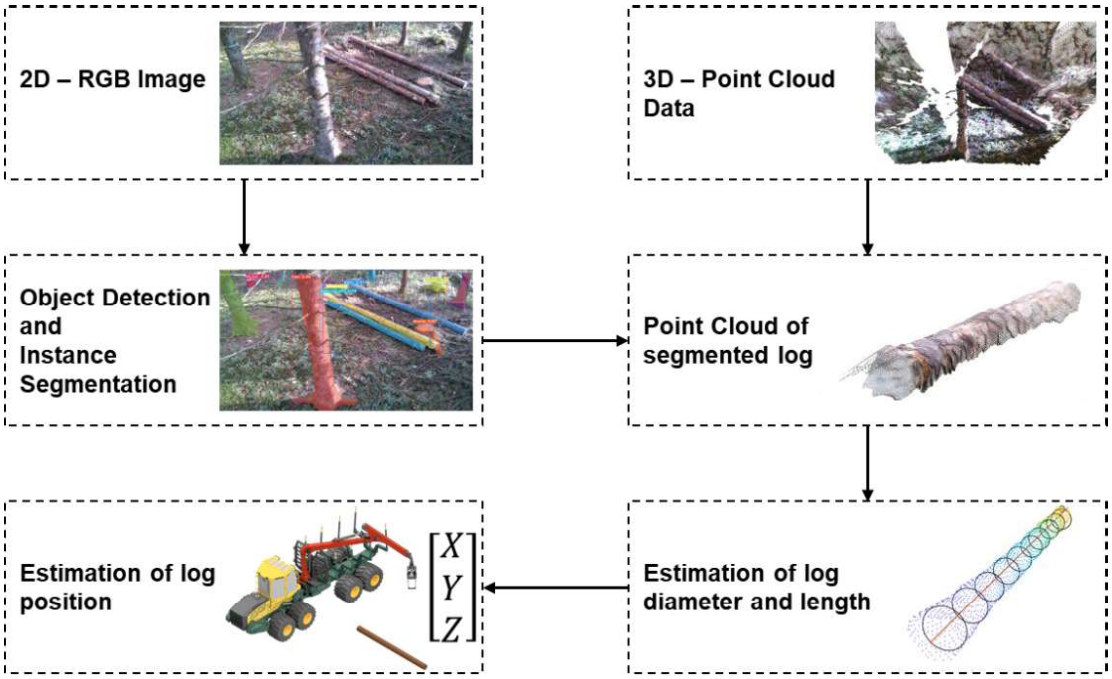

Figure 1: Object detection in logging sites

3. Assistance System 'AutoLoad'

The gripping point serves as target point for the automatic crane drive. When the operator steers the grapple into a sphere of 4 m around the gripping point, the machine control overtakes automatically the control of the crane and manoeuvres the grapple towards the target point. The accuracy of the crane control is below 5 cm. Reaching the target point, the log is gripped and lifted up, while the grapple tips are moving parallel to the underground avoiding its penetration. As basis for the automatic crane drive, a boom tip control resting on a weighted pseudoinverse of the crane kinematics Jacobian matrix was developed. It can be operated in different modes specialized for clearcut, thining or final felling.

The effect of the assistance system was measured with reproducible reference loading cycles. Therefore, 2 inexperienced operators fulfilled these reference cycle each 30 times with ('AutoLoad) and without ('Serie') the assistance system, compare figure 2. The cycle time is reduced up to 40% when operating with AutoLoad, verifying the effectiveness of the assistance system.

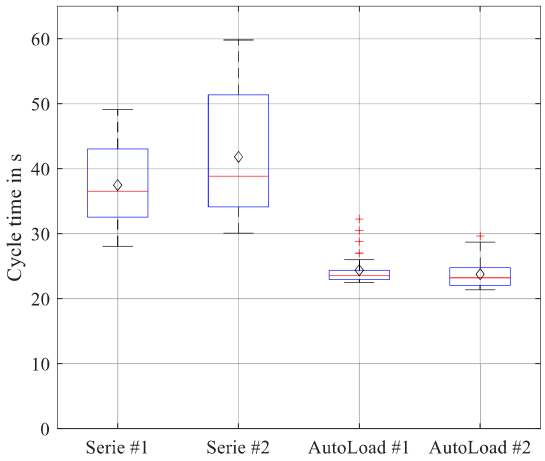

Figure 2: Cycle time during reference cycle for 2 inexperienced operators

4. Conclusion & Future Work

The presented assistance system was successfully tested with an 11-ton HSM-208f forwarder under laboratory conditions. Using the assistance system, the productivity of beginner operators is highly increased. The assistance system will be tested under real working conditions on a logging site during thinning in near future.

5. Acknowledgements

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