Path tracking for autonomous forwarders in forest terrain

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Automation in the agriculture sector has been subject to intensive research for many years, resulting in several farming systems operating with various levels of autonomy. In comparison, automation in forestry is far behind agriculture. This is mainly due to the difficulties involved in navigating unstructured forest terrain, where operation paths are rarely straight or flat and obstacles are common. In forestry, the forces driving mechanisation and automation are a lack of workers, amounts of hard physical work involved, aspiration to conduct forestry operations year-round and for more hours per day and the desire to reduce costs and lead-times between logging and industrial processing (Sundberg 1978, Silversides 1997). Moreover, human performance can limit work efficiency. For instance, the technical potential is not fully used in many machine movements as humans have difficulties to precisely guide machines or machine parts at high speeds for long periods of time (Hellström *et al.* 2009, Pilarski *et al.* 2002).

We have evaluated a system designed to autonomously follow previously demonstrated paths in a forest environment, which is seen as a partial solution in the development of fully autonomous forwarders. The evaluated system consisted of a Valmet 830 forwarder equipped with a high-precision GPS system to measure the vehicle's heading and position. A gyro was used to compensate for the influence of the vehicle's roll and pitch. On a clear-cut forest area with numerous stumps and other obstacles, two different tracks where selected. One track was 74 m long and almost level. The other track was 85 m long with an almost circular shape that made the vehicle travel down, parallel, and up the main slope direction. The vehicle was able to follow the two tracks, four times each, with a mean path tracking error of 6 cm and 7 cm respectively. The error never exceeded 35 cm, and in 90% of the observations was less than 14 cm and 15 cm, respectively. This accuracy is well within the necessary tolerance for forestry operations. In fact, a human operator would probably have a hard time following the track more accurately. Hence, the developed systems function satisfactory when using previously demonstrated paths. To reduce soil damage, increase traction, and reduce fuel consumption it is important to reduce the amount of wheel slip. To determine the amount of wheel slip for different ground conditions a method using the difference between GPS and wheel velocities was developed. The resulting slip on asphalt and gravel ground was almost zero. On loose sand, slip values up to 80% was detected. The conclusion is that the proposed method can be used in future studies of wheel slip in forest terrain.

In the future we will challenge the studied system with additional conditions normally found in the forest work environment. In boreal forestry, machinery must be able to function under tree canopy, in slippery slopes, in snow and in temperatures far below 0°C. Moreover, it is essential to evaluate the system's performance when carrying out its actual work; to transport logs. With the basic functionality of system granted, vehicle load and its effect on vehicle dynamics will be evaluated. The ultimate aim of future studies would be to contribute in the development of a forwarder that is not dependent on initial operator guidance to find its path. For example, a path to pick up log piles with a forwarder can be automatically generated based on the harvester path and locations of the left piles. Regardless of how a suitable path is generated, a method like the one presented in this paper, it is still required to guide the vehicle along the wanted path.

References:

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