Self-learning steering algorithm optimised for Hageroboten Jeeves

There are over 1.5 million gardeners in Norway. Of these, 46.1% experience slugs or weeds as their main gardening challenges. Based on this need, we developed “Hageroboten Jeeves”, an autonomous robot utilising AI and optical navigation to locate and remove slugs and weeds. The goal of Jeeves is to reduce time spent on undesirable gardening tasks. We estimate that Jeeves annually could save Norwegians about 8.32 million hours of tedious work, reduce the need for elderly persons to leave their current residence, and improve biodiversity by reducing invasive species. Future opportunities to utilise Jeeves technology are in support of low scale agriculture, e.g., for weeding and pest protection, harvesting of fallen fruits, etc.

The core functionalities of this new garden robot, which need collaborative commercial/academic research to develop, are:

- **Auto traction gain setting:** An automatic traction control system that can adapt to the different terrain surfaces that Jeeves will operate on.
- **Navigation; 3D visual:** No external electromagnetic signal sources such as DGPS are used. Jeeves has object detection capabilities based on stereo cameras and high-frequency radar.
- **Digital twins for predictive maintenance:** Digital twins are used with rich sensors for predictive maintenance.
- **Species recognition, biodiversity protection, removal of invasive species:** The robot can determine different bio-species. It will only remove invasive species and leave naturally occurring species.
- **Robot swarm:** With the simultaneous use of several robots, they will cooperate to complete the assigned task. Robot swarms will have access to cloud computing capabilities to solve demanding tasks for embedded processors. Also, in a swarm configuration, Jeeves can take on agricultural tasks for professional farmers.
- **Sensor fusion:** Sensor fusion is used for “greater than the sum of parts” parameter detection.

Jeeves shall traverse different surfaces under varying conditions and cannot use the same algorithm all the time. For example, a sensor algorithm that is ideal for gravel could be suboptimal for grass, and the surface on a given location may change depending on various factors, such as weather or time of day. A digital twin is developed in this pre-project, proven through optimisation of traction control, will be a prerequisite also for the other functions and will support the decision for an upcoming main project.

Results from the RFF pre-project

A digital twin of the Jeeves to be used for steering control optimisation has been developed. The twin includes a track-road interaction model for the robot, and a driveline model for the motors. The digital twin can account for track-road interaction with a track-road friction coefficient that changes to the road condition and slip ratio. A speed and slide control method was developed and investigated using the digital twin. The controller was optimised across four conditions; dry asphalt, dry concrete, snow and ice. The optimisation minimised slip to reduce ground surface damage, which is critical in gardening applications, whilst maintaining a good acceleration profile. Numerous simulations were performed, and the control conditions for slippage prevention were identified. Based on the results obtained, optimal control designs for each type of road surface were established. Lastly, the control designs were exported to C codes for implementation within Jeeves.

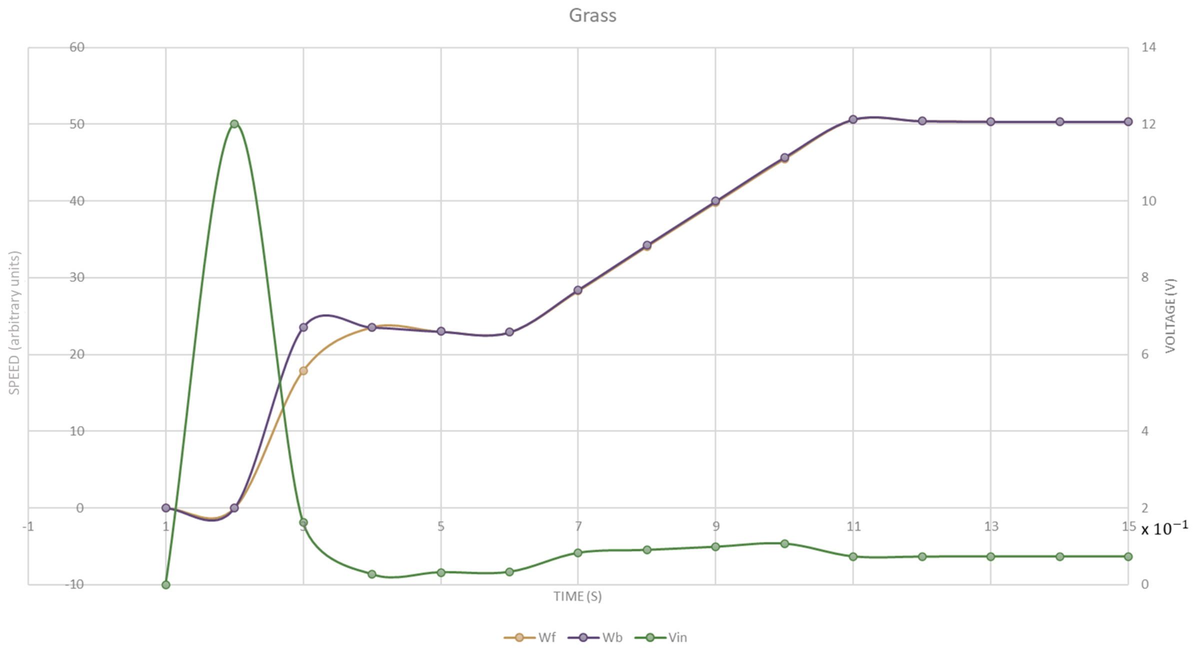

Fig 1 - An example of minimal slippage occurring on Grass (terms: Wb - Track Speed, Wf - Robot Speed, Vin - average voltage to motor); slight slippage occurs around 3s, but is quickly controlled.