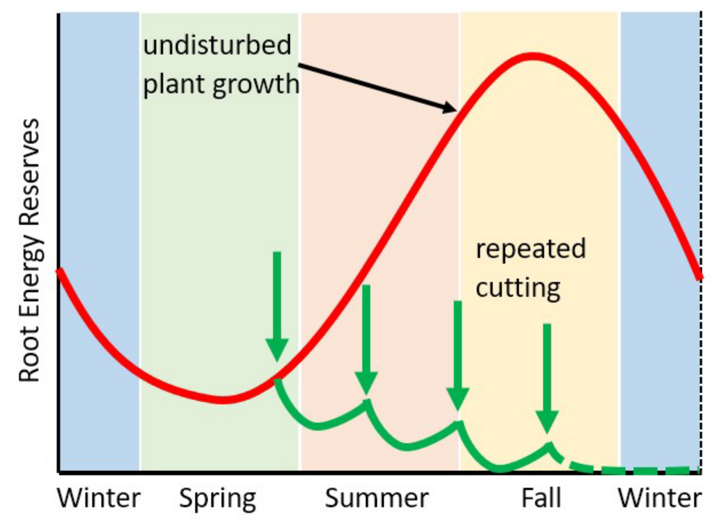
HSLU Hochschule Luzern

Engineering& Architecture
Master of Science in Engineering
Mechatronics & Automation

Autonomous Agricultural Robots

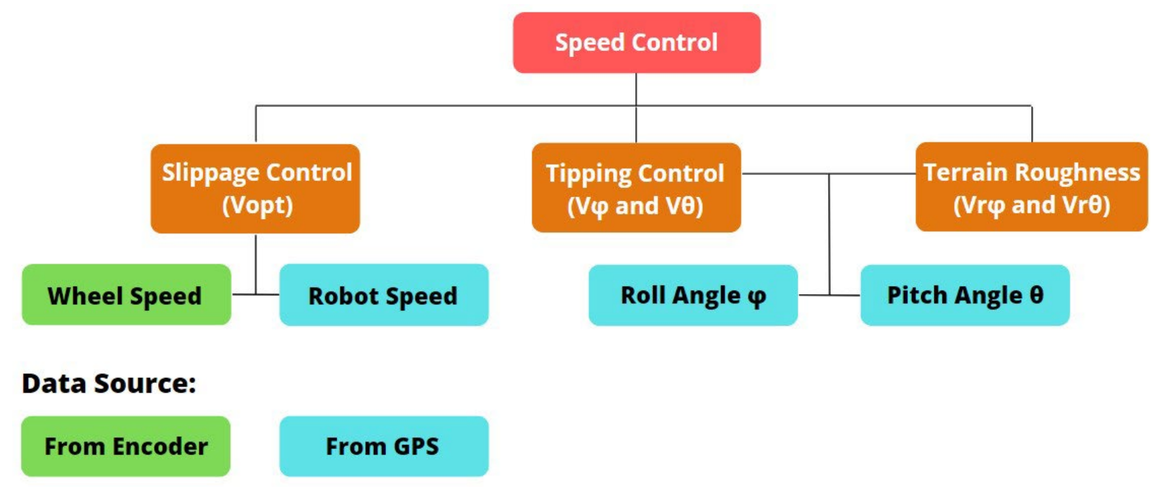
Performance Margin Estimation for an Agricultural Robot



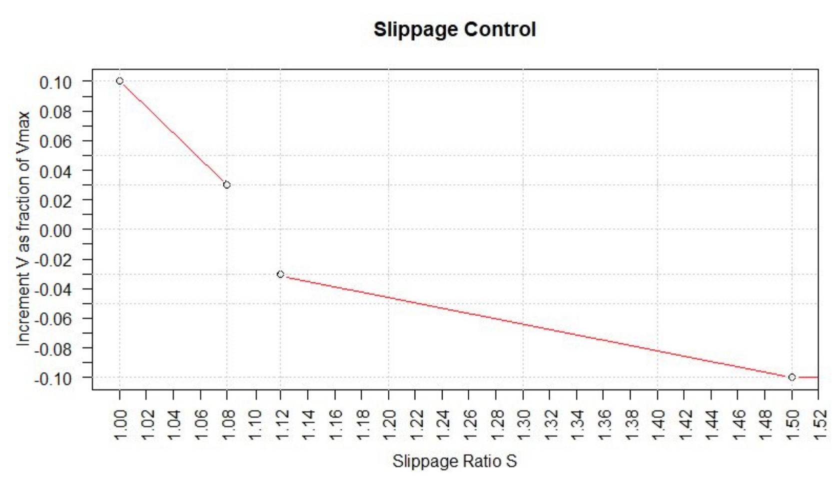
© Figure 1: Root energy reserves and systematic mowing effect

© Figure 2: AS 940 Sherpa 4WD RC

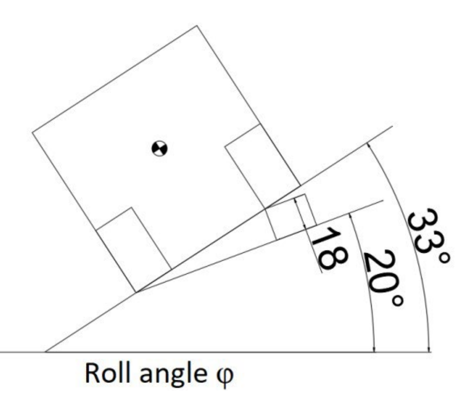
$V_{set} = V_{opt} - \max [Vp, V\varphi, V\theta, Vr\varphi, Vr\theta]$



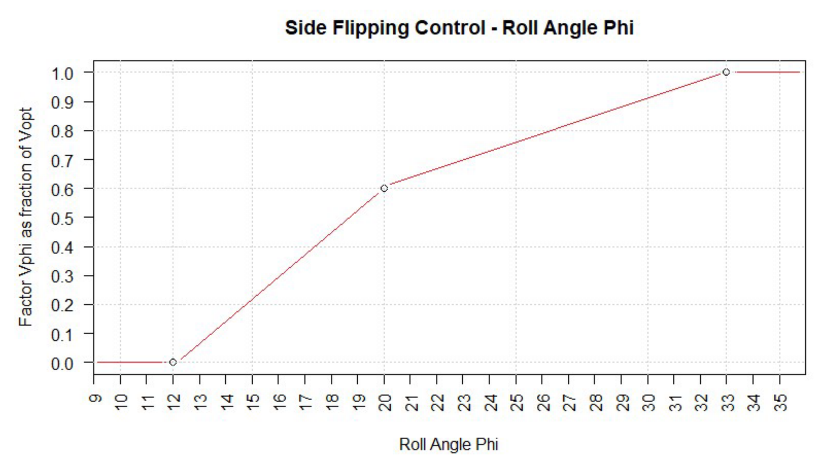
© Figure 3: Speed control diagram



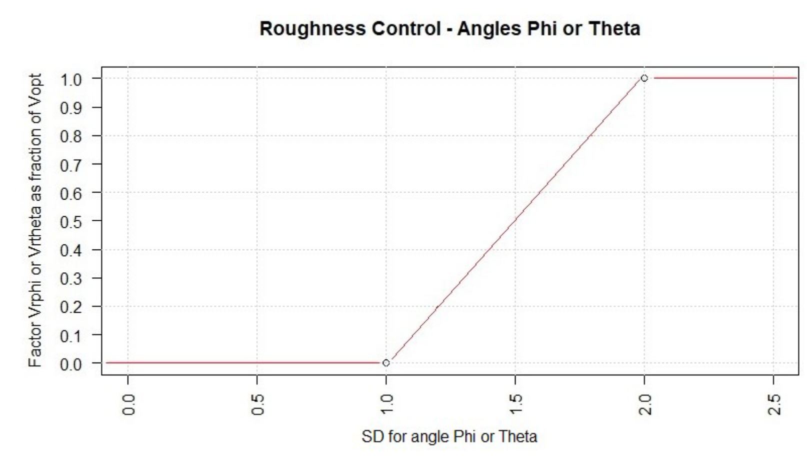
© Figure 4: Slippage Factor Chart



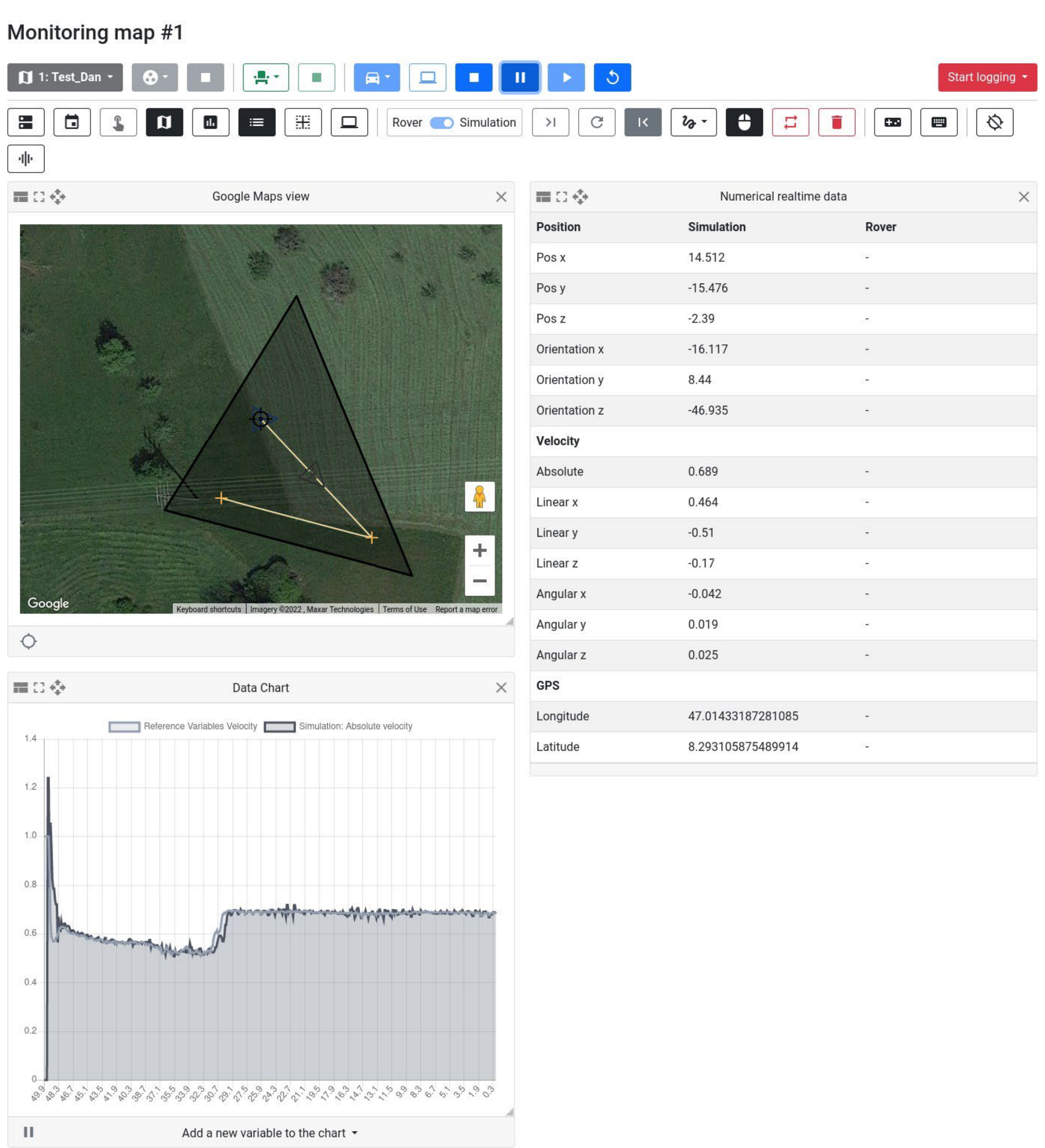
© Figure 5: Risk angles for flipping



© Figure 6: Side tipping factor Vφ

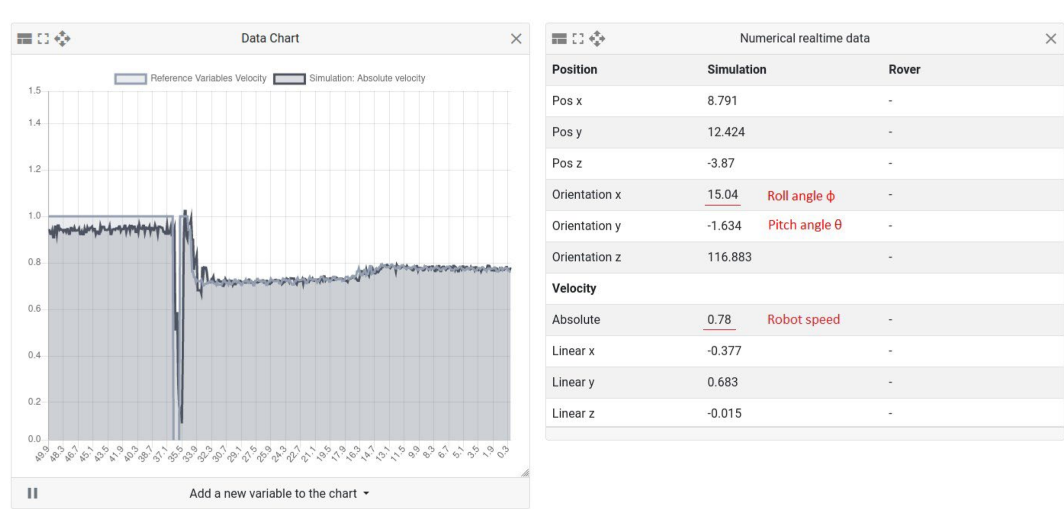


© Figure 7: Roughness factors Vrφ and Vrθ



© Figure 8: Simulation environment

© Figure 9: Simulation Location



© Figure 10: Speed control acting

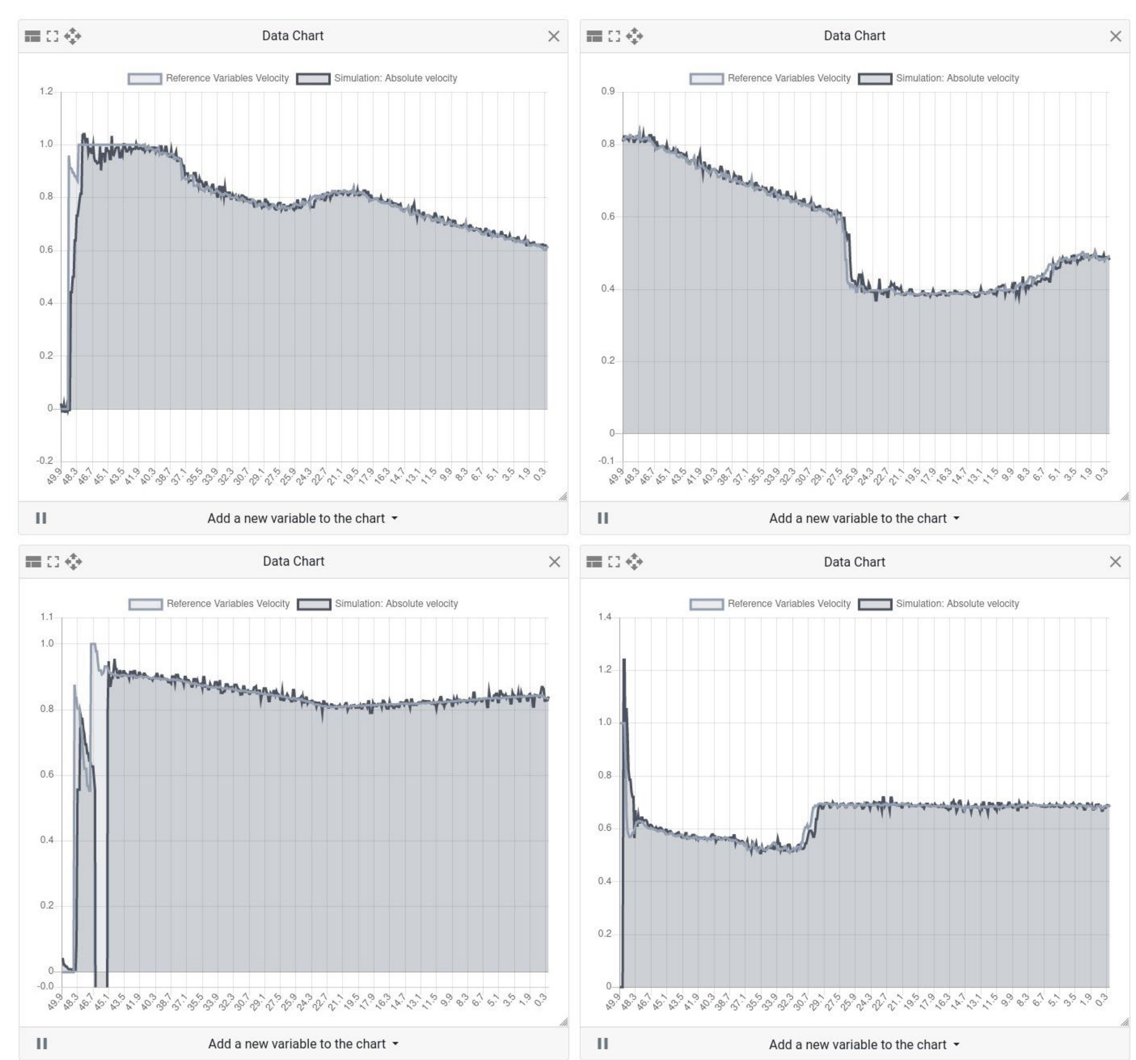


Figure 11: Speed control during the simulation

Problem
The problem that inspired this project is the undesirable presence of weeds in pastures and the issues they can cause. One of its main complications is the competition for nutrients in the soil, which can cause a non-optimal use of the pasture area.

Periodic mowing is an excellent option for controlling weeds where equipment can be utilized. Repeated mowing reduces weeds' competitive ability, depletes carbohydrate reserves in their roots, and prevents them from producing seeds. Some weeds, mowed when they are young, are consumed and enjoyed by livestock. One-time mowing will not be enough to control specific weeds, but mowing three or four times per year over a myriad of years can dramatically reduce and occasionally extinguish most weeds.

Solution Concept
This research focuses on the development of an envelope protection for an autonomous agricultural robot. Its goal is creating a speed control that responds to the main challenges and dangers such a robot could face during an off-road operation: lack of power, slippage, side/back tipping, and terrain roughness. With the aid of existing research that defines the optimum velocity for off-road vehicles and the use of limiting factors based on the environmental conditions, a method for the envelope protection is proposed:

$V_{set} = V_{opt} - \max [Vp, V\varphi, V\theta, Vr\varphi, Vr\theta]$.

The idea is that the set speed of the machine (V_{set}) will be an optimum velocity (V_{opt}) – based on the slippage due to the terrain type – minus the maximum value amongst several velocity limiting factors. The factors are based on the available power (Vp), roll angle (Vφ), pitch angle (Vθ), and terrain roughness (Vrφ, Vrθ).

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