Autonomous Farming: Sensing and Control

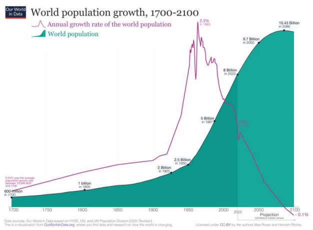
Viktor Uvesten (Väderstad AB / LiU)
viktor.uvesten@liu.se

Martin Enqvist (LiU)
martin.enqvist@liu.se

Background

Today's world faces complex challenges such as,

- biodiversity loss
- growing population.
- climate change

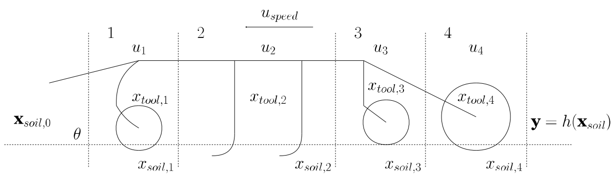


This drives the need for a sustainable and efficient food production. Agriculture, which is central to this effort, is constrained by shrinking arable land, declining interest in farming, and strict regulations on fertilizers and pesticides.

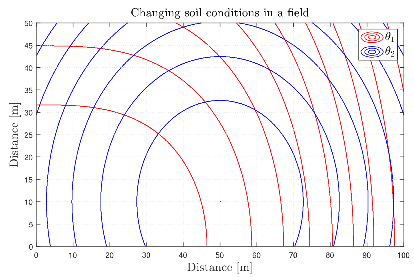
One potential solution is autonomous farming machinery. While autonomous tractors are gaining attention, fully autonomous farming remains a challenge.

Väderstad AB, a Swedish company specializing in agricultural machines, is addressing these issues through a new department developing connected and autonomous-ready machines.

Problem Formulation



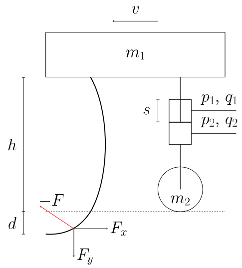
A generic Väderstad tillage machine has sequential tools aimed at changing the soil state from $\mathbf{x}_{soil,0}$ to a desired $\mathbf{x}_{soil,r}$ via tool setting adjustments. The soil is influenced by the settings $\mathbf{x}_{tool}$, machine speed u_{speed} and soil composition θ. The machine is controlled by the signal $\mathbf{u}$. Only the final soil state $\mathbf{y} = h(\mathbf{x}_{soil})$ is measured, introducing a delay based on tool distance and machine speed. Throughout the field, the soil composition changes, making it a dynamic disturbance. Here visualized using two different compositions in a field.



Initial Work

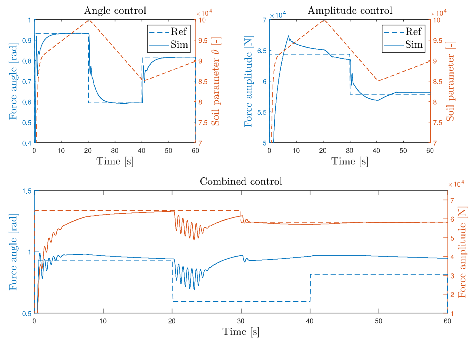
As this is pioneering research, the first step is to study the dynamical system through system identification for control. Initial work will focus on simulating dynamic behavior and disturbance effects, with particular emphasis on the known hydraulic system controlling the tools and the unknown soil dynamics.

To get initial insights, a simple model has been derived. Here, a single tool controlled by one hydraulic cylinder is considered. The force in the soil is modeled as:



$$F = \begin{cases} F_x(d,v) = \theta_s^{0.95} \cdot d \cdot v^2 \cdot e^{(\frac{-1}{20d}+2)} \\ F_y(d,v) = \theta_s \cdot v^2 \cdot e^{(\frac{-1}{50d})} \end{cases}$$

where d is the depth, v is the speed and θ_s is a soil specific parameter. The depth is controlled by changing the stroke s of the cylinder. The control of the force is shown below. The amplitude and angle are controllable separately but fails in combination.



LINKÖPING UNIVERSITY
SEDDIT Sensor informatics and Decision-making for the Digital Transformation
UPPSALA UNIVERSITET