

OST

Ostschweizer
Fachhochschule

Digital Farmer – an Overview

Let the machines do the work.

Prof. Dr. Dejan Šeatović
Institute for Lab Automation and Mechatronics ILT
Head of Intelligent Systems Group
Oberseestrasse 10
8640 Rapperswil

Departement of Mechanical Engineering and Innovation M|I



Greetings from Switzerland's most beautiful campus!

ILT Research Areas



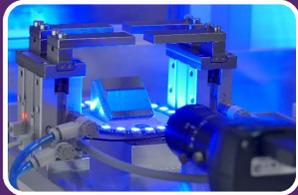
MECHATRONICS

Sensors, Actuators, Vision
and Control Systems



LIFE SCIENCES

Lab Automation
Liquid / Cell handling



INDUSTRIAL AUTOMATION

Connected Production
Cyber-Physical Systems



SMART FARMING

Autonomous Systems
Artificial Intelligence



ROBOTICS

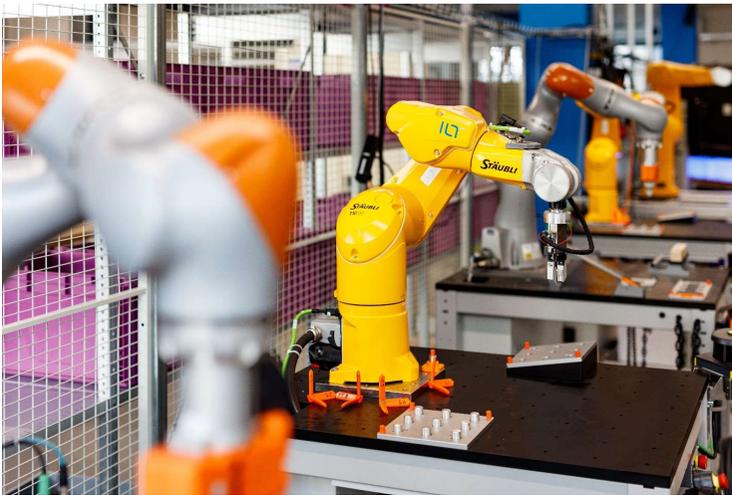
Collaborative Robotics
Mobile Robotics



MEDICAL ENGINEERING

Assistive and therapeutic
Rehabilitation

Smart Robotics Lab



Colaborative Robtics



Intelligent Systems



Rehabilitation



Towards Autonomous Field Systems and Smart Farming

Weed detection and treatment





Scope

- Conventional farming and potential paradigm change in food production
- Farmer dilemma considering weed control
- Automatic weed detection, a review
- New generation of machines on the field: Can we achieve similar productivity level as conventional farmers achieve nowadays?
- Building blocks of an autonomous weeding system and their challenges
- Glimpse in the new project starting this autumn and our goals. How to make money with weeding system?



A Few Farming Facts





Conventional Agriculture





Farmers Dilemma: Conventional or Organic?

- Conventional farming allows massive food production, while keeping the production costs low.
 - The field machines are GNSS controlled and require almost no human interaction to operate efficiently
- Companies such as Case or John Deere cover entire process with their machines, sensors and software.
- The food prices nowadays are low, and trends show that no change is to be expected.
- A comparison ...





Price Comparison Wheat – Copper

Wheat Prices



Copper Prices

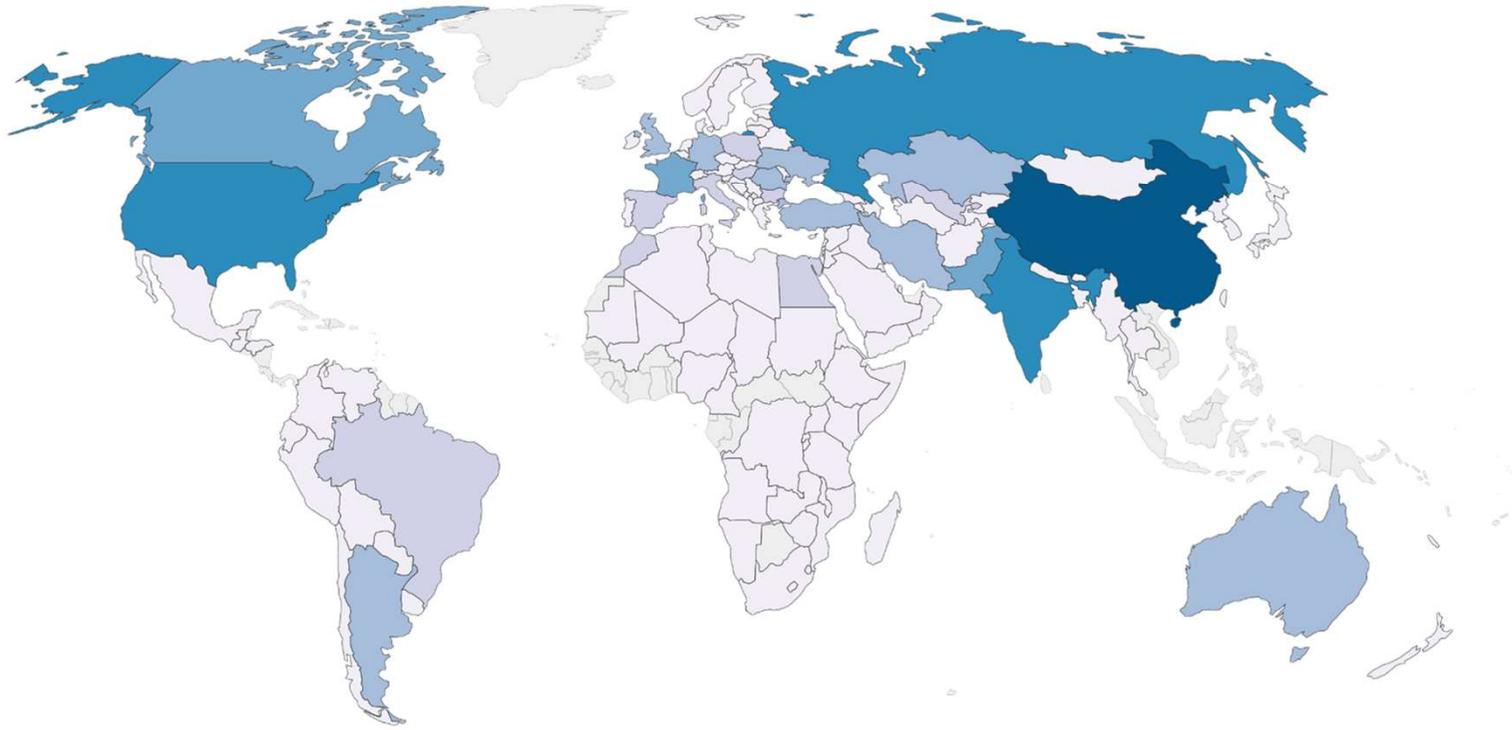


<https://www.macrotrends.net>

Wheat production, 2018

Wheat production is measured in tonnes.

Our World
in Data



Source: UN Food and Agriculture Organization (FAO)

OurWorldInData.org/agricultural-production • CC BY

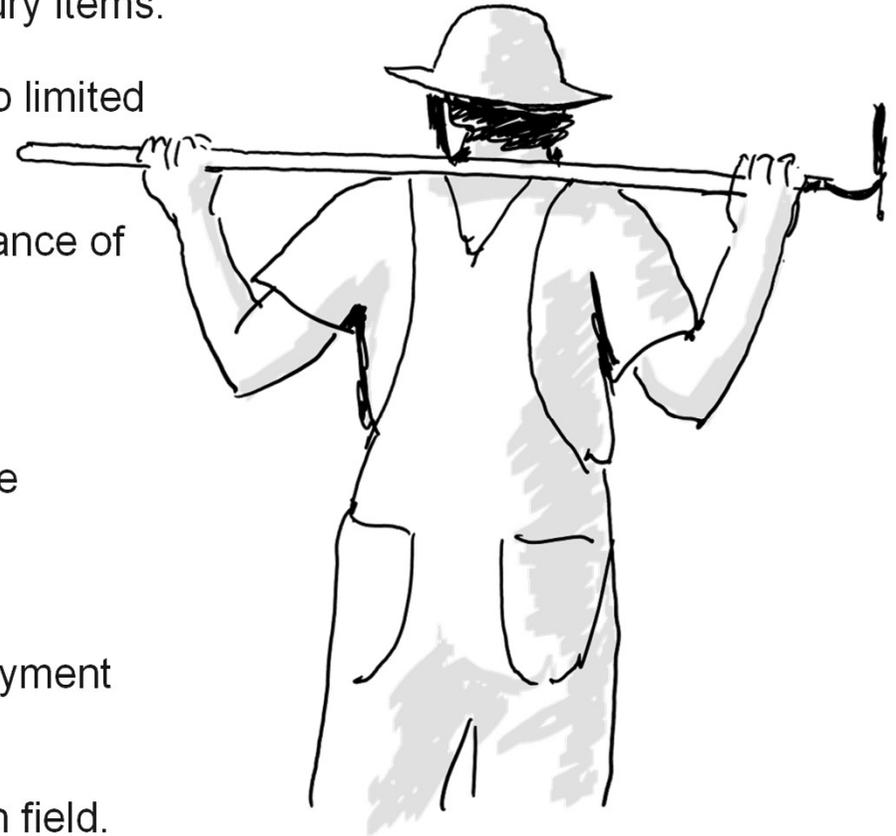
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra





Farmers Dilemma: Conventional or Organic?

- Organic groceries and food are (still) considered as luxury items.
- The profit margin of such products is higher since due to limited supply as compared to demand.
- Environmental enhancement and protection (and avoidance of future expenses to mitigate pollution).
- Higher standards for animal welfare.
- Avoidance of health risks to farmers due to inappropriate handling of pesticides (and avoidance of future medical expenses).
- Rural development by generating additional farm employment and assuring a fair and sufficient income to producers.
- Organic farmers require additional level of automation in field.





How to compete with conventional farmers in these fields?



Arable Crops

Grasslands

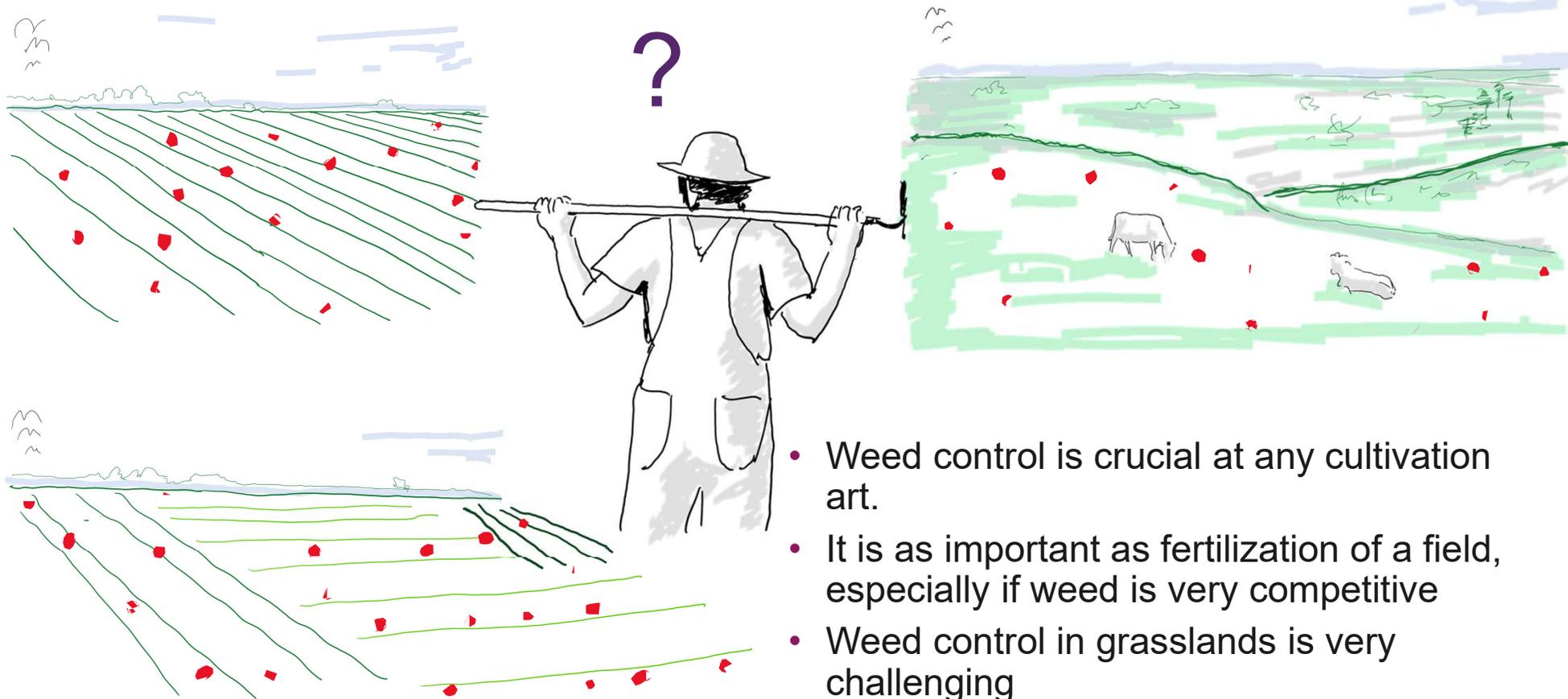


Olericulture





The Farmer Dilemma: Herbicide or No Herbicide

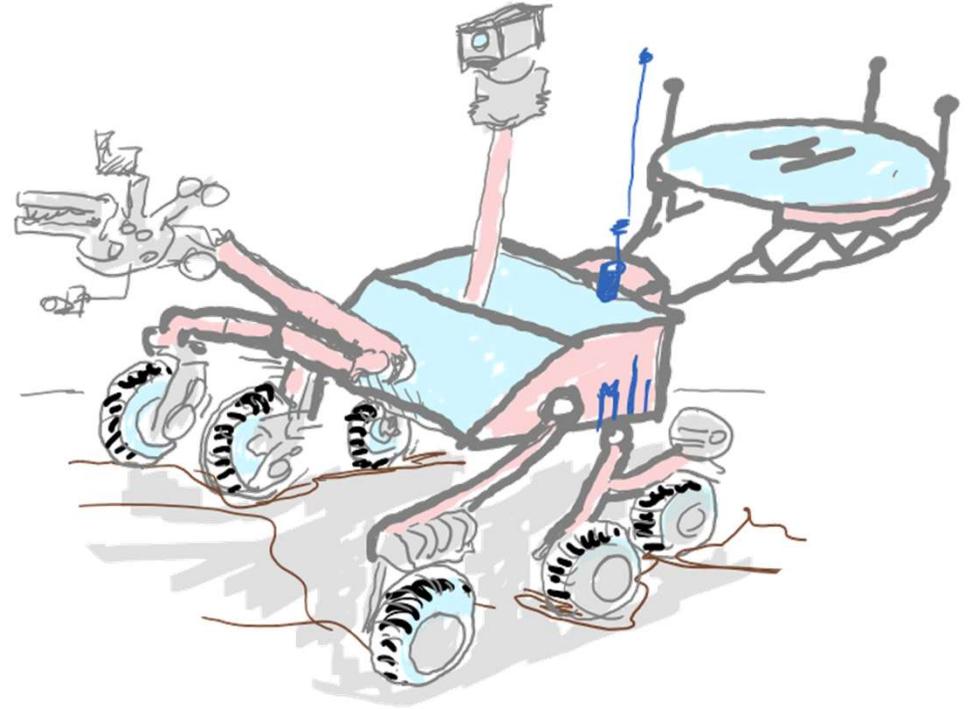


- Weed control is crucial at any cultivation art.
- It is as important as fertilization of a field, especially if weed is very competitive
- Weed control in grasslands is very challenging



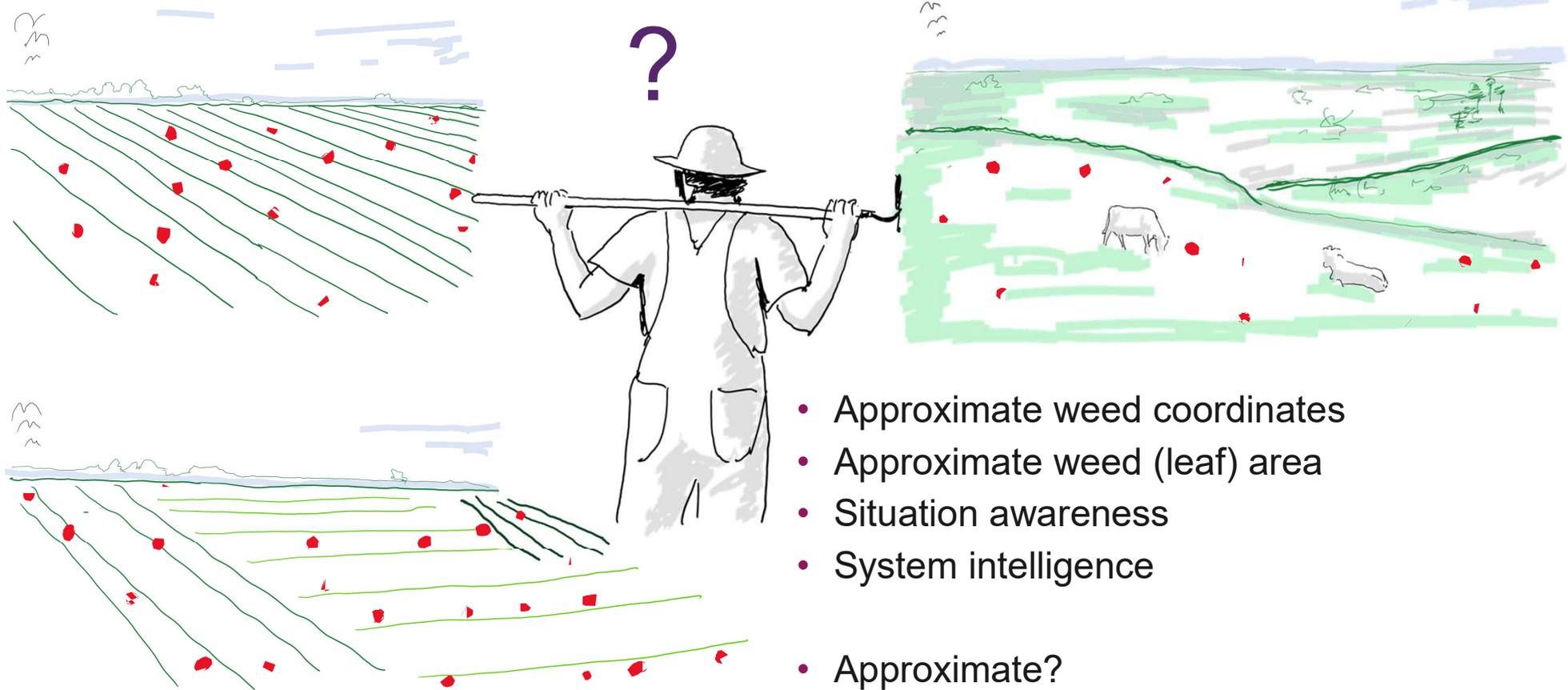
The Idea

Robotic Assisting System





Assisting System Requirements

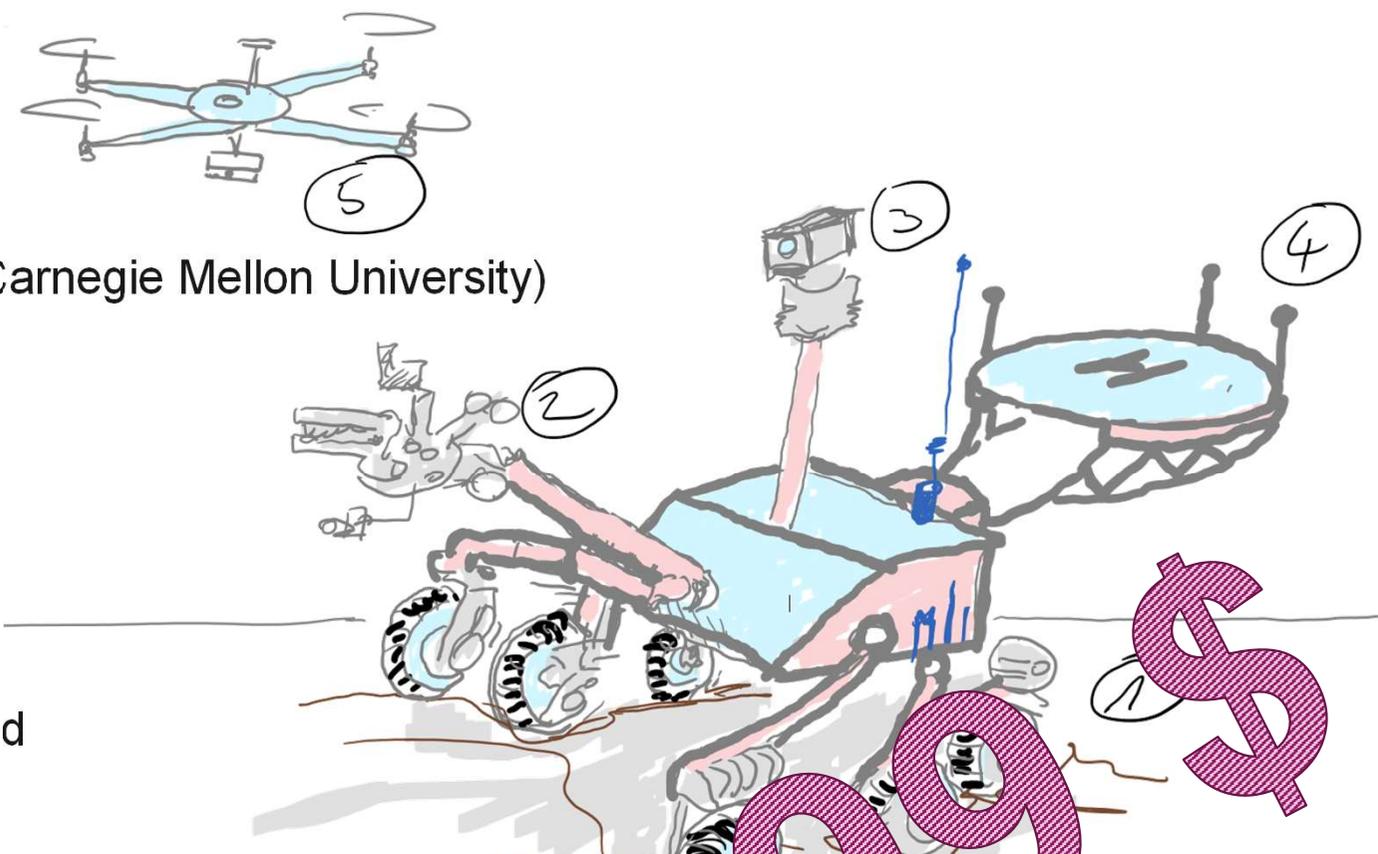


- Approximate weed coordinates
- Approximate weed (leaf) area
- Situation awareness
- System intelligence

- Approximate?

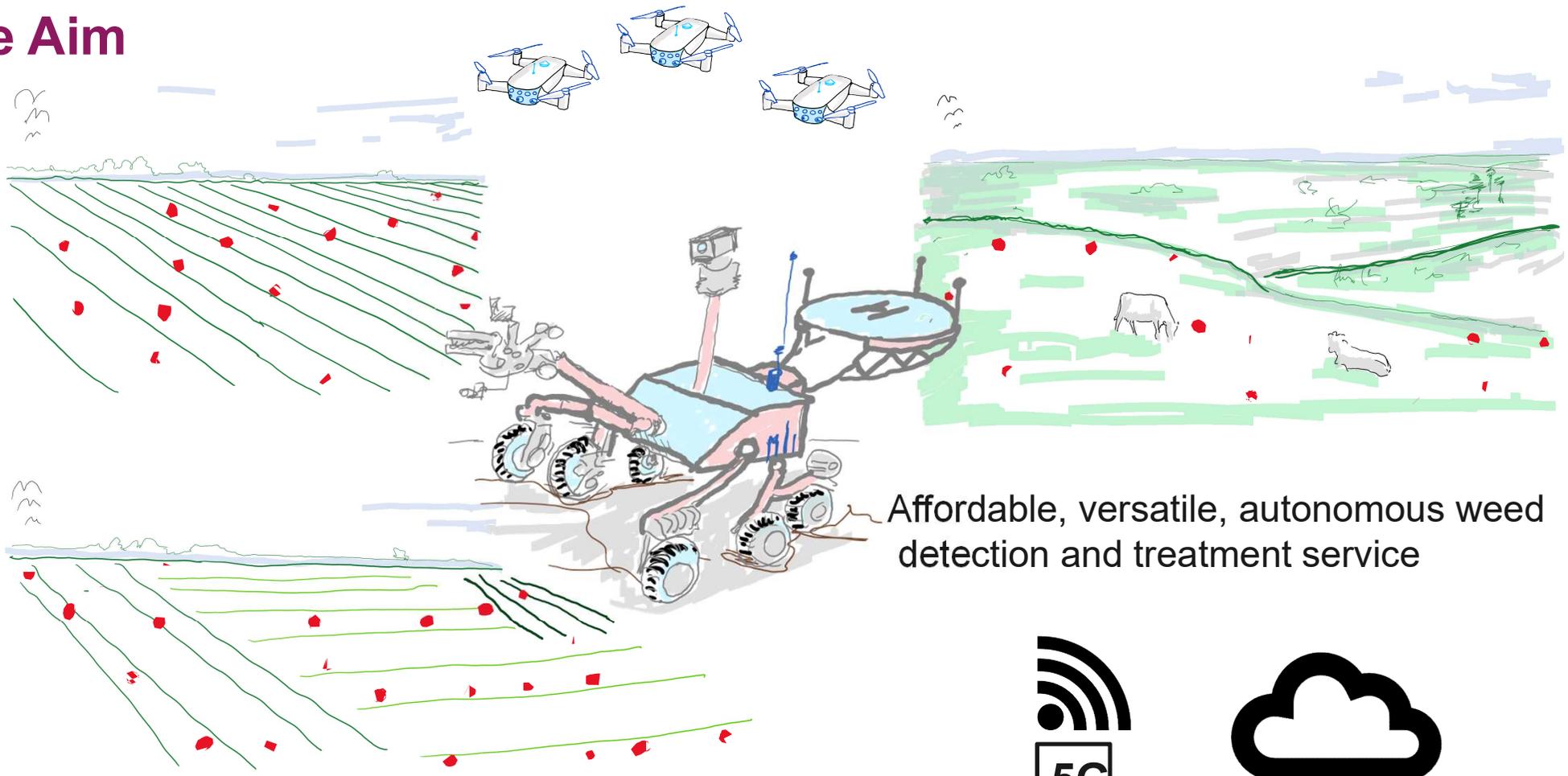
The Idea

1. UGV – A carrier (Design by Carnegie Mellon University) a UGV inspiration
 2. Manipulator
 3. Ground sensing systems
 4. A UAV – Landing platform
 5. A UAV for remote sensing and reconnaissance
- We are certainly not first to have such idea
 - We are probably first group that want to build such system for 5000 \$US

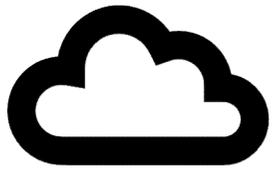


49999 \$

The Aim

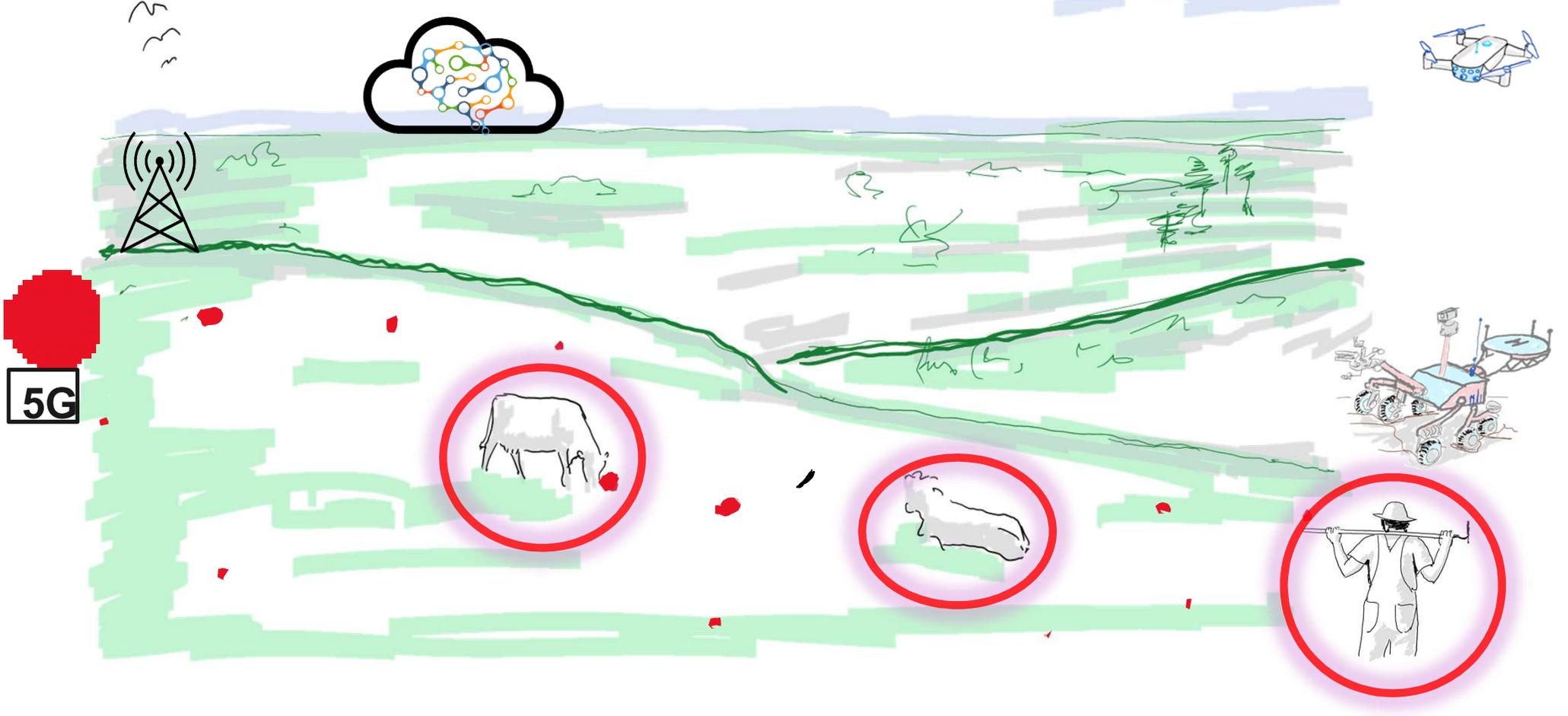


Affordable, versatile, autonomous weed detection and treatment service





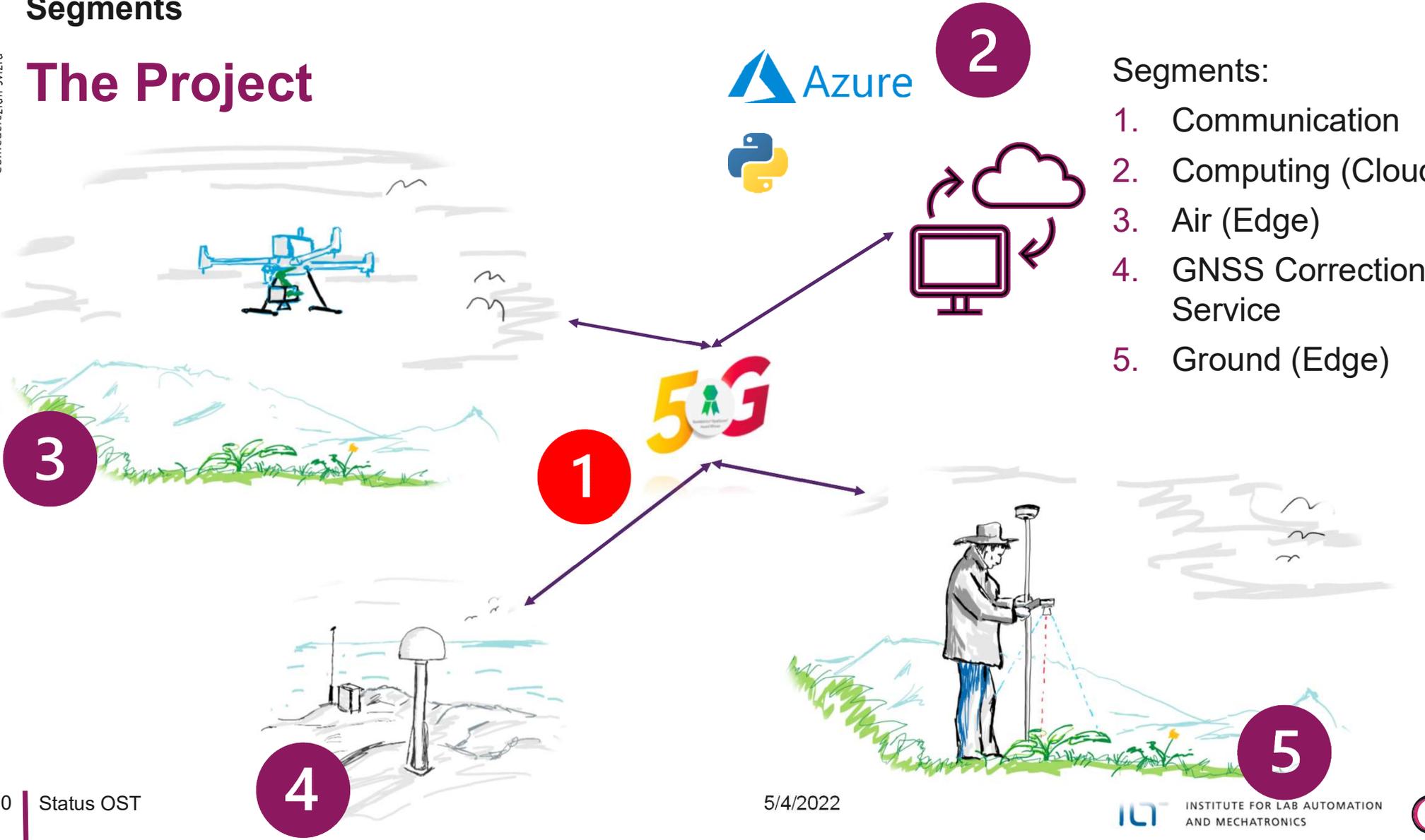
Weed Detection and Treatment in Grasslands





Segments

The Project



Segments:

- 1. Communication
- 2. Computing (Cloud)
- 3. Air (Edge)
- 4. GNSS Correction Service
- 5. Ground (Edge)





Vision Realisation

Building Blocks of the Weeding System





Building Blocks Realized

- ✓ Low-Cost GNSS navigation system based on U-Blox ZED-FP9
- ✓ Low-Cost robotic operating system, ROS::
- ✓ Low-Cost and yet powerful inference (weed detection) system NVIDIA AGX Xavier
- ✓ Carrier vehicle, not low-cost
- ✓ Robotic manipulator, not low-cost
- ✓ Hot water treatment unit, experimental



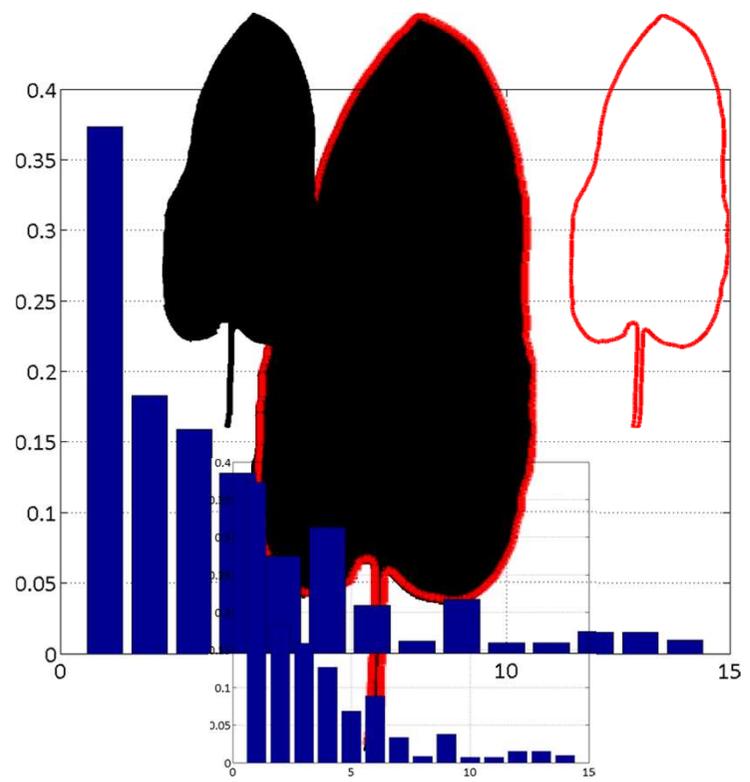
Weed Detection

The Machine View of Weed Control

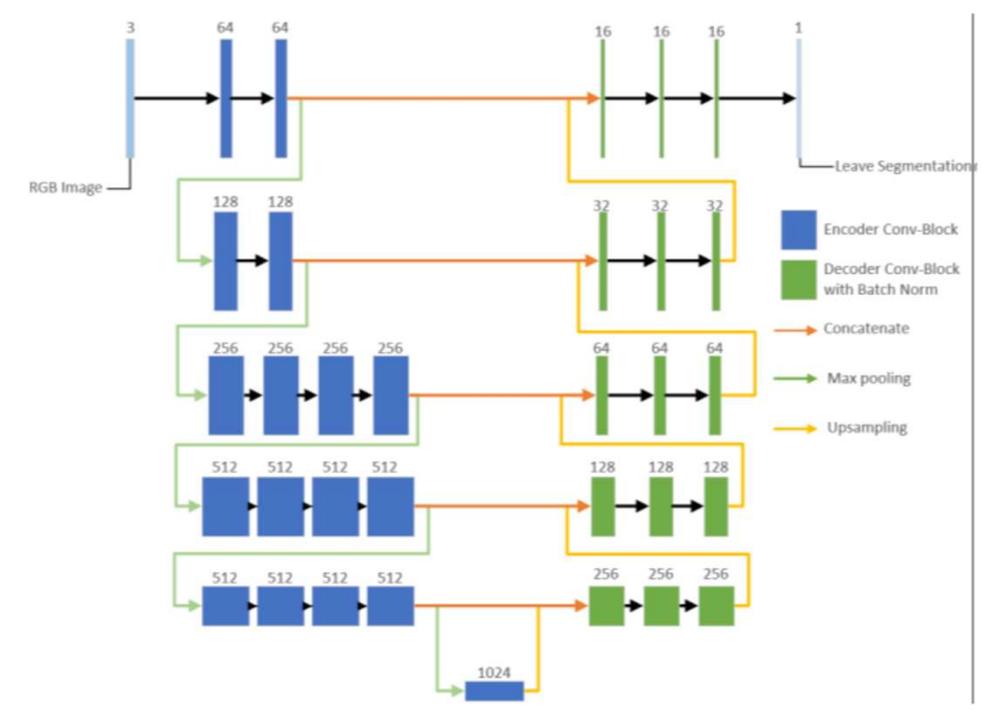
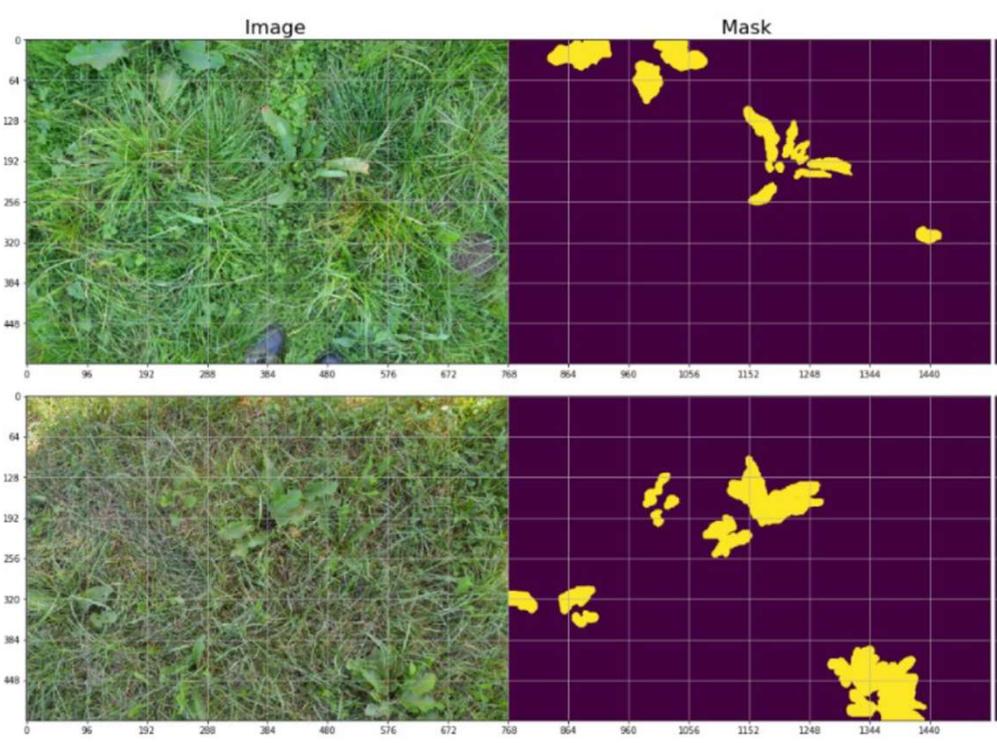




How a Machine “Sees”



U-Net Based Segmentation Algorithm Detects 95% of Plants





Weed detection

- A real time plant root detection has been developed
- In non-optimized state, the system processes 4 frames per second
- A deep-stream solution will increase the processing rate to 20 frames per second
- Plant roots are not visible in any images
- The root location is 3 cm accurate





Root Detection: Detect Unseen Features

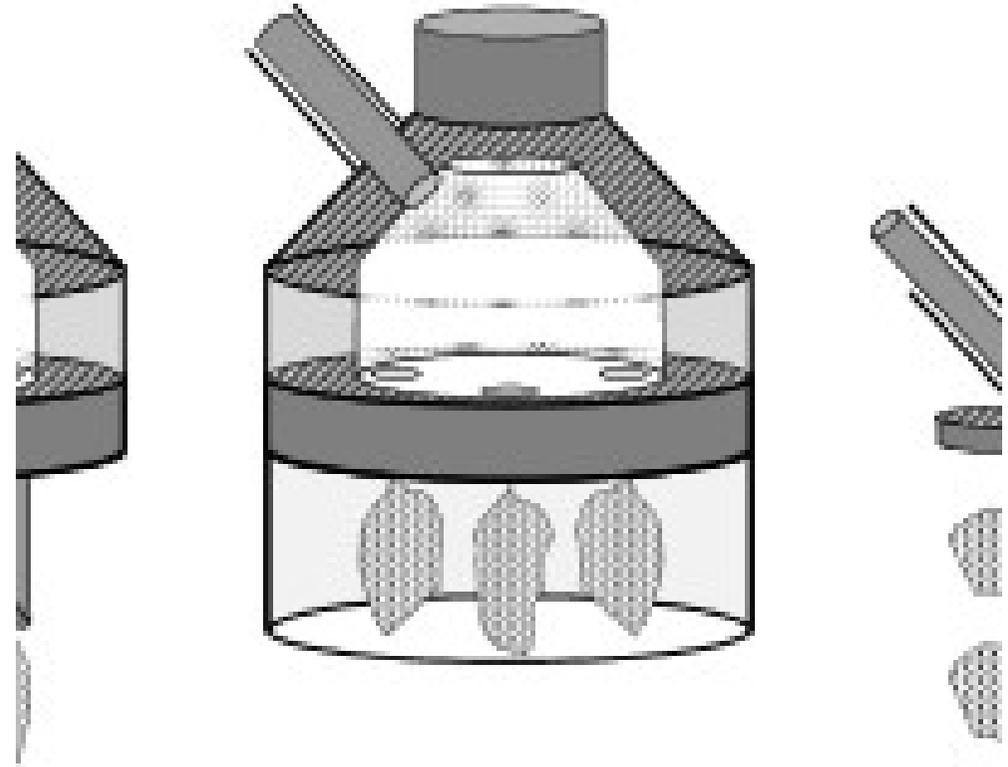




Hot Water Treatment

Roy Latsch & Joachim Sauter

Agroscope





R. Latsch, J. Sauter

Hot Water Treatment

- Hot-water treatment is practicable
- Mortality rate of 80 % reached at:
 - Water temperature: >80 °C
 - Water amount: Ø 1,6 litre per plant
 - Fuel oil requirement: Ø 0,02 litre per plant
 - 50 plants per litre fuel oil

- Handling:
 - Treatment time ca. 10-15 seconds
 - Spot stream of rotary nozzle breaks up the soil structure
 - „Contactless“ treatment
 - Mud has to properly enclose the dock root
 - Mud should reach a depth of about 15 cm



R. Latsch, J. Sauter

Hot Water Treatment: New Wave

- At Rapperswil we **are** developing new, more advanced hot water unit
- We aim to reduce treatment time to 5-6 seconds
- The water pressure 13 MPa@90°C (at source!)
- At Rapperswil we **have** developed a scara robotic arm for more efficient treatment process





Florian Eisenring & Patrick Zellweger

The Vehicle

- The Vehicle, WeedEraser, is our “weak spot”
 - 900 kg
 - Modified used Golf-Cart (1175 CAD)
 - PLC, Steering modifications, etc. 16 585 CAD.
 - 1500 Hours of students work
 - Three ArduSimple RTK Receivers
 - Positioning accuracy 3 cm
 - Navigation accuracy 30-50 cm, depending on occlusions and satellite constellation
 - Strong EM interferences
 - Vehicle control is very challenging!





Automating Hot Water Treatment

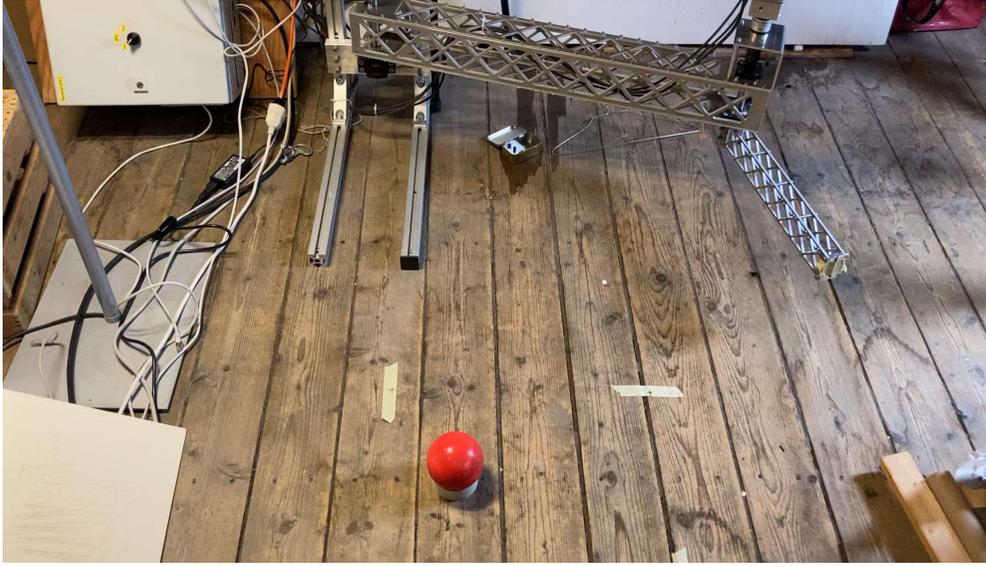
Building Blocks





Matthias König

Scara Robotic Arm: A Preview





Damian Schori

And COVID-19 Proof of Concept of Root Tracking



Video Matthias König, BSC Thesis, HSR



Areal Weed Detection Challenges



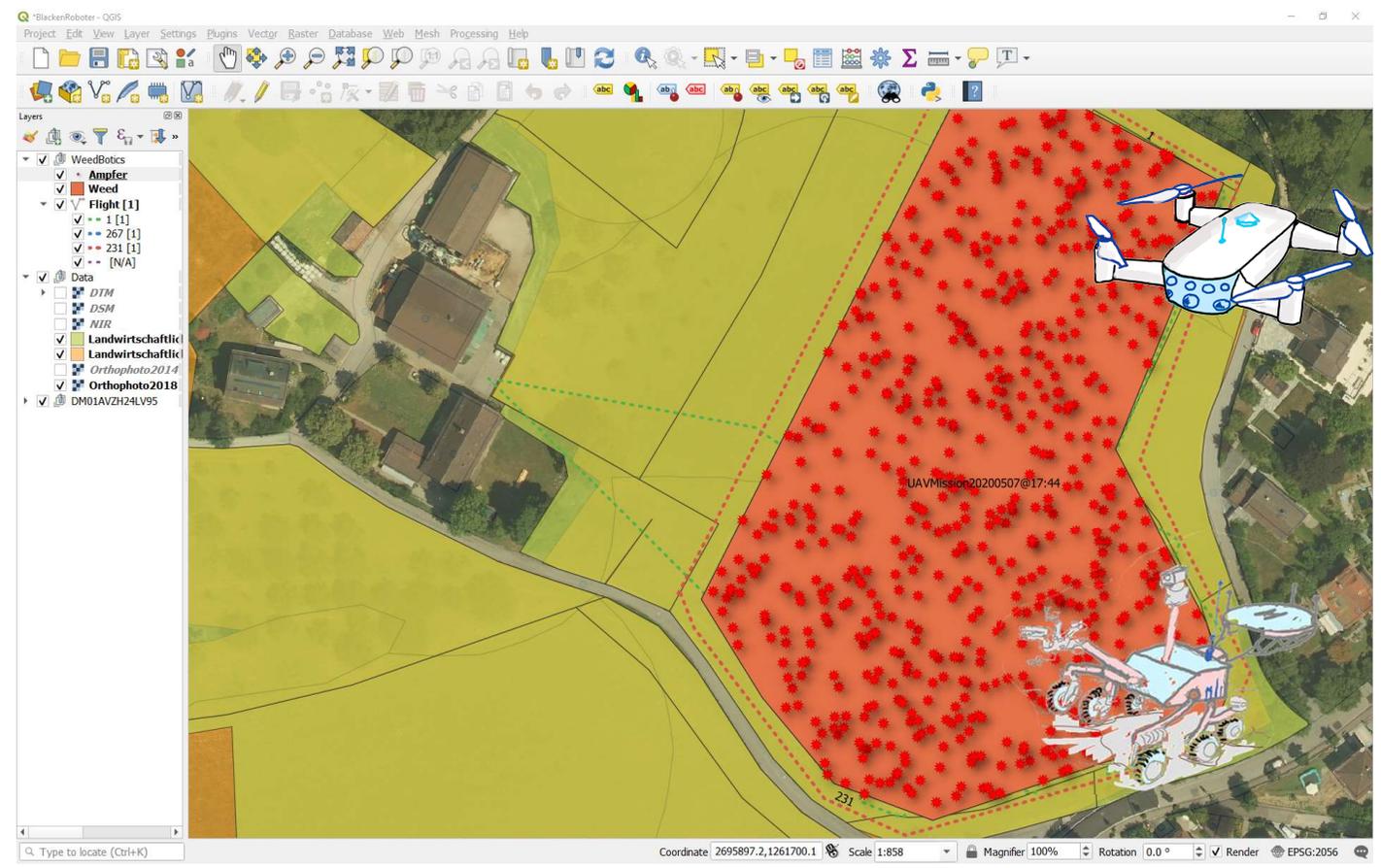


Image quality is crucial for weed detection!



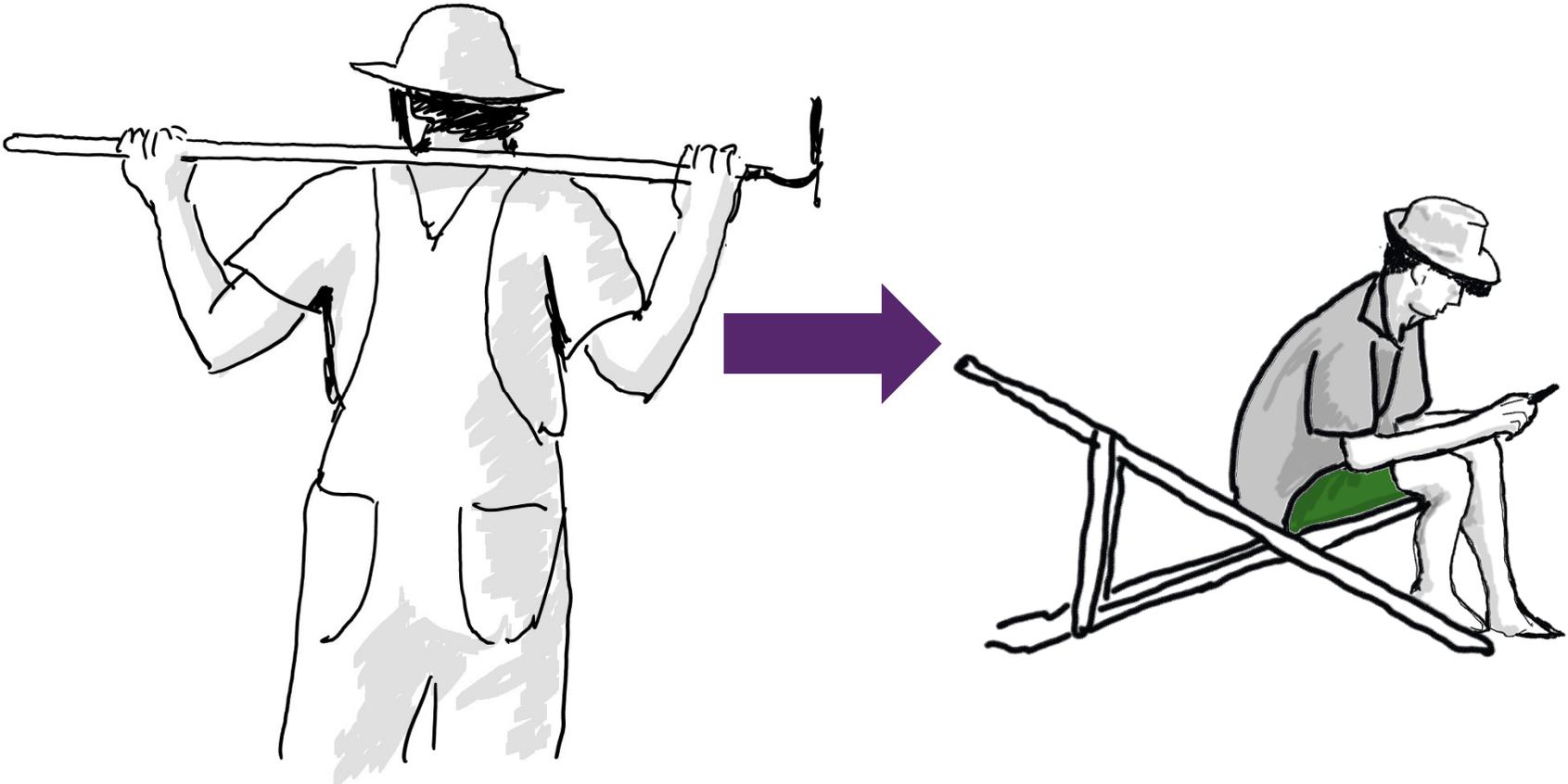


The Weed Locations Map





From manual to semi automatic weed control





Digital Farmer: The Number 5





Q&A

Thank you for your attention

