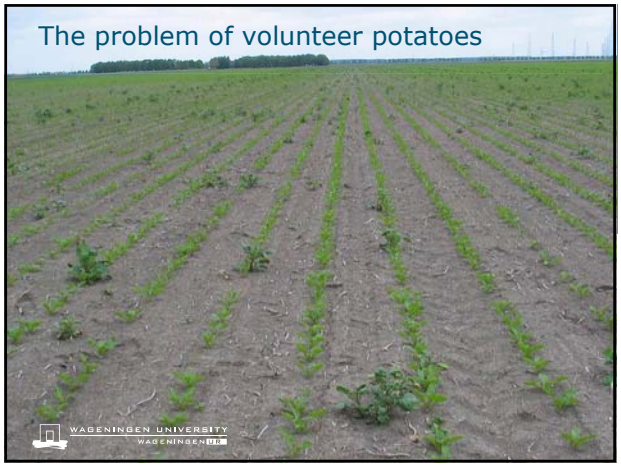
The difference between green and green

How to detect weeds between plants

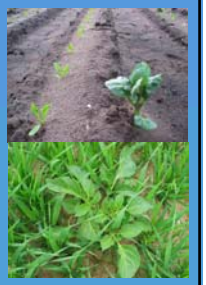
April 11th, 2012 | Jan Willem Hofstee | The Sense of Contact

The problem of volunteer potatoes



Why are volunteer potatoes are a problem?

- They are a source for the spread of diseases as *Phytophthora infestans*
- They interfere with the crop rotation necessary for a healthy crop and soil
- They are a weed and compete with crops



- Volunteer potatoes have to controlled by law
  - There is a maximum level that may be present in a field by July 1st.

Current practice for control of volunteer potatoes

- Manual
  - Labour intensive
  - Limited availability qualified personnel
  - 1 ha is nice, 40 ha is not
- Mechanized
  - Only control between rows and not in the row and volunteer potatoes grow everywhere

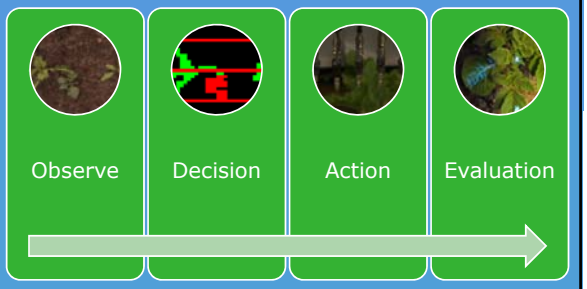
There is a need for an automated method to control volunteer potatoes

- Potatoes are a very important crop in the Netherlands
- There are NO selective herbicides available
- Available chemicals are not very effective
- Control is required by law
- Qualified labour is costly and not always available

What is required for an automated solution?

- Effective control
  - Maximal 5% of sugar beets may be destroyed
  - At least 95% of volunteer potatoes have to be controlled
- Low cost: economically profitable
- High capacity: 1.5 – 2 m/s driving velocity
- Able to operate under a large variety in environmental conditions
- Detection and control integrated in one operation
- Low environmental load

What has to be done to control volunteer potatoes?



Observing the volunteer potato plants

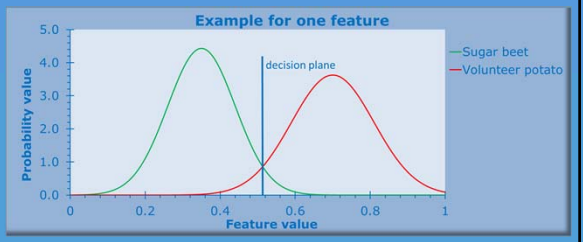
- Measurement in daylight is not easy
- Closed box with artificial lighting
- Measurements with two cameras
  - RGB
  - NIR

Is it a volunteer potato or not?

- Based on feature values of sugar beet and volunteer potato
  - Value of Red, Green, Blue, Near Infrared (NIR)
  - Value of Hue, Saturation or Intensity
  - Difference between colours
    - Excessive green: $EG = 2 \times Green - Red - Blue$
  - Ratio between colours
    - NDVI: $NDVI = \frac{Red-NIR}{Red+NIR}$

Up to six features are input for a Bayesian classifier

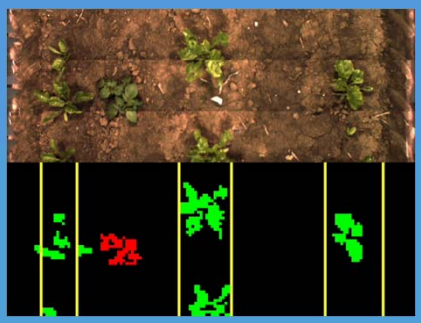
- Bayesian classifier: $P(C_i \mid F_k) = \frac{P(C_i)P(F_k|C_i)}{P(F_k)}$



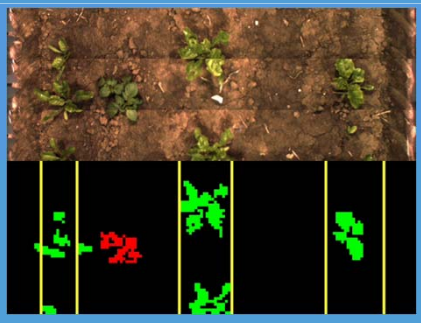
Potato and sugar beet plants vary from day-to-day and field-to-field

- A solution that may perfectly work in one field, may not work in the same on another day or in an other field on the same day
- An adaptive solution is needed
- The Bayesian classifier is self learning
  - the a-priori decision functions are based on the most recent classifications

Detection of volunteer potatoes



Detection of volunteer potatoes

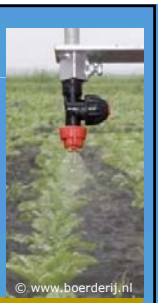


How to kill a volunteer potato?

- Cut the leaves off?
  - It will regrow
- Dig the tuber out of the soil?
  - Hard to find, can be very deep (> 30 cm)
- Pull out the plant and tuber?
  - The tuber will likely stay in the soil and the plant will regrow
- Control with the systemic herbicide glyphosate is very effective

How to apply this herbicide?

- With a spray nozzle?
  - The sugar beets are very sensitive too and just some drift will kill them too
- With a micro sprayer?
  - Droplets have to be positioned very precise
  - Droplets may not splash
    - Use of gel



How much to be applied?

A = 0.1%, B = 0.5%, C = 1.0%, D = 2.0%, E = 5.0, F = 10.0%

Microsprayer with five nozzles

Nozzles can be individually controlled

Nozzles can be individually controlled

Detection, decision and action are integrated into one frame

What did we achieve?

- Maximum travel velocity 0.8 m/s
  - Limited by actuation frequency of nozzles
- Accuracy
  - ±1.4 cm in longitudinal direction
  - ±0.75 cm in transversal direction
- Control
  - 84% volunteer potato plants were killed with 1.4% damaged sugar beet plants
  - 95% can be achieved; there is a trade off between killing volunteer potatoes and sugar beets

Perspective

- Developed prototype is effective
- Industry has interest to manufacture and market the machine

- Not ready for the market yet
- Usability has to be increased
  - Volunteer potatoes in more crops than only sugar beet
  - More weeds than only volunteer potato

Thanks for your attention

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