

Detecting weeds by artificial vision in carrots: towards optimization of herbicide use

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Climate change: challenges, risks and impacts on cropping systems

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Horticulture and herbicides

- There is significant potential for the reduction of GHG emission by reducing the amount of pesticides both in manufacturing (15%) and applying phases (30%)⁻⁵
- Weed control continues to cause a problem for horticulture
 - One solution is the use of Precision Horticulture

Diapositive 2

-5

Source USDA - NRCS

-; 2/04/2009





Precision horticulture

- Precision horticulture is the use of advanced horticultural management systems based on a spatial information platform. It includes:
 - Development of spatial information tools
 - Use of remote sensing tools
 - Development of proximity sensing tools (e.g. **image processing based sensors**)
 - New data capture tools in the field (micro-sensors)
 - Sensor fusion of the information provided by several sensors (temperature, solar radiation, plant growth,)
 - Etc.



Image processing based sensors

- Existing tools = Local positioning systems for mechanical weeding using machine vision
 - Mechanical weeding between the rows: the distance between the rows is known 
 - In-row cultivation: the plant spacing in the row is known 

Mechanical weeding between the rows

- An articulated mechanism produces a lateral displacement of the cultivator relative to the tractor
- This displacement relative to the plant rows is measured by a machine vision system and used in a feedback control loop
- The localisation of the cultivator between the rows is thus very accurate



Cultivation of beans

Eco-Dan



In-row cultivation: the plant spacing in the row is known

- Images analyses of the crop are performed
- Individual plants are tracked through the image by applying a predetermined grid
- The weeding rotors are working around each individual plant
- The in-row rotors are then followed up by a set of inter-row cultivation units to complete the all round cultivation process



Robotcrop InRow (Garford)

- Performance: 2 plants/s
- Weeding coverage of up to 98.5% surface area has been achieved

In other cases, there is no commercial solution...

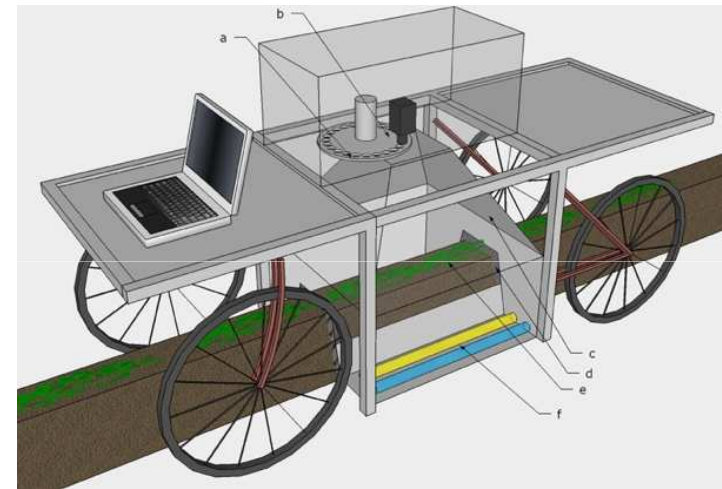
- It is still a difficult task to recognize by machine vision weeds which are mixed with plants in a random manner
- Example: **carrots**
 - Carrots are densely sown
 - They do not follow a regular pattern
 - Some weeds are very similar to plants regarding their shape or colour
 - Weeds are often overlapping



Typical organic carrot lines with weed infestation at an early growth stage.

Recognition on basis of the spectral reflectance (1)

- Goal
 - To select the most appropriate wavelengths for the image acquisition
- Method
 - Filter wheel equipped with 22 band pass interference filters
 - Selection of the best combination of 2, 3 and 4 filters to get the best classification accuracy



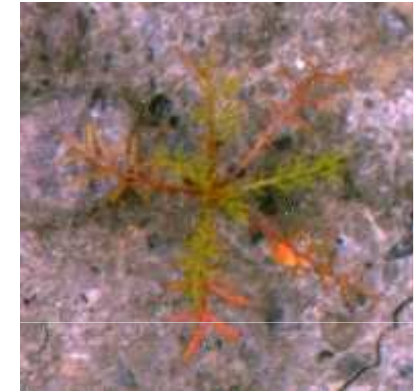
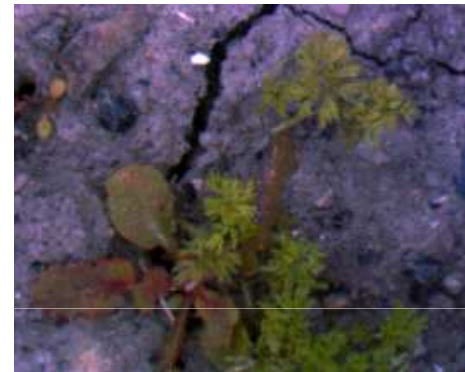
- a. Filter wheel
- b. Camera
- c. Reflector
- d. Brushes
- e. Carrot ridge
- f. Lighting

Recognition on basis of the spectral reflectance (2)

- Results

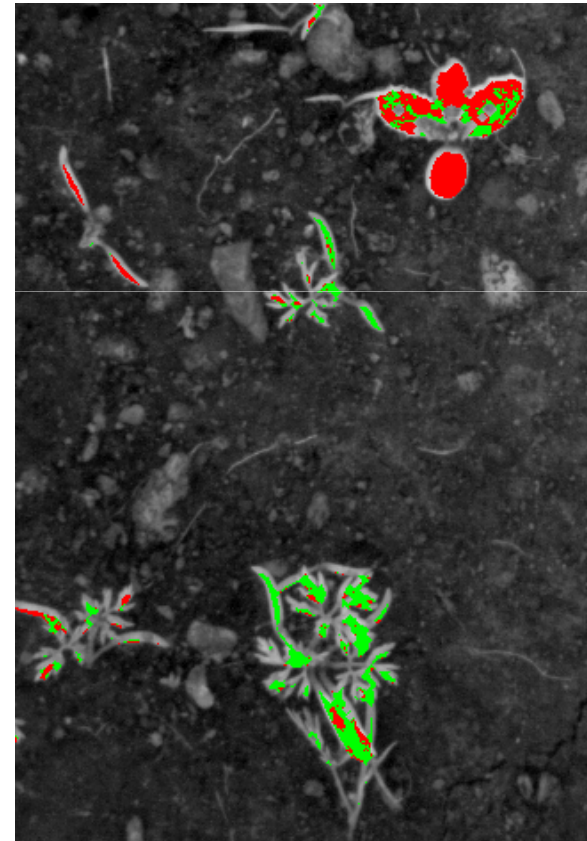
- Best combination of filters: 450-80, 550-80 et 700-50 nm

- Classification accuracy = 72 %



Recognition on basis of the spectral reflectance (3)

- Results
 - A given plant may have different spectral characteristics, with following consequences:
 - In some cases, the centre of the weeds is correctly classified while the outer regions are misclassified
 - Cotyledons are nearly systematically misclassified

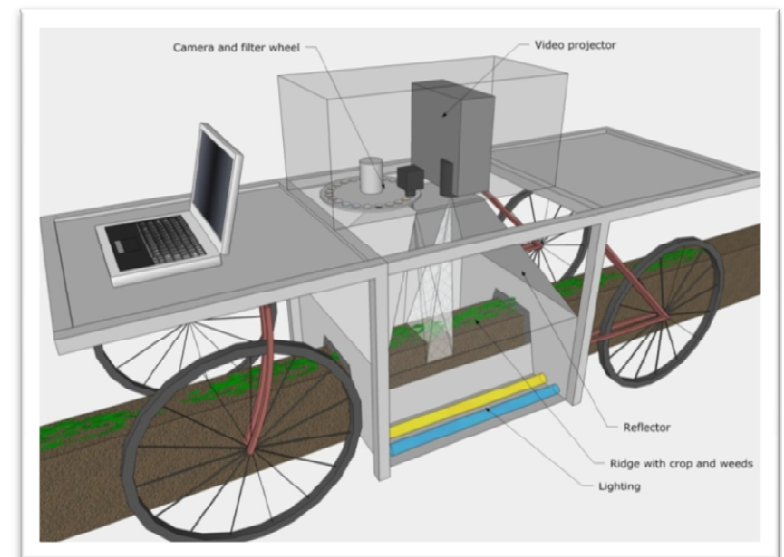


Recognition on basis of plant height (1)

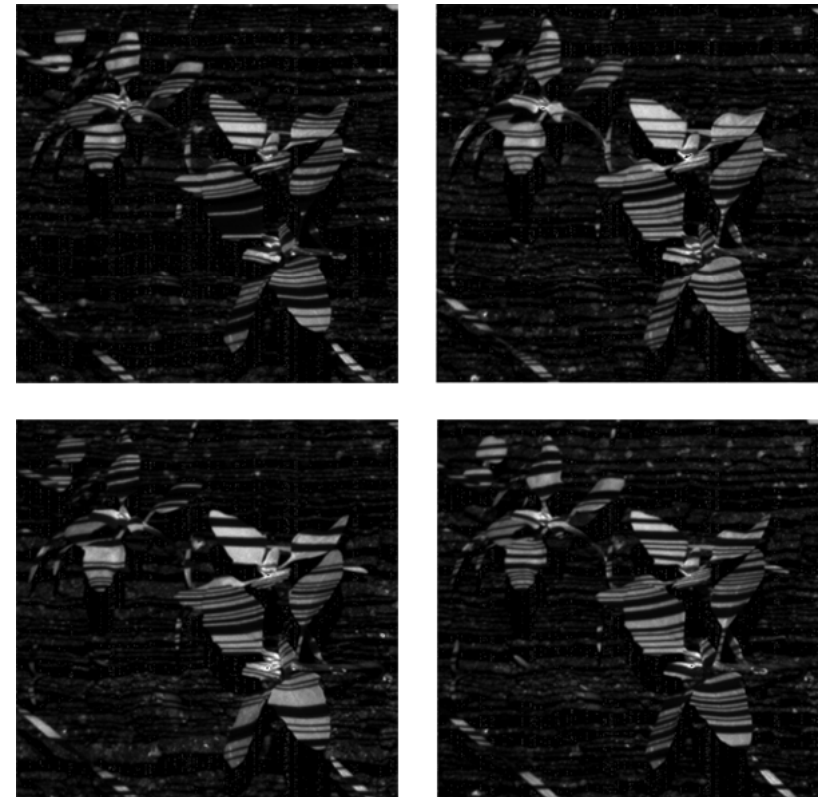
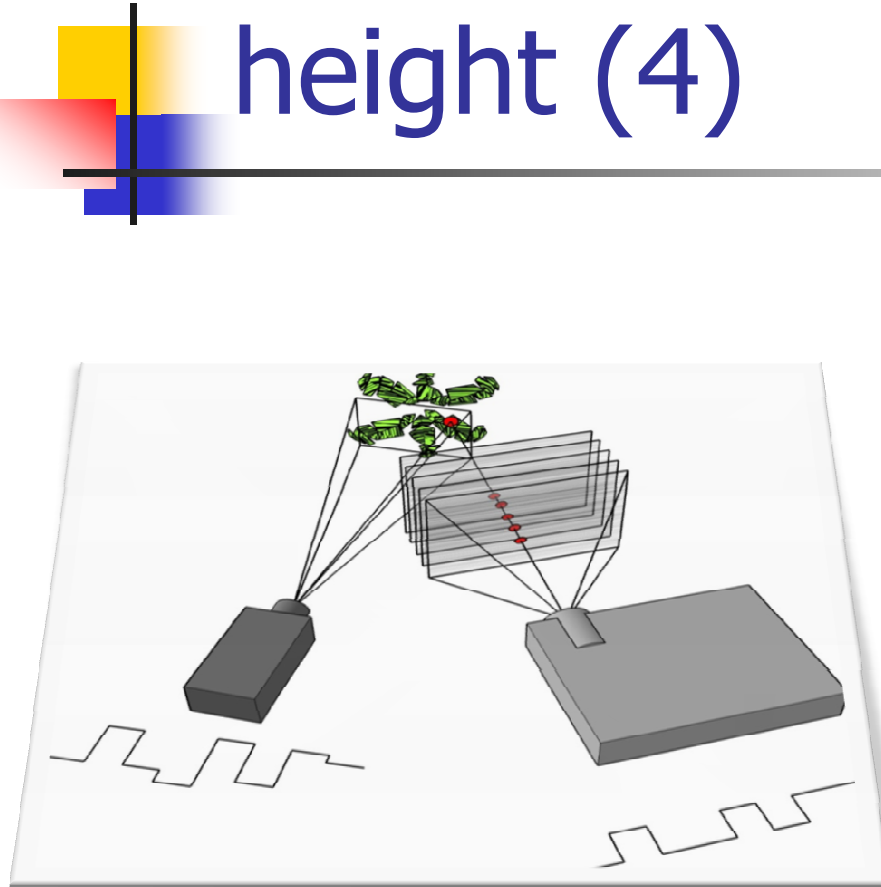
- Goal
 - To discriminate plants and weeds on basis of the height difference
- This relies on following assumption: *the carrots height is more uniform than the weeds heights*

Recognition on basis of plant height (2)

- How to measure the plant height ?
- Active stereovision:
 - A set of light patterns produced by a video projector is projected onto the scene
 - A camera is used to image the projection of the pattern on the scene
 - The plant height is computed



Recognition on basis of plant height (4)



Recognition on basis of plant height (5)

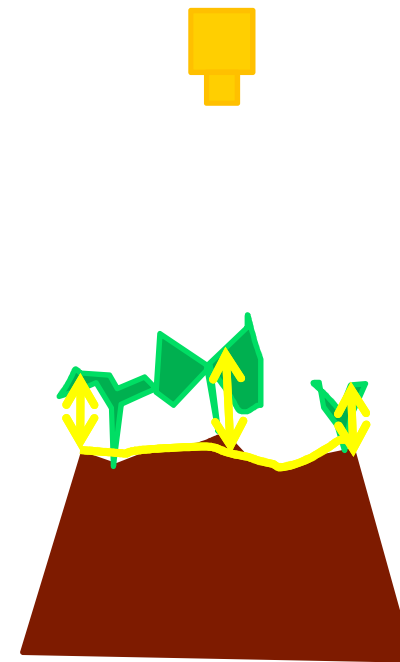
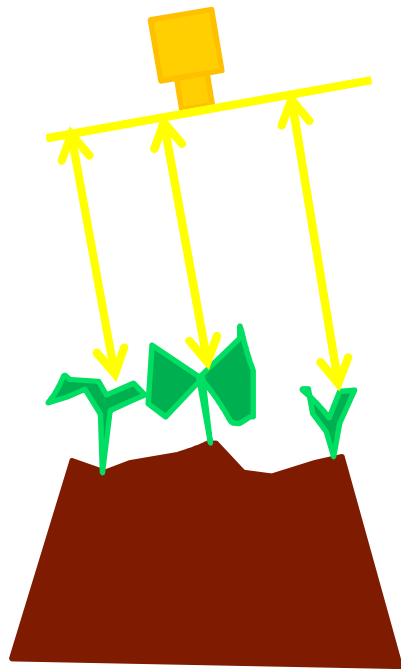
■ Results



The brighter pixels are near the camera
The soil unevenness clearly appears (this justifies the applied correction)

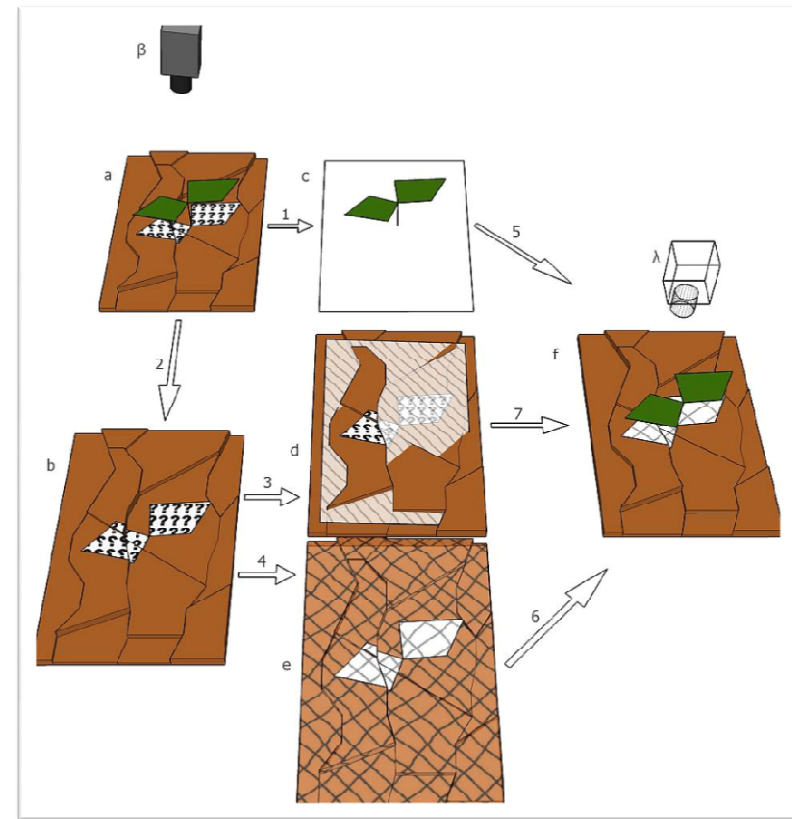


Recognition on basis of plant height (6)



Recognition on basis of plant height (7)

- The computation of the actual plant height implies several stages
 - Classification soil / plant (multispectral) (1,2)
 - Plane fitting through soil (3)
 - Surface fitting through soil (4)
 - Combination of reconstructed soil with plant pixels (5,6)
 - « Alignment » of ridge and camera (7)



Recognition on basis of plant height (8)

- Results

- The results are better than those obtained with the spectral reflectance (72%)

	Parameter	
	Non corrected plant height	Plant height parameter
Overall	66	83
Carrots	75	85
Weeds	57	80



Conclusion

- The proposed solution has the potential to be implemented on a machine
 - Reflectance and plant height give good weed detection results
 - Corrected plant height is necessary to classify plants in field conditions
- Some points have to be checked
 - Real Time acquisition (reflectance + 3D)
 - How to automatically determine crop height ?



Thank you for your attention
