Automatic detection of tulip breaking virus (TBV) in tulip fields using machine vision

Gerrit Polder, Gerie W.A.M. van der Heijden,
Ton A.H.M.C. Baltissen, Joop van Doorn
Wageningen University and Research

Outline

- **Introduction to the problem**
  - Disease (TBV) detection
- **Imaging platform**
  - 2011 (RGB based)
  - 2012 (Multispectral – RGB – NIR)
  - Image classification
- **Field trails**
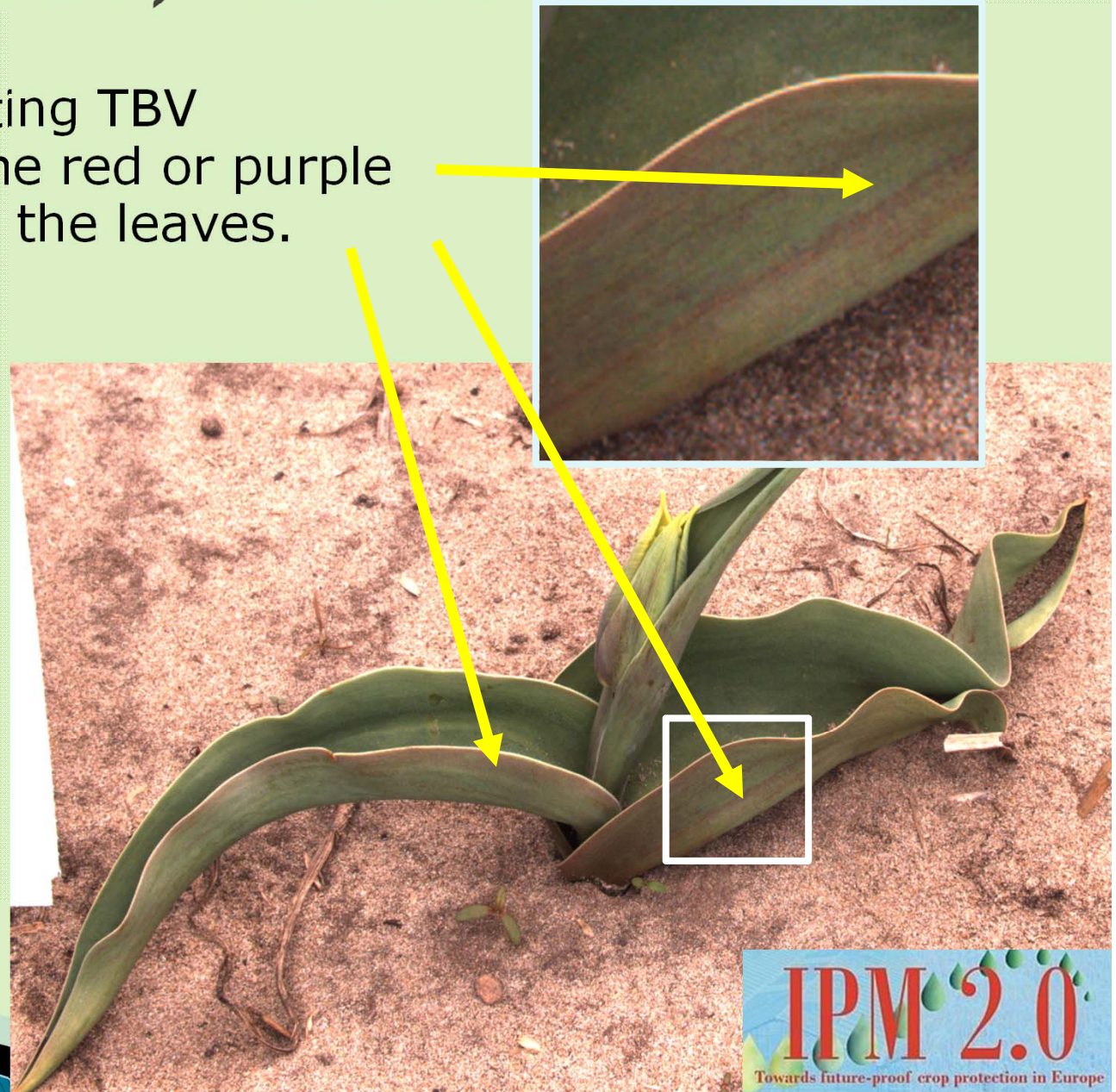- **Results**
- **Discussion and future plans**

Introduction to the problem

Disease (TBV) detection

- most discriminating TBV symptoms are the red or purple spot patterns on the leaves.

▸ Segmentation of plant against soil.
▸ Segmentation of disease pattern.

IPM '2.0
Towards future-proof crop protection in Europe

Imaging platform

- Universal mobile platform, with a light resistant canvas cover, to exclude ambient light.
- Fluorescent daylight (6000k) lamps.
- IR LED (850 nm) floodlight (2012).
- Cameras:
  - 5-megapixel RGB color cameras (Prosilica GC2450) (2011)
  - 1.3-megapixel multispectral RGB-NIR cameras (JAI AD-130GE) (2012)
  - under a zenith angle of 45 degrees, at 90 degrees difference in azimuth angle, viewing two sides of the plants.
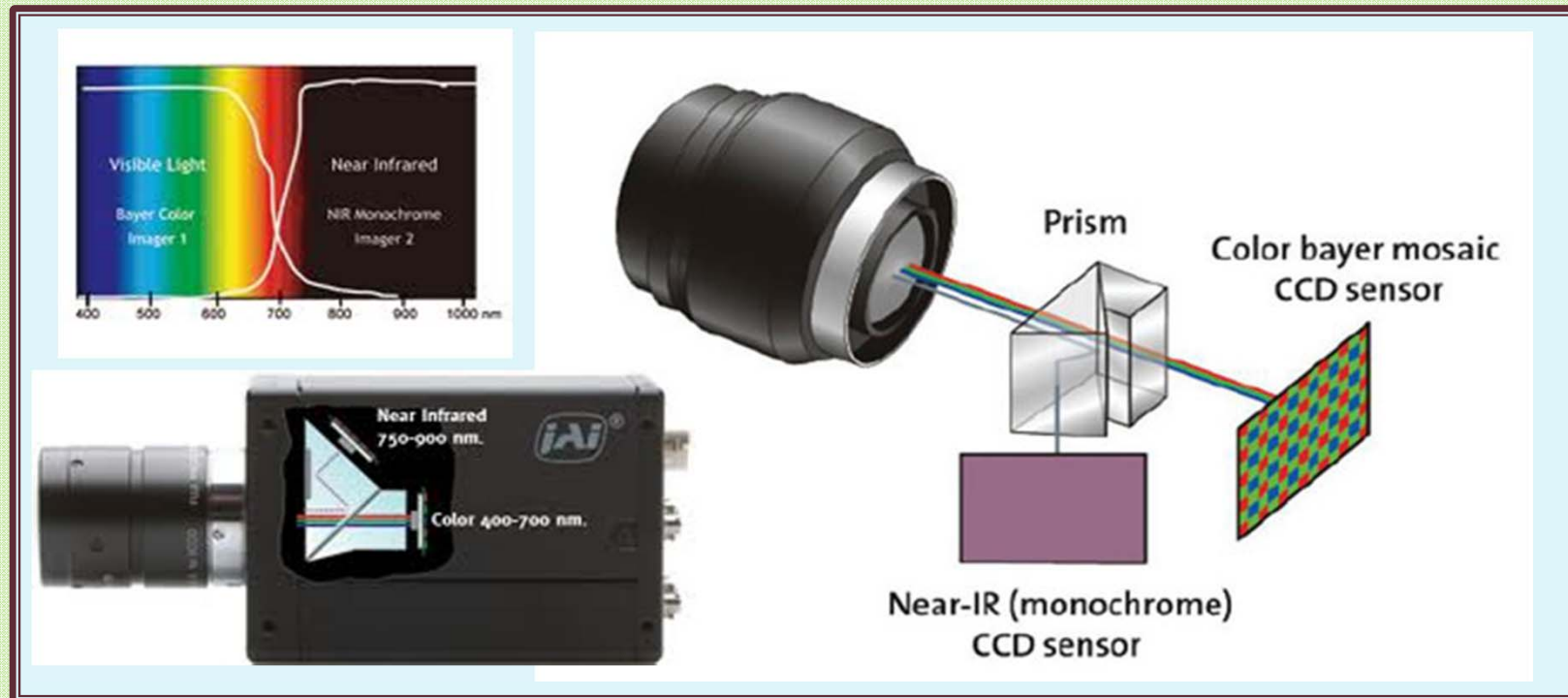

IPM 2.0
Towards future-proof crop protection in Europe

Imaging platform

▸ 2011 – RGB camera, sometimes false segmentation of the plant against the background.

Segmented image

adapted mask (by hand)
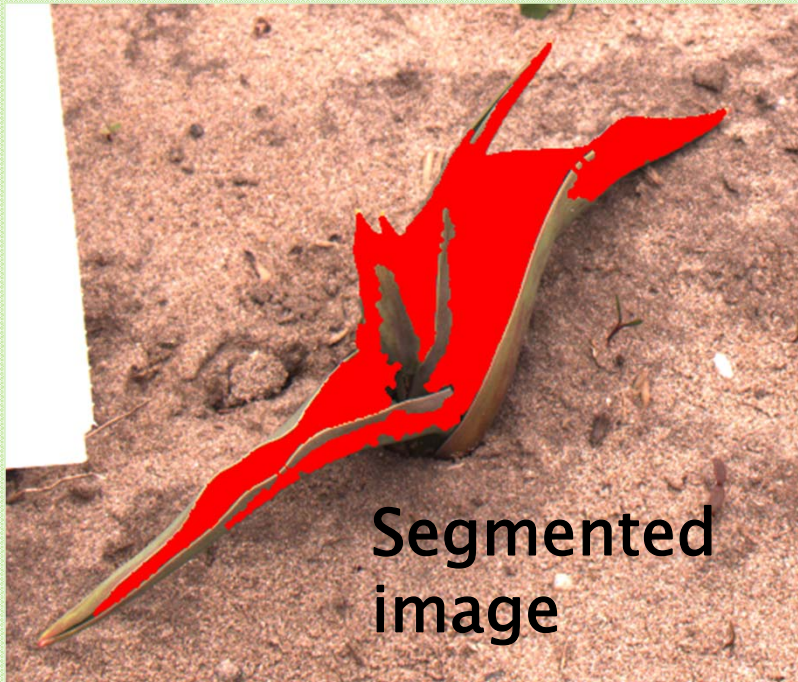
Imaging platform
Multispectral camera (2012)

- Color– measure virus symptoms
- IR – threshold plant from background

Imaging platform

- 2012 – RGB-NIR camera.
  - Dark (clay) soil, segmentation on NIR image
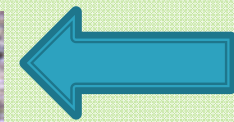 - Light (sandy) soil, multispectral segmentation

Imaging platform

Multispectral threshold

Color threshold

IPM 2.0
Towards future-proof crop protection in Europe

Image classification (for the wiz kids)

- Fraction of red pixels – $\Sigma((R-G)>15)/area$
- Mean normalized red value – $\Sigma R/\Sigma(R+G+B)$
- Mean normalized green value – $\Sigma G/\Sigma(R+G+B)$
- Ratio of contour pixels of spots – $\Sigma(spot\ contour)/area$
  - R, G and B – red green and blue pixel values within the mask of each plant.
  - area – pixel-count of the mask.
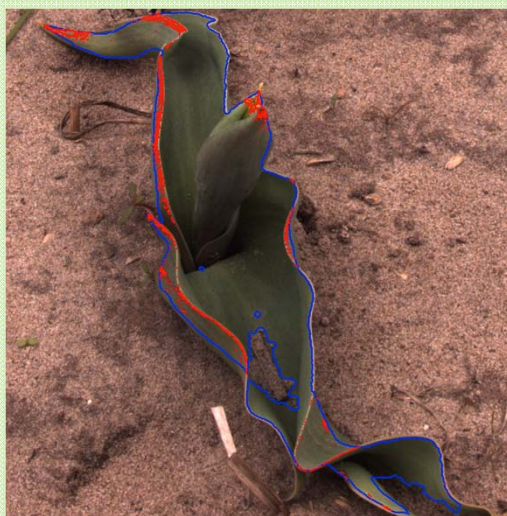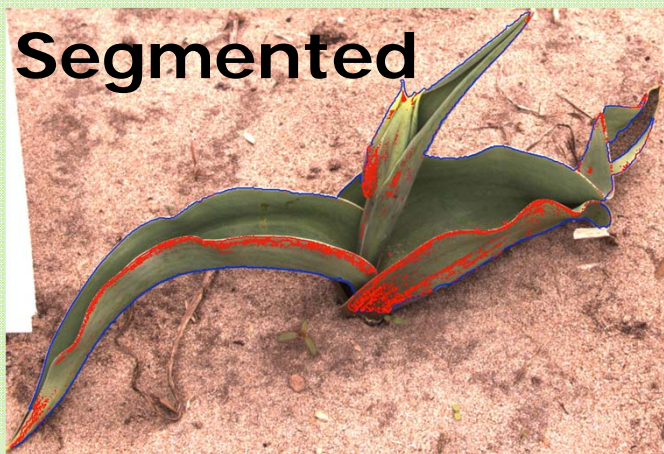 - spot contour – red pixels touching green pixels $((R-G)<15)$, indicates patchiness of the spot pattern.

Image classification

Side

Front

Segmented

IPM 2.0
Towards future-proof crop protection in Europe

Field trails

2011

- 3 plots (single plant density)
  - Mixed
  - 100% diseased
  - 100% healthy
- 1 measurement date.

2012

- 2 plots (single plant density)
- 8 plots (production density touching plants)
- weekly measurements during growth season (5 weeks from first 2 leaves until flowering).

- Ground-truth = biochemical immunoassay (ELISA)
- Machine vision results compared to highly qualified crop experts.

IPM '2.0

Towards future-proof crop protection in Europe

Results (2011)

▸ 3 plots, 199 plants, 1 measurement date.
▸ Total error machine vision: 9%; crop expert: 2%

|		Machine vision (Crop expert)		
		Healthy	TBV	Total
Elisa	Healthy	80 (83)	7 (4)	87
	TBV	11 (0)	101 (112)	112
	Total	91 (83)	108 (116)	199

Results (2012)

▸ 2 plots, 40 plants, 5 weekly measurements.
▸ Total error machine vision: 10%; crop expert 15%

| Week 3: Machine vision (Crop Expert)			
	Healthy	TBV	Total
Healthy	18 (18)	2 (2)	20
TBV	2 (4)	18 (16)	20
Total	20 (22)	20 (18)	40

(Row header label: **Elisa**)

Results (2012)

▸ Total error crop expert / machine vision.
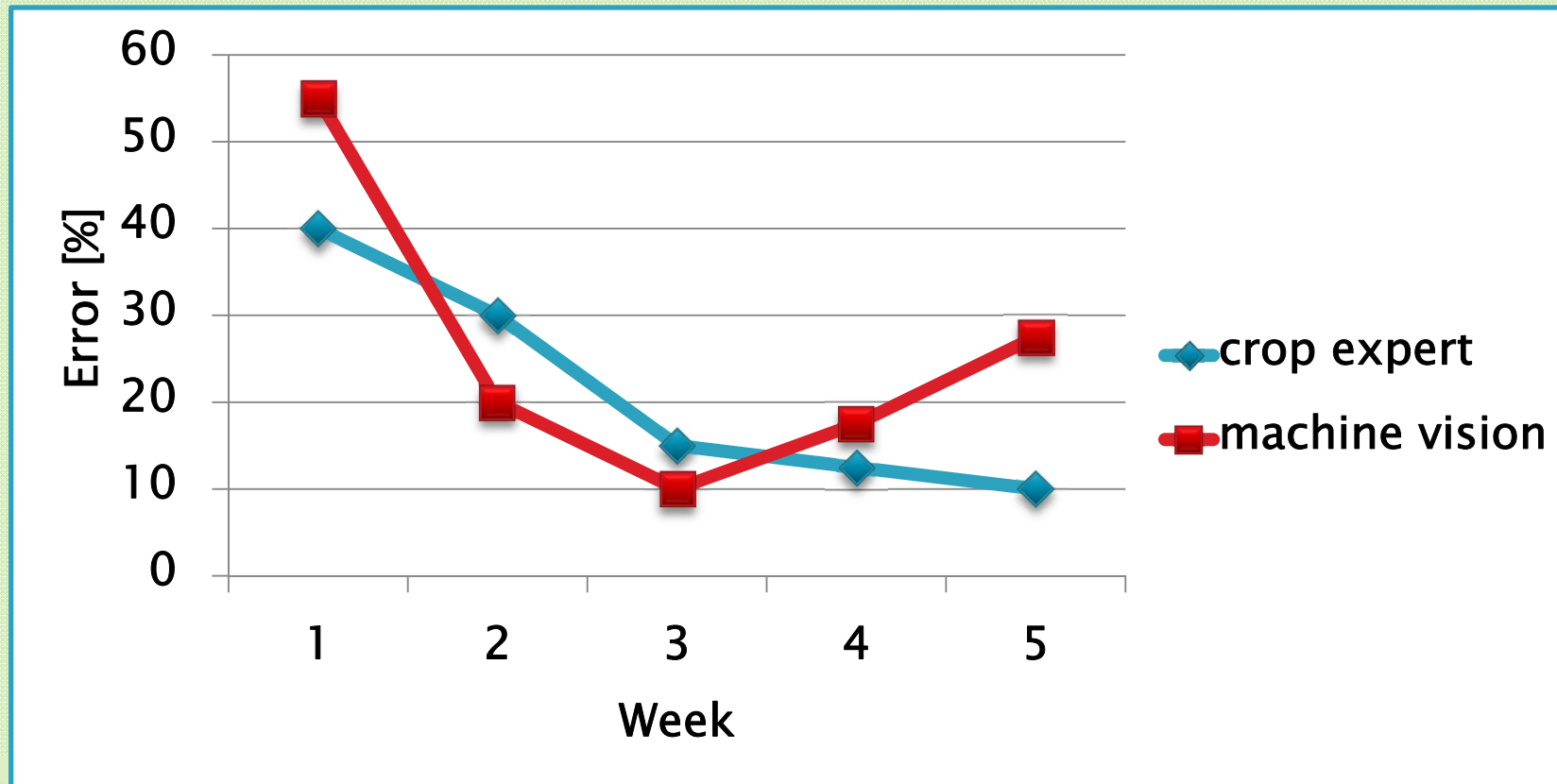
Discussion

- ▸ Results are promising.
  - ◦ Farmers request equal performance as average crop-expert.
- ▸ Optimal detection date (week 3).
  - ◦ intensity of colouring decreases over time.
  - ◦ Crop expert uses prior knowledge in week 4 and 5 of 2012.
- ▸ Multispectral (RGB-NIR) camera adds significantly to plant segmentation.
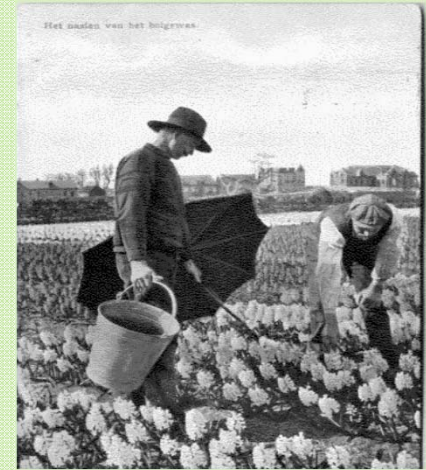
Future plans

▸ **Analysis of plots with production density (overlapping plants)**

▸ **Illumination (Intense LED strobe)**

▸ **Removal of diseased plants**

▸ **Autonomous robot**

Acknowledgements

(Product Board for Horticulture)

Productschap Tuinbouw

Ministry of Economic Affairs, Agriculture and Innovation

IPM 2.0
Towards future-proof crop protection in Europe

Questions?