Computer Vision for Automatic Detection of the Tulip Breaking Virus (TBV)

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Abstract

Tulip breaking virus (TBV) causes severe economic losses in flower bulbs in the Netherlands. To prevent further spread by aphids, infected plants must be removed from the field as soon as possible. Until now screening is done by visual inspection in the field. As the availability of human experts is limited there is an urgent need for a rapid, automated and objective method of screening. Based on laboratory experiments, we developed a vision method for use in the open field. From 2009 to 2012 field trials were carried out and the techniques were tested and improved. First field trails were tested at single plant density to avoid overlapping plants. In 2012 an experiment was conducted in a tulip field plot planted at production density of 100 and 125 plants per square meter, resulting in images with overlapping plants. The final score of our system in this production density experiment approached the scores obtained by the experienced crop experts.

1. Introduction

Tulip breaking virus (TBV) causes severe economic losses in flower bulbs in the Netherlands. To prevent further spread by aphids, infected plants must be removed from the field as soon as possible. Until now screening is done by visual inspection in the field. As the availability of human experts is limited there is an urgent need for a rapid, automated and objective method of screening. In this abstract the research steps to develop a TBV detection machine are described.

1.1. Testing optical sensors under lab conditions

The first step was to test promising techniques under lab conditions. Four different optical sensor techniques were tested in this study:

- an RGB color camera,
- a spectrophotometer with a spectral range from 350 to 2500 nm,
- a hyperspectralspectral camera with a range from 400 to 900 nm,
- a chlorophyll fluorescence imaging system, which measures the photosynthetic activity.

Results show that the hyperspectral imaging system was the best optical technique, followed by the RGB camera. The total error was only slightly larger than the visual assessment error[3].

1.2. Field experiments using single plant density

From 2009–2012 field experiments were carried out with tulips planted at a density of 4 bulbs m^{-2}. This way the plants do not touch each other and single plants can be segmented from the background. The camera technique used is a 4 band RGB + NIR multispectral camera. The system approached the scores obtained by the experienced crop experts[2]. Figure 1 shows an overview image of the trail field, a classified plant an a graph of the results.

1.3. Field experiments using production density

In 2012 a second experiment was conducted in a tulip field plot, planted at production density. Densities of 100

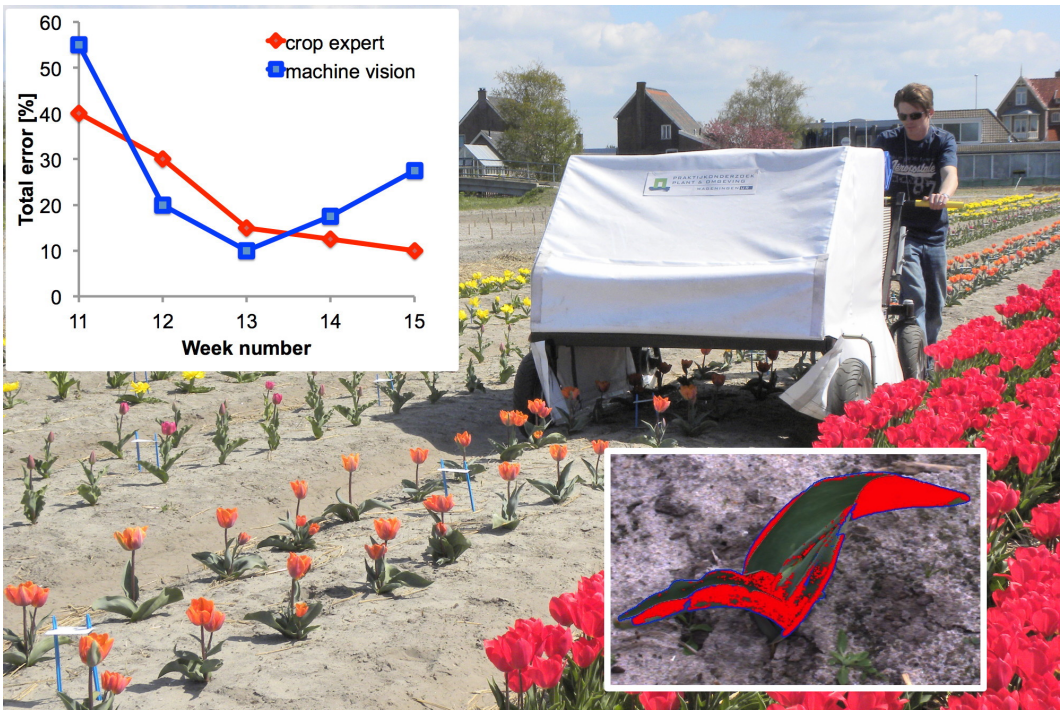

Figure 1. Overview image of the trail field, a classified plant an a graph of the results..

and 125 plants per square meter were tested, resulting in images with overlapping plants. The computer vision algorithms developed in the previous experiments were adapted resulting in a final score which also in this experiment was comparable to the scores obtained by the experienced crop experts, although the timespan for detection is smaller[1]. As an example table 1 shows the confusion matrix of week 13, where the visibility of the symptoms were optimal according to the opinion of the crop experts. They found 89% of the diseased plants, and 1.7% of the healthy plants were wrongly classified as diseased. For the machine vision 80% of the diseased plants were found, which is somewhat less than the score of the crop experts, but the false-positive rate was lower (0.9%).

Table 1. Confusion matrix of machine vision and (crop expert) scores, week 13

	Healthy	TBV	Total
Healthy	627 (622)	6 (11)	633
TBV	18 (10)	73 (81)	91
Total	645 (632)	79 (92)	724

2. Conclusion

The results, as obtained in commercial field densities indicate that a field robot for automatic removal of TBV infected tulips might be reality within years.

References

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