Automatic plant counting in open fields by a machine vision system

Pieter M. Blok[1], Jochen Hemming[2], Wim van den Berg[3]

[1] *Plant Research International, Wageningen University and Research Centre, Droevendaalsesteeg 1, 6708 PB, Wageningen, The Netherlands*

[2] *Wageningen UR Greenhouse Horticulture, Wageningen University and Research Centre, Droevendaalsesteeg 1, 6708 PB, Wageningen, The Netherlands*

[3] *Applied Plant Research, Wageningen University and Research Centre, Edelhertweg 1, 8219 PH, Lelystad, The Netherlands*

The quality assessment of seeds and particularly the crop emergence rate is an important parameter in plant breeding, especially in open field crops which should withstand fluctuating and unfavorable conditions. To evaluate different plant varieties and to assess the effect of different cultivation methods on plant growth, breeders and researchers conduct the counting of emerged plants. This is a time consuming and labor intensive activity and therefore often only conducted on a limited area. Besides this, plant counting by humans is susceptible to error due to loss of concentration or in case of multiple counters different counting methods.

An automatic machine vision system was built to automate and to speed up the plant counting process. The system consist of three color cameras mounted on an implement facing straight downwards, lamps for illumination, an encoder wheel and a computer system. Natural light was blocked by a surrounding cover to limit the effect of variable outdoor light conditions on the image quality. The computer vision software makes use of an excessive green algorithm (2G – R – B) to segment the plant material from the soil. As the crop plants are sown by a precision sowing device in a regular pattern a method based on the fast-fourier transform (FFT) is used to distinguish crop plants from weed plants. The expected crop plant distance in the row is used as an input of the FFT. The mixed signal of weed and crop plant pixels in the image is processed with a FFT followed by an inverse FFT to reveal the crop plant positions. In consequence, the number of crop plants in the field can be counted. The system was validated in an open-field sugar beet crop (*Beta vulgaris var. altissima L.*) at the growing stage of four leaves. Thirty-three subplots were manually counted by experienced plant counters. These counts, with a mean equal to 55.9, were used as the “true counts”. On the same plots the computer vision system was used to count the plants. The machine counts were lower, with a corresponding mean of 55.7. An ANOVA F-test ($P<0.05$) was used to discriminate the two counting methods. The F-probability was 0.061 and just above the significance level. So the H_0 hypothesis that there is not a difference between human count and machine vision count was not rejected. Possible causes of the lower machine count were the inability of the system to detect plants damaged by animals and very small plants which were occluded by clods or bigger plants. Volunteer potatoes exactly emerging on an expected sugar beet spot were counted as “sugar beet” in case the size of such a plant was comparable to a sugar beet. Nevertheless, with improvements on the vision software and camera/lamp configuration, the system is profitable for a fast and accurate plant count.