Automatic Detection and Classification of Weed Seedlings under Natural Light Conditions

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In recent years, robots have been developed for controlling weeds in agriculture and thereby optimising yield while minimising the use of pesticides.
The commercial success of robots and other precision weed control techniques have, however, been limited, partly due to a combination of a high acquisition price and low capacity compared to conventional spray booms. This has limited the usage of precision weed control to high-value crops such as lettuce and onions, but not cereals and maize, which take up most of the farmland.
Nonetheless, conventional spray booms are rarely used in an optimal way as it requires a preliminary analysis of the field. This analysis should determine which weeds are present in the field and the density of those weeds so that herbicides targeting those weeds may be selected, and other herbicides can be avoided.

In the present PhD thesis, cost-efficient methods for automatic detection and classification of weeds in images is demonstrated. The system allows for the farmer to take pictures of weeds in his field using his cell phone, and it will tell him the species of the plants in the pictures without any user inputs.
In order to train the computer to recognise weeds, thousands of images of weeds have been analysed, and the location and species of the plants in the images have been annotated. A computer has been programmed to find patterns in the images and the annotations automatically; first to determine where the individual plants are located in the image, and later on also to find characteristics for each species.
As a result, the computer has been enabled to detect and classify 17 different weed species in images automatically, and it predicts the weed species correctly for 87 percent of the plants.
The method works in different weather conditions, different camera models, and even for overlapping plants where only part of each plant is visible. The method is, therefore, applicable to most Danish fields including cereal fields, which take up more than haft of the Northern European farmland.

Because of the ability to handle weed detection and classification in natural environments, these methods has the potential of reducing herbicide usage by more than 40% with only little investments from farmers, as the farmers can use their existing equipment.
Moreover, the images can be turned into weed distribution maps, enabling the farmer to see which parts of his fields are the most critical regarding weed infection. By utilising these maps the farmer can adjust the herbicide use to the local needs in his fields and thereby avoid spraying where there are only few weeds, which will be of benefit for both the farmer’s economy and the environment as it will further reduce the herbicide use.