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Potato disease detection using a UAV equipped with commercial off-the-shelf digital cameras

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Introduction

Unmanned Aerial Vehicles (UAV) have become useful and affordable research tools that show great promise for a variety of precision agriculture applications due to the unique aerial perspective they can provide (Shahbazi et al. 2014). In Scotland Blackleg disease is largely caused by Pectobacterium atrosepticum (Pba), via contaminated seed tubers (Skelsey et al. 2016). Worldwide, blackleg disease is a major contributor to the loss of potato crops and checking for its presence is time consuming and can inadvertently damage the crop canopy. Therefore this project was initiated to answer the question:

❖ Can the onset of blackleg disease be detected using a UAV equipped with commercial off-the-shelf (COTS) digital cameras?

Trial Layout and Aerial Capture Methods

32 drills of potatoes containing 12 tubers in each (Fig.1a) were planted on 5/5/2016 and surveyed regularly across the growing season using a custom built UAV carrying two COTS digital cameras, with one modified to capture near infra-red (NIR) wavelengths of light (Fig. 1b).

Emergence Analysis

The data from each survey was analyzed visually initially and then automatically using a pixel based approach that used a simple growth model to allow plants emerging at different dates to be identified (Fig. 2). 385 emerged plants were detected using both methods and all plants had emerged by 21/6/2016 however two cases of non-emergence and three extra plants were discovered (left over tubers had been planted). Emergence detection agreement between visual and automatic analysis by date was high, resulting in a total accuracy (TA) of 95% and Kappa coefficient (K) of 0.88.

Disease Detection Analysis

The emergence points were used to denote regions of interest for each plant using Thiessen polygons (Fig. 3a). Initial visual analysis of each survey was conducted with the assessor making use of true and false colour orthomosaics to identify diseased plants. Automatic analysis used an object based image analysis approach to classify potato vegetation and flowers per drone, which led into a model that marked plants as diseased if they showed slower vegetation ground cover growth and a mean height one standard deviation lower than the grand mean height of all the plants for that sensing date (Fig. 3).

Results

The ground truth conducted on the 14/7/2016 (and updated to include obvious diseased plants on the 19/7/2016), indicated that 98 plants showed signs of disease, caused by Pba and other infections. Visual analysis detected 80 diseased plants with no false positives and automatic analysis detected 115 diseased plants, with 83 being valid and 32 false positives (Table 1, Fig. 4).

<table>
<thead>
<tr>
<th>Disease detection comparison</th>
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<th>O</th>
<th>C</th>
<th>PA</th>
<th>UA</th>
<th>TA</th>
<th>Kappa</th>
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<tbody>
<tr>
<td>Ground Truth vs Visual Analysis</td>
<td>98</td>
<td>80</td>
<td>85</td>
<td>82 %</td>
<td>100 %</td>
<td>95 %</td>
<td>0.87</td>
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<tr>
<td>Ground Truth vs Automatic Analysis</td>
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<td>115</td>
<td>83</td>
<td>85 %</td>
<td>100 %</td>
<td>72 %</td>
<td>0.70</td>
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Conclusions

❖ The type of disease detecting a plant could not be determined.
❖ Visual analysis of UAV generated imagery is effective at identifying disease, but only when it has started to affect the canopy of the plant.
❖ Automatic analysis tended to detect disease slightly earlier due to using height information but produced more false positive results.
❖ A more accurate GPS system onboard the UAV would eliminate the need for ground control points and could reduce the number of false positives by improving image alignment between sensing dates.

Acknowledgements and references

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