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Aerial Image-Based Crop Row Detection and Weed Pressure Mapping for Variable-Rate Weeding Systems

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INTRODUCTION

In precision agriculture, variable-rate weeding equipment—such as row cultivators, ground spraying machines, or spraying drones—requires information on the location and density of weeds in a given area. Before crop emergence, identifying weeds is straightforward, as all green plants are considered weeds. However, once crops appear and grow alongside weeds, creating a weed pressure map becomes much more challenging.

MATERIALS AND METHODS

The study described a feature-based computer vision method that avoids the need for extensive training data and deep learning models. It uses UAV images (Figure 1) or orthophotos and goes through six phases:

1. Identifying plant coordinates and sizes using computer vision techniques.
2. Calculating crop row directions and average crop spacing.
3. Performing clustering and fitting lines to the point data.
4. Filling gaps in crop rows and determining row locations.
5. Eliminating plants in the crop rows to isolate weeds.
6. Generating a weed pressure map, heat maps, and shapefiles.

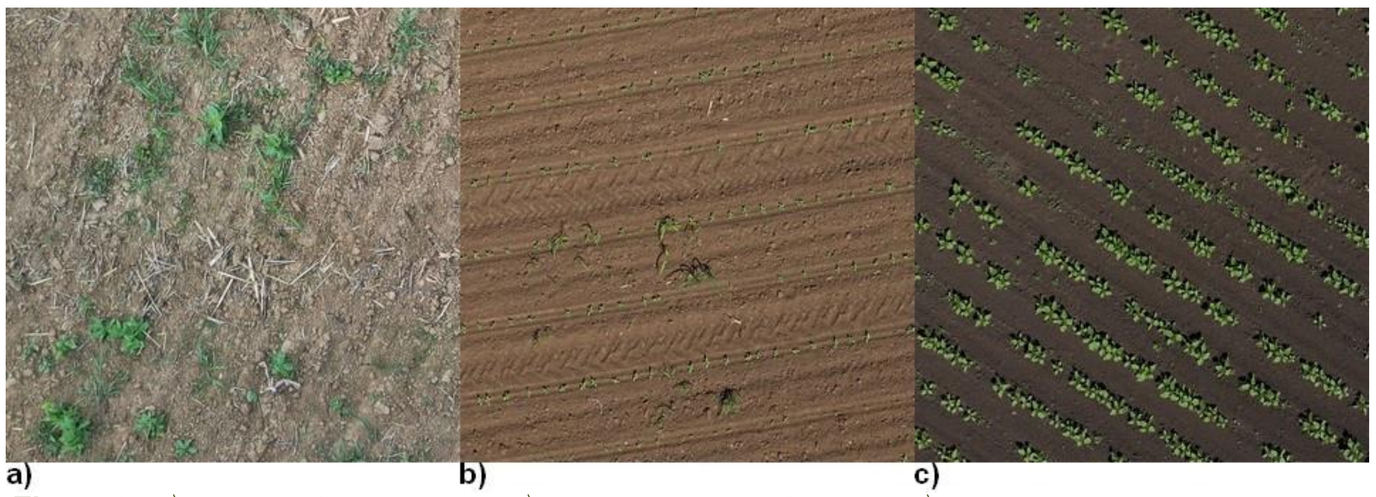


Figure 1: *a) weeds without crops; b) separated crops in rows; c) crops grow to each other;*

RESULTS

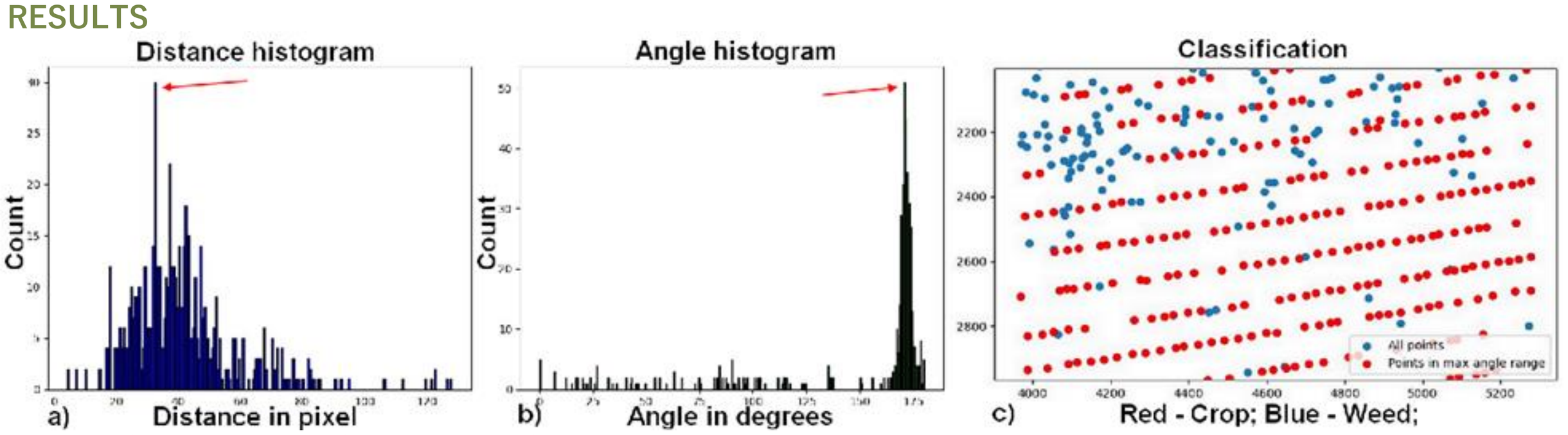


Figure 2: *a) distance histogram; b) angle histogram; c.) classification: red points are considered crop plants, while blue points are considered weeds;*

The results show, that crop rows can be detected, but it is sensible for the green color threshold. That threshold needs to be adjusted manually. Next the distance and angle histogram calculation needed to determine the crop rows (Figure 2a; Figure 2b). The classification looks nice in Figure 1c, only a small fraction of crops are mistakenly detected as weeds, and there are slightly more weeds located in the center of a row that are eliminated as crops. However, these two cases are rare, and weeds generally appear in groups. It means that when there are some weeds between rows, there are usually some between the crops too. But it is rare that weeds hide between crops when none are between rows. This suggests that the resulting heatmap (Figure 3) accurately represents weed pressure, even with occasional misclassifications. In the future, we should calculate some classification measurements, but it is hard to make that ground true datasets, because even the expert can't be sure from that resolution which is crop and which is weed. There are two options: make close images with big resolution and make a manual classification here, and after, we resize the images, or we could use artificially generated images in the future.

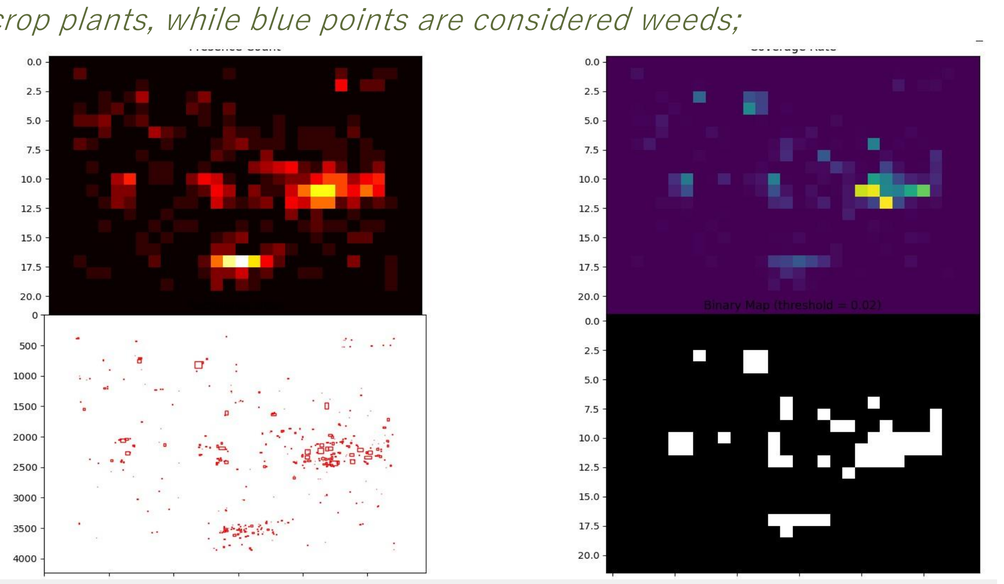


Figure 3: *heatmap calculation and the binary map for shape file.*

CONCLUSION

Weed pressure heatmaps and shapefiles can be generated from drone images without requiring significant computational capacity or training datasets. The method is flexible, regardless of the crop type or weed species present, and can accommodate a wide range of development stages. This approach is also highly efficient, as images can be captured from higher altitudes, reducing the need for storing large amounts of detailed imagery.

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