Counting with Confidence: Accurate Pest Monitoring in Water Traps

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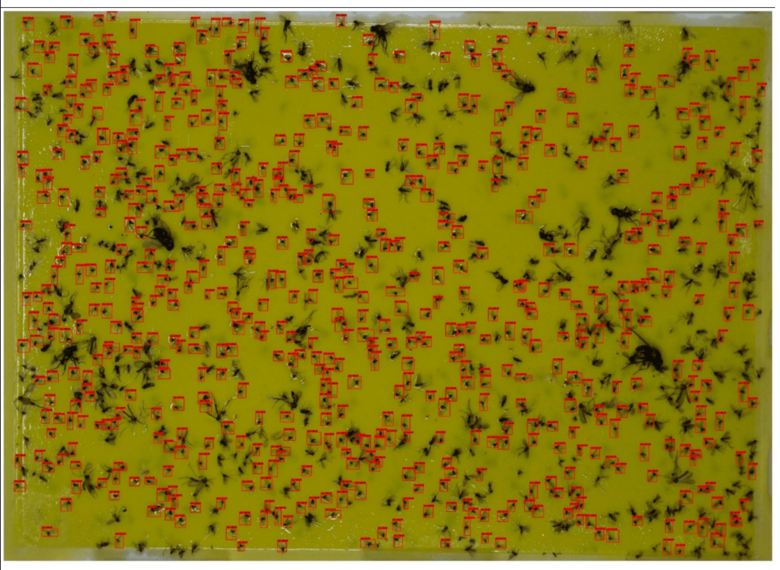
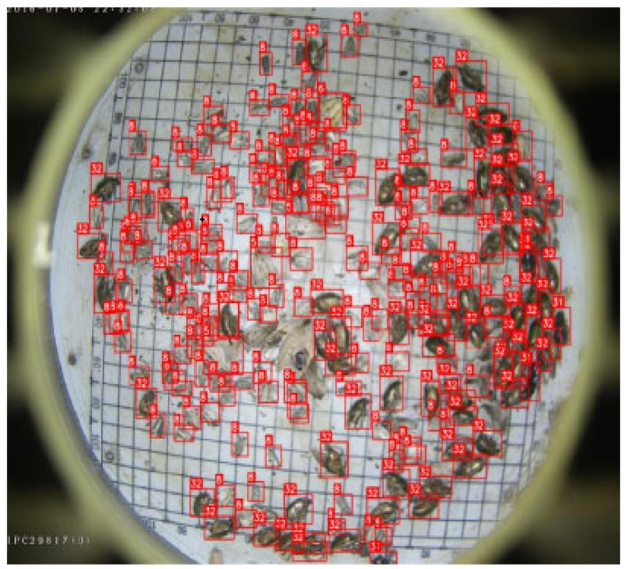
Background

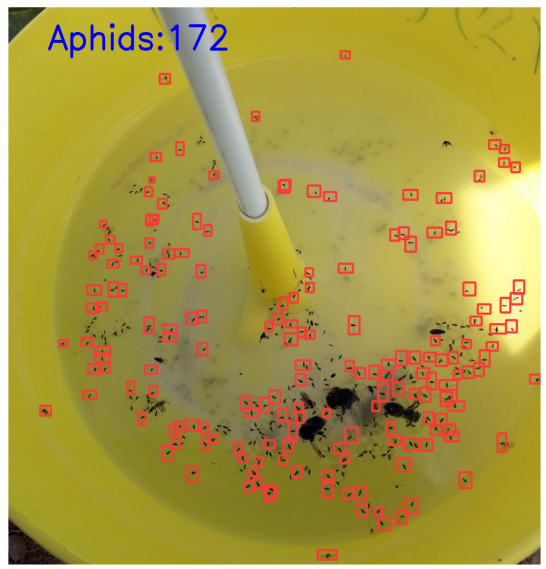


(a)

(b)



(c)



(d)

Fig. Some typical works of automatic pest counting [1-4]

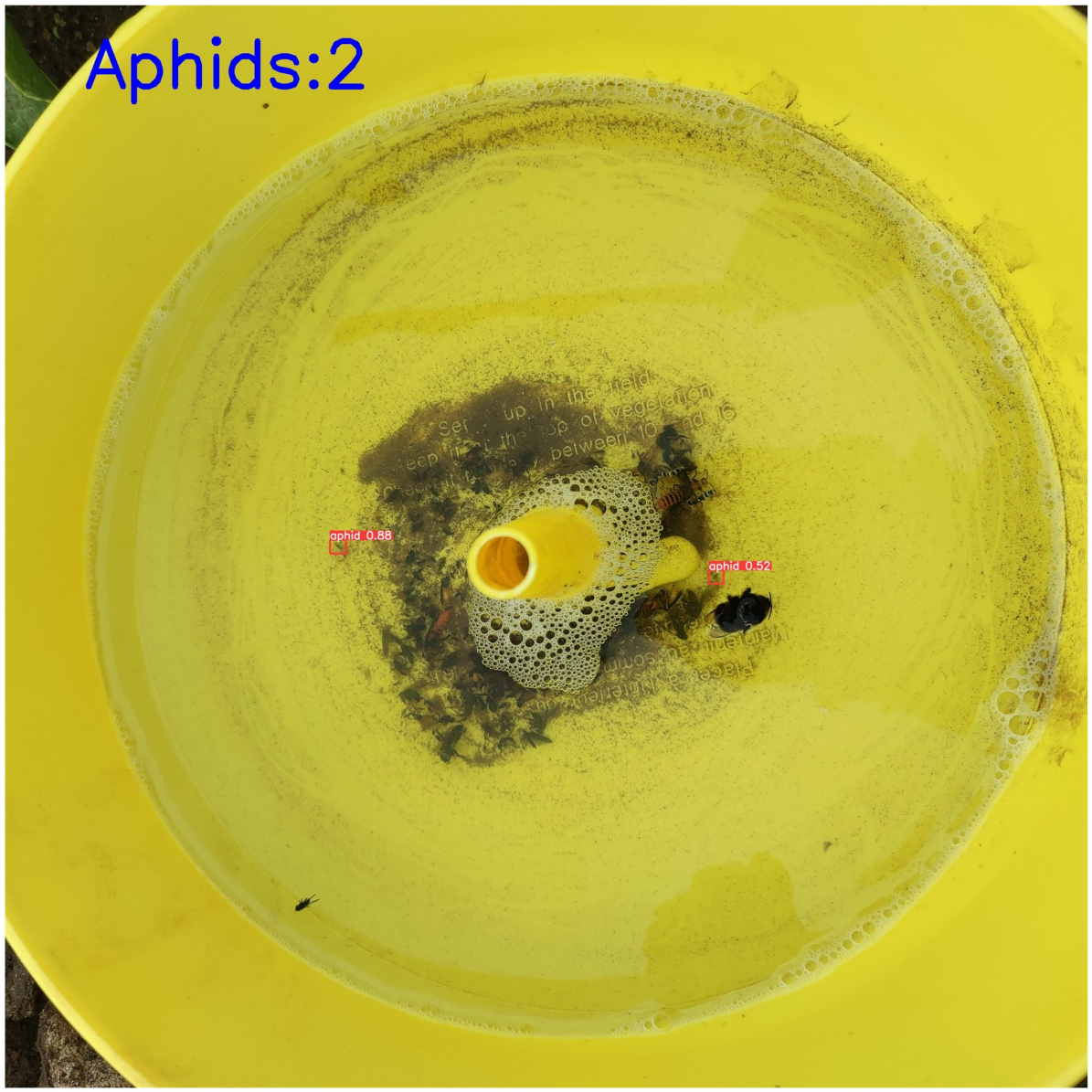
Common Limitations:

a) Static counting

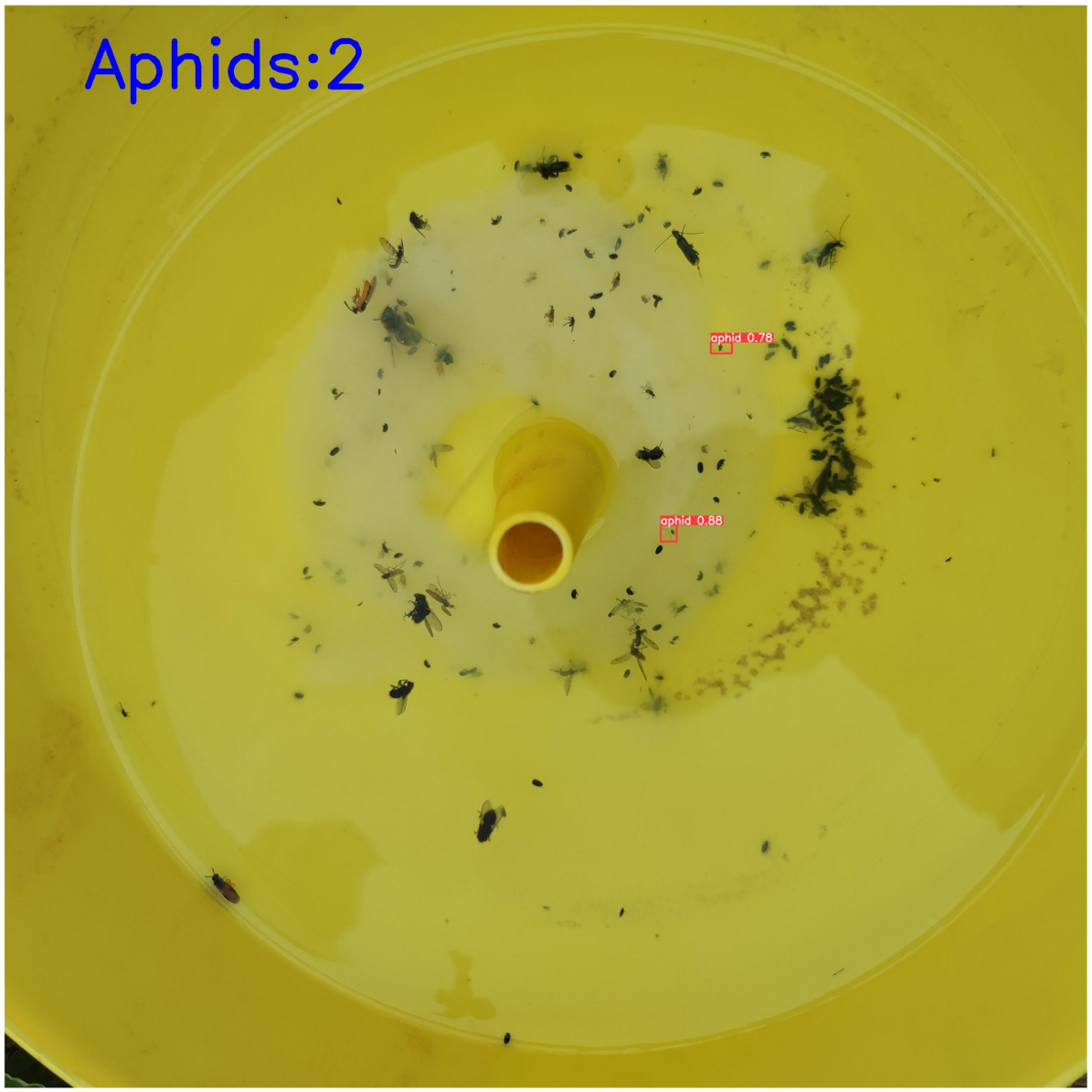
b) Inaccurate (severity of undercounting)

c) Occlusions (aggregation, foreign objects) or Submersion

Questions



Sinking to the bottom and clustering

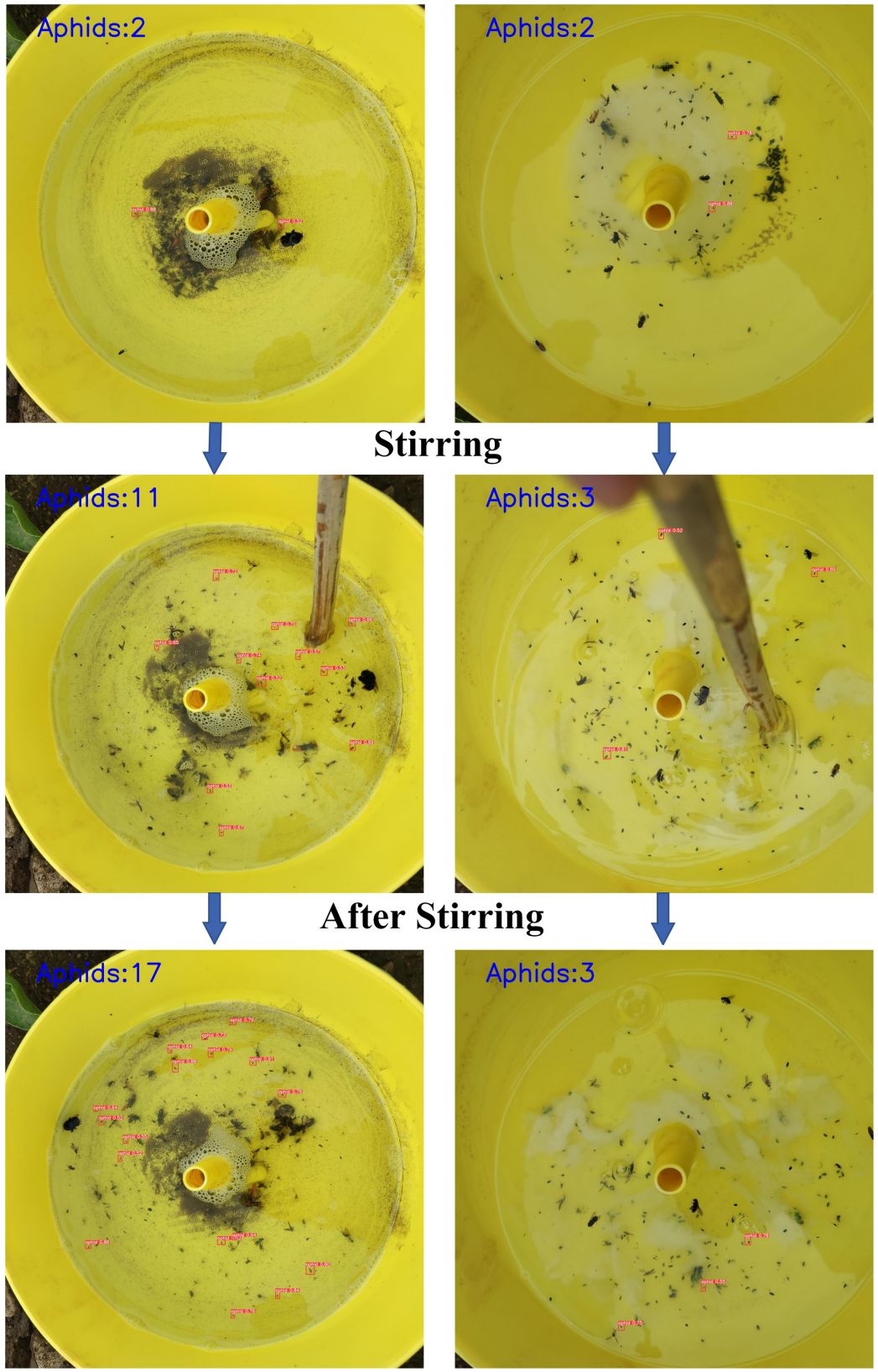


Sinking to the bottom and invisible areas

1) How to count aphids in severely occluded?

2) Are there any aphids in the invisible areas?

Solution



Maximum count = Final count ??

Limitations: Maximum count ≠ Final count

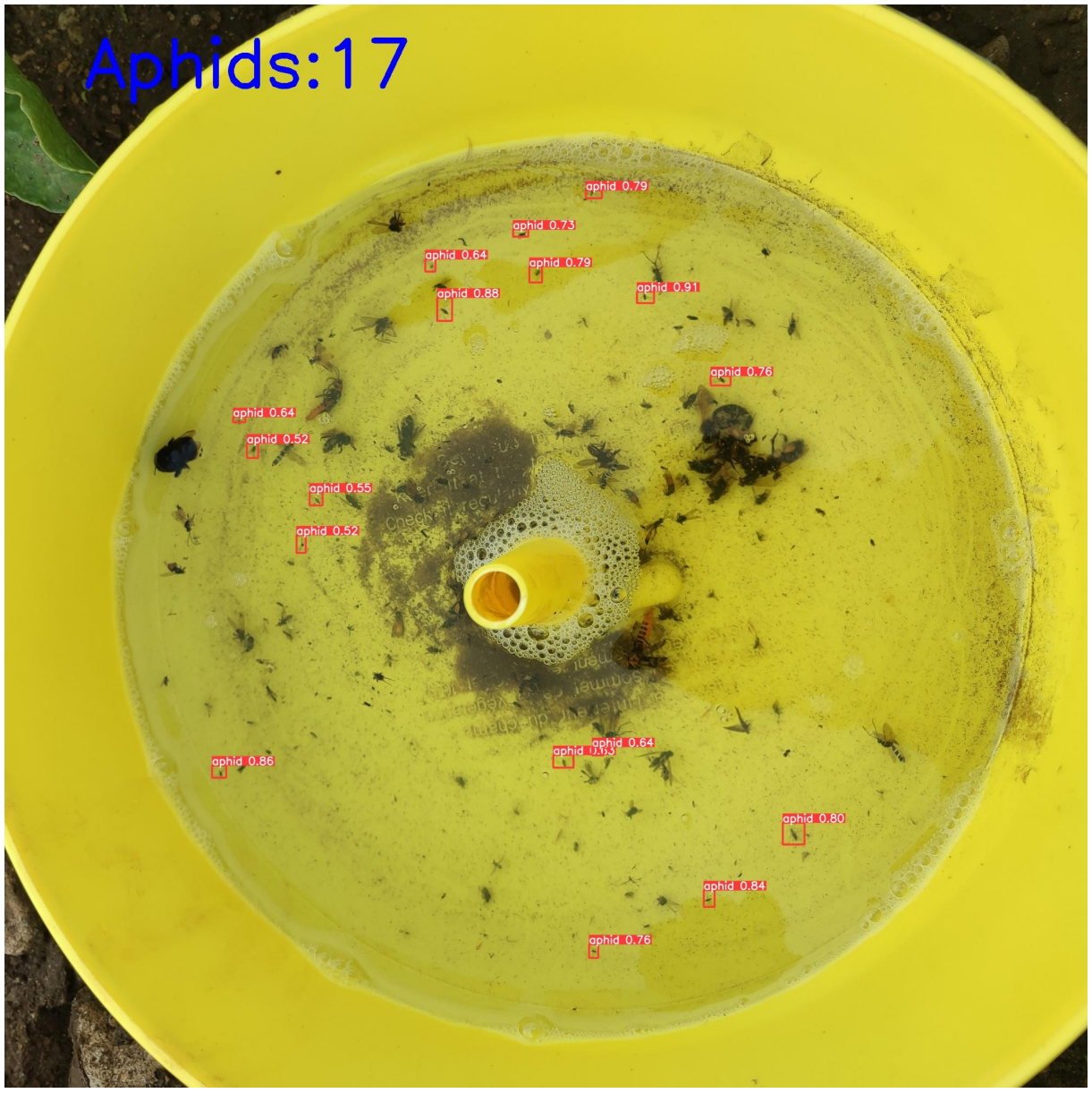


Fig. Visualization of counting results

** Total_aphid_number = 17*

Fig. Visualization of counting results (TP, FP, FN)

** Green detection box (TP): correct detection 10*
Blue detection box (FP): false detection 7
Red detection box (FN): missed detection 2

To what extent can this counting result be trusted?

$$Counting\_confidence = \frac{TP}{TP + FP + FN}$$

Counting with Confidence

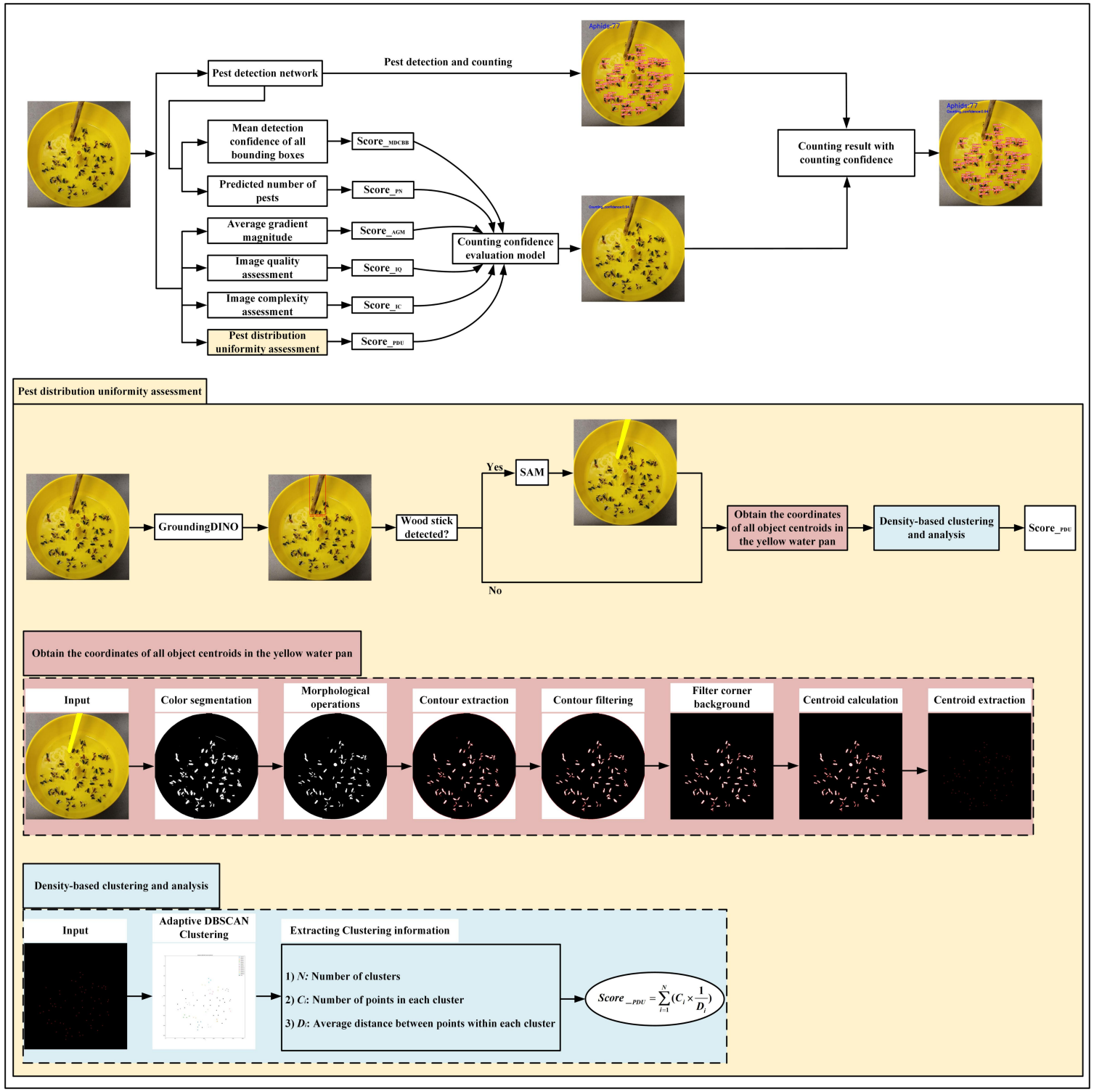


Fig. The overview of our proposed method for evaluating counting confidence

Counting with Confidence

Dataset: we collected dataset under varying conditions, totaling 890 images, and split them into training and test sets at a 7:3 ratio.

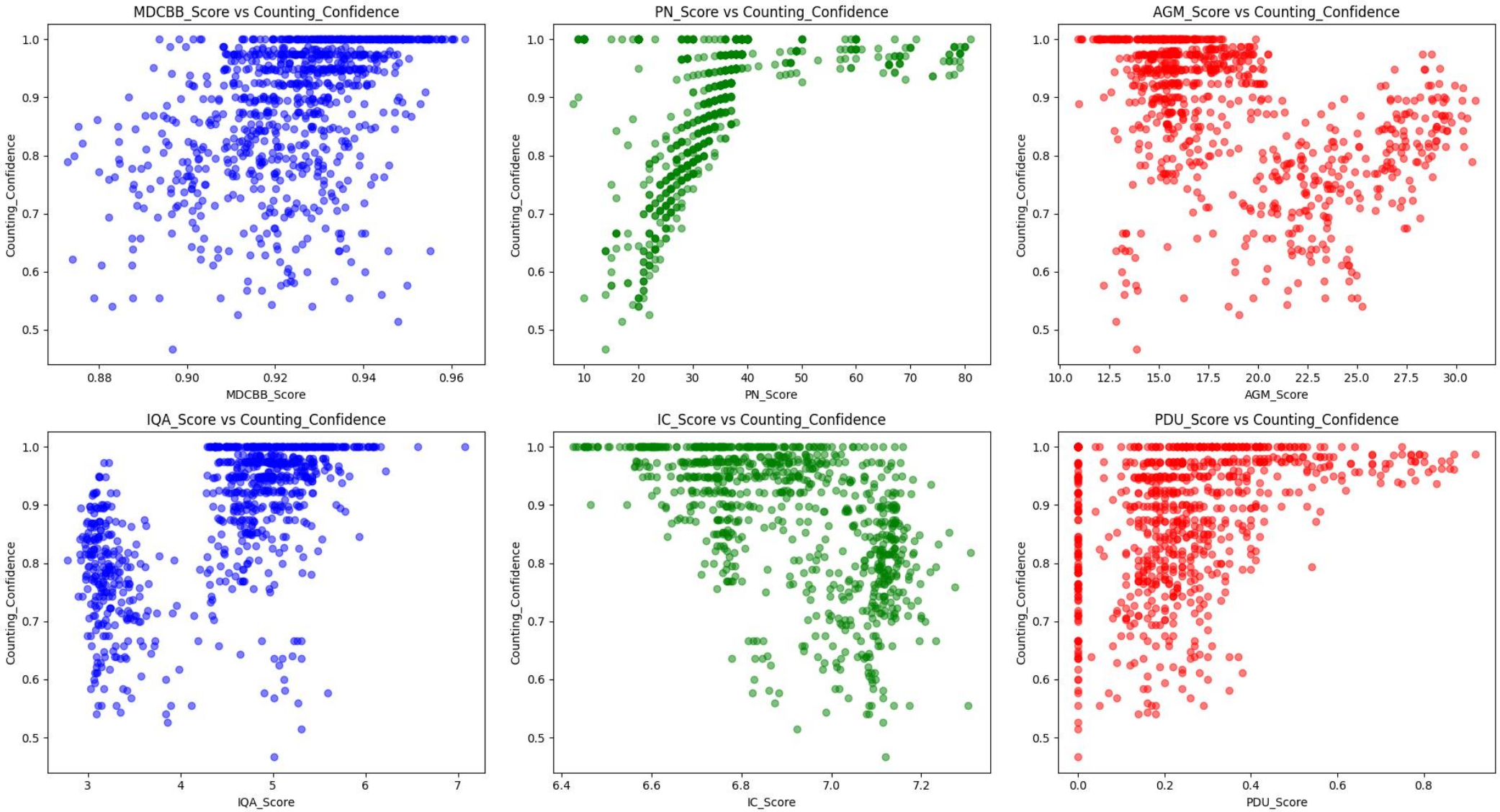


Fig. The scatter diagrams of each influencing factor's scores against counting confidence

Nonlinear relationships! -> Polynomial regression

Counting with Confidence

Table. The comparative results of the pest counting confidence evaluation across different factors

Factors	MSE	R^2
PDU	**0.0112**	**0.1135**
MDCBB	**0.0107**	**0.1524**
AGM	**0.0104**	**0.1737**
IC	**0.0094**	**0.2559**
IQA	**0.0092**	**0.2722**
PN	**0.0090**	**0.2869**
Baseline (MDCBB+AGM+PN) [5]	**0.0041**	**0.6740**
Ours (MDCBB+AGM+PN+PDU+IC+IQA)	**0.0028**	**0.7765**

** MSE (Mean Squared Error)*
** R^2 (coefficient of determination)*

1) Each influencing factor exhibited R^2 values exceeding **10%** on the counting confidence test set, demonstrating that all have a significant impact on counting confidence.

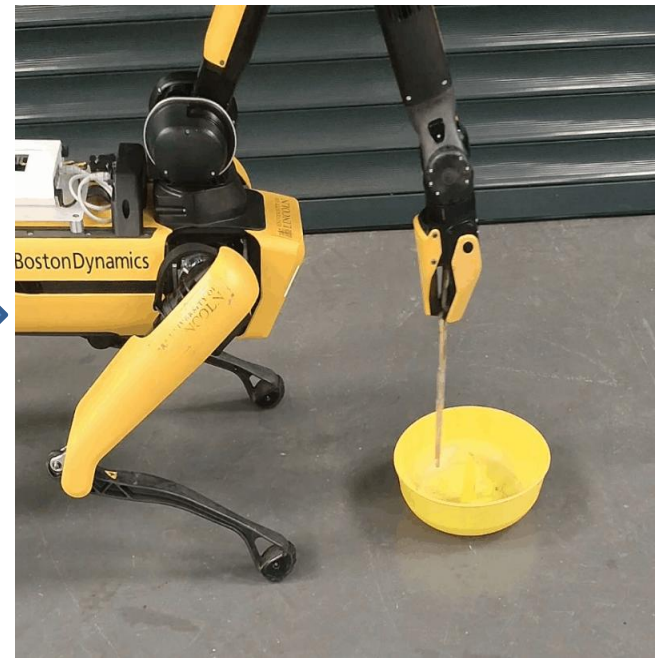
2) The method proposed significantly outperformed the baseline, achieving a **31.7%** reduction in MSE and a **15.2%** increase in R^2

3) It needs further validation using real aphid data collected from field environments in future work

Future work

1) Collect sufficient real aphid data from various field environments to further validate the assumptions and models.

2) Utilize a robotic arm to replace manual stirring operations, and study the relationship between stirring actions and aphid counting performance.



References

[1] Zhang, W., Huang, H., Sun, Y. and Wu, X., 2022. AgriPest-YOLO: A rapid light-trap agricultural pest detection method based on deep learning. Frontiers in Plant Science, 13, p.1079384.

[2] Hong, S.J., Nam, I., Kim, S.Y., Kim, E., Lee, C.H., Ahn, S., Park, I.K. and Kim, G., 2021. Automatic pest counting from pheromone trap images using deep learning object detectors for matsucoccus thunbergianae monitoring. Insects, 12(4), p.342.

[3] Lee, J.H. and Son, C.H., 2023. Trap-based Pest counting: Multiscale and deformable attention centerNet integrating internal lr and hr joint feature learning. Remote Sensing, 15(15), p.3810.

[4] Gao, X., Xue, W., Lennox, C., Stevens, M. and Gao, J., 2024. Developing a hybrid convolutional neural network for automatic aphid counting in sugar beet fields. Computers and Electronics in Agriculture, 220, p.108910.

[5] Gao, X., Stevens, M., & Cielniak, G. (2024) Interactive Image-Based Aphid Counting in Yellow Water Traps under Stirring Actions. The 27th International Conference on Pattern Recognition VAIB Workshop (ICPR2024), Kolkata, India.

Questions?

Please contact me (25766099@students.lincoln.ac.uk) if you have any questions.

THANKS

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