Corn Tassel Emergence and Height Identification Based on Unmanned Aerial Vehicles

Junfeng Ma，Dongliang Chu, Xukang lyu, Aiqin Hou, Leping Feng, Xu Wang，Chase Wu

Xinxiang Agricultural Science and Technology Institute

Zhejiang Newrise Digital Technology Co.

Northwest University

New Jersey Institute of Technology

Aims and Contributions of Our Paper

Aims:

The research focuses on identifying the growth and development stages of corn plants, as well as monitoring the timing of tassel emergence.

Contributions:

i) RTK point positioning technology is used to accurately analyze and determine the precise location of each corn plant.

ii) We perform segmentation on corn field images and use YOLOv8 to detect the tassel status of each plant, along with their positions and emergence times.

iii) We collect point clouds of the corn field and aligned them with RTK coordinates in the same projection system. Based on elevation data from the top point cloud and the root point cloud of a mature corn plant, we can calculate the height of each corn.

Locating the Position of Each Corn Plant

RTK equipment is used to accurately analyze and determine the location of each corn plant.

(a) RTK1

(b) RTK2

Identification of Corn Tassel

1) Capturing Images of Corn Fields at Different Growth Stages for Tassel Emergence Identification

The DJI M300 drone, equipped with RTK and the H20 camera, regularly captures orthographic images of the corn fields. By combining these orthographic images with the RTK coordinates provided by the drone, a direct correspondence between the pixel positions in the images and the RTK coordinates is established. It is important to note that these images include both a timestamp and the RTK coordinates of the pixel positions.

2) Image Feature Region Extraction and Tassel Emergence Detection

A square frame with a side length of 25 cm is placed at the center of each corn plant, which is the feature extraction region for the tassel status detecting.

The deep learning-based YOLOv8 (medium) network is applied to identify the corn tassels based on 1000 images. We used 810 images for the training set and 190 images for the test set. The corn tassel at each plant position within the detection frame is detected. The test results show that the accuracy rate can reach 82.5%.

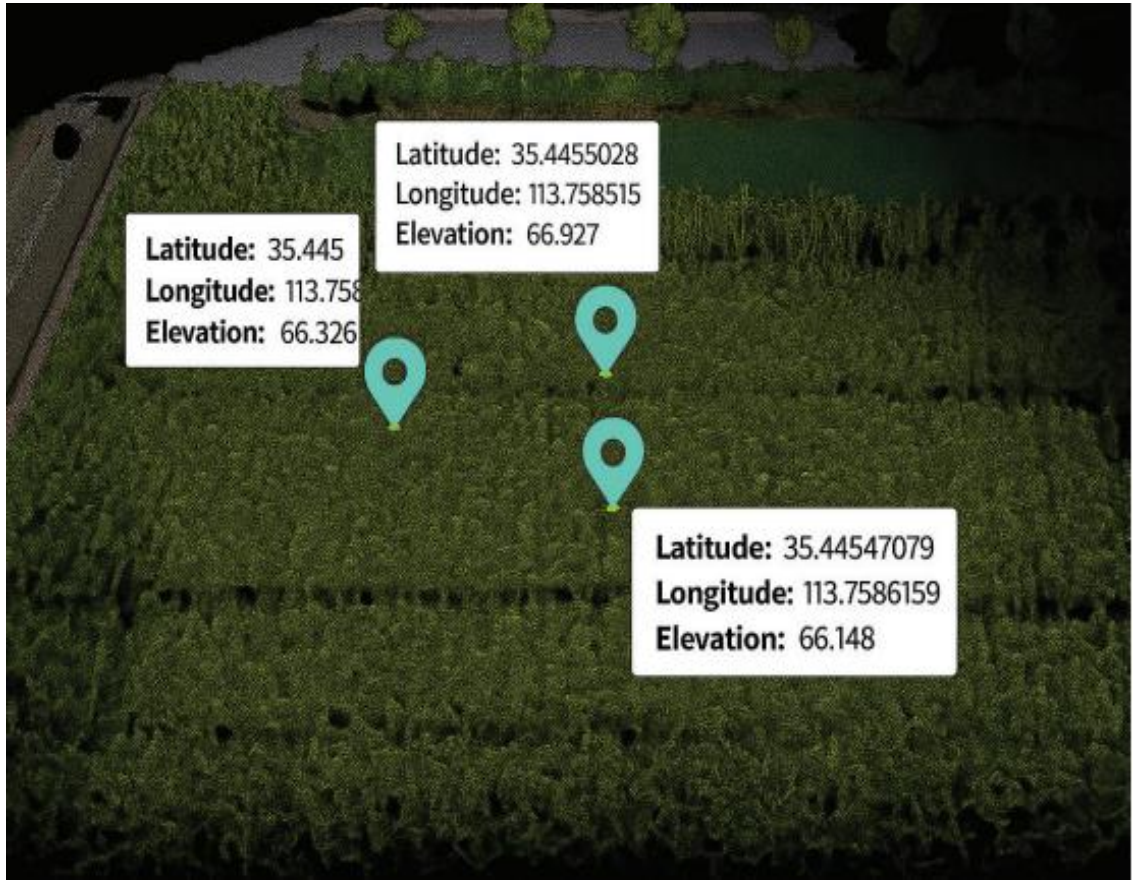
Calculation of Corn Plant Height

1) Capturing Images of Corn Field During the Mature Period

To calculate the height of corn plants, the DJI M300 drone, equipped with a laser radar (L1), captures images of mature corn plants along with point cloud coordinates in local coordinates. The 3D point cloud coordinates are represented as (x, y, z).

Additionally, these images include pixel-to-RTK coordinate correspondence, which helps in locating the position of each corn plant and recording the timestamp when the images are taken.

Two key points need to be marked on each corn plant: the “root" (the base of the stem close to the ground) and the “tip" (the top of the male spike or the highest point of the plant). The pixel coordinates of the tip are crucial for height measurement.



Calculation of Corn Plant Height

2) Unifying Point Cloud and RTK Coordinates into a Global Coordinate System

We unify the point cloud coordinates and RTK coordinates into the same projection coordinate system. The conversion formula, using a seven-parameter model, is employed to convert the local coordinates of the point clouds (x, y, z) into global coordinates (X, Y, Z), as follows:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{\text{global}} = \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + (1+k) \cdot \boldsymbol{R} \cdot \begin{bmatrix} x \\ y \\ z \end{bmatrix}_{\text{local}}$$

$$\boldsymbol{R} = \boldsymbol{R}_Z(\omega) \cdot \boldsymbol{R}_Y(\phi) \cdot \boldsymbol{R}_X(\kappa)$$

$$\boldsymbol{R}_X(\kappa) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\kappa & -\sin\kappa \\ 0 & \sin\kappa & \cos\kappa \end{bmatrix}$$

$$\boldsymbol{R}_Y(\phi) = \begin{bmatrix} \cos\phi & 0 & \sin\phi \\ 0 & 1 & 0 \\ -\sin\phi & 0 & \cos\phi \end{bmatrix}$$

$$\boldsymbol{R}_Z(\omega) = \begin{bmatrix} \cos\omega & -\sin\omega & 0 \\ \sin\omega & \cos\omega & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Where $[X \;\; Y \;\; Z]^T$ stands for global coordinates, $[x \;\; y \;\; z]^T$ stands for local coordinates of point cloud, $[\Delta X \;\; \Delta Y \;\; \Delta Z]^T$ is a translation vector, used to represent the position offset transformation model formula for the origin of the local coordinate system in the global coordinate system, $\boldsymbol{k}$ represents the scaling factor, and $\boldsymbol{R}$ represents a rotation matrix:

Calculation of Corn Plant Height

3) Calculating Corn Height

The highest point in the point cloud is detected as the center elevation of the plant, which corresponds to the “tip.

The base of the stem, close to the ground, is defined as the “root."

Therefore, the height of the corn plant is calculated as the difference between the global coordinates of the tip and the root. The formula for calculating the actual height of the corn plant is as follows:

$$Height = Z_{tip} - Z_{root}$$

Where Z_{tip} represents the elevation of the tip’s coordinates of the corn in the global coordinate system, and Z_{root} represents the elevation of the root’s coordinates of the corn in the global coordinate system.

Calculation of Corn Plant Height

3) Example for Height Computing

Taking the example shown in the right figure, we calculate the height of the corn as:

$$
\begin{aligned}
Height &= Z_{tip} - Z_{root} \\
&= 66.911 - 64.602 \\
&= 2.309(m)
\end{aligned}
$$

Conclusion and Future Work

Conclusion:

By leveraging high-resolution drone images, precise RTK positioning, YOLOv8-based tassel detection, and 3D point cloud analysis, we achieved accurate and automated extraction of critical agronomic traits at the single-plant level. This approach not only reduces the labor intensity and potential errors associated with manual measurements but also provides efficient data support for large-scale breeding trials, thereby improving the efficiency of high-quality germplasm selection.

Future work:

Future work should include precision, recall, and F1 score for a more complete assessment. We also plan to expand monitoring to traits such as tassel height, stem thickness, and fruiting characteristics, and to integrate multi-source data with advanced models to enhance robustness.

Thanks

EMAIL: chongdongliang@newrisedt.com,
houaiqin@nwu.edu.cn.