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Automated morphometric quantification of maize cob kernels via lightweight rgb image analysis and cellpose-based deep learning segmentation

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Abstract

Maize (*Zea mays* L.) constitutes a cornerstone of food security and agricultural livelihoods across tropical and subtropical farming systems, where accurate kernel quantification and morphometric assessment are indispensable for yield evaluation, varietal selection, and climate-adaptive breeding programs. Conventional manual enumeration methods, however, remain inherently limited by operator subjectivity, poor scalability, and incompatibility with the throughput demands of contemporary crop improvement pipelines. Here, we present a low-cost, image based computational workflow employing Cellpose deep learning architecture for automated instance segmentation, enumeration, and morphometric characterisation of individual kernels from standard RGB photographs of intact maize cobs.

The preprocessing pipeline isolates the kernel bearing cob region through sequential colour space filtering (HSV masking) and connected component analysis, followed by Cellpose driven instance segmentation to delineate individual kernel boundaries. For each segmented kernel, the workflow extracts pixel area, centroid position, and relative size class, such as small, medium, or large, based on area percentiles, and generates individual kernel image tiles for visual inspection. Interquartile range based outlier detection is subsequently applied to flag morphologically anomalous or potentially mis segmented kernel instances. The pipeline operates entirely on standard RGB images without specialised imaging hardware, cloud infrastructure, or internet connectivity, making it well suited for deployment at tropical research stations and resource constrained breeding facilities.

Preliminary testing on a representative set of cob images demonstrates consistent kernel localisation and outlier flagging; however, formal statistical validation of morphometric outliers across diverse varieties and imaging conditions has not yet been performed. The segmentation approach was designed to accommodate variable cob orientations and heterogeneous field lighting conditions, though systematic generalisation tests remain for future work. Compatibility with minimal imaging setups facilitates rapid deployment and enables real time kernel phenotyping directly at the point of harvest, a critical capability for advancing precision agriculture in low resource tropical and subtropical environments. The workflow also produces visual outputs, including numbered kernel maps, size class overlays, and kernel montages, sorted or grouped by size, supporting manual quality control and downstream analysis.

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