Drone-imagery phenotyping using deep learning approaches to estimate plant maturity and stand count at dry beans

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A dry beans (*Phaseolus vulgaris* L.) cultivar must fit the environment in which it will be grown. Therefore, days to maturity (DM) is the most important physiological component affecting yield and grain quality outcomes. Additionally, dry bean stand count (SC) at early growth stages estimation provides useful information for agronomic decision-making and can measure root rot loss due to damping-off. The visual inspection to determine the accurate maturity date and the final number of emerged plants is labor-intensive, time-demanding, and tedious. Therefore, there is an increasing demand for alternative approaches to estimating DM and SC in a high-throughput phenotyping mode (HTP). In this study, we developed a Deep Learning (DL) HTP pipeline to capture the sequential behavior of time series data for estimating DM and to identify target plants in the early growth stage for SC estimation using field dry bean data obtained from aerial RGB images at the plot-level. A state-of-the-art hybrid model combining Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) was used to extract DM features and capture the sequential behavior of time series data. Faster R-CNN object detection method was deployed to SC. The DL model to estimate DM was tested on five different environments across years, and SC was done comparing different ground sample resolutions in two trials. Results suggest the effectiveness of the CNN-LSTM and Faster R-CNN models employed compared to traditional methods. Furthermore, this study highlighted the technical parameters that can influence the DL model results in the breeding program decision-making.