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Project Title: A Smartphone and Deep Learning Based Imaging Technique for Malt Acrospire Inspection to Replace Manual Counting

Project Intro:
Acrospire length is a visual indication of the degree of malt modification in the malting process, and an indicator of the uniformity of the germination. Traditionally, maltsters rely on their visual reading of the acrospire growth to judge the process of malting and make process decisions to deliver the in-spec malt. Acrospire length distribution is a common specification of brewers so they can tell the degree of malt quality. The industry still practices this method manually in the lab, but it is tedious, time consuming and subject to human error. A digital approach to evaluate the parameter will greatly enhance the productivity and consistency of the results. Some imaging techniques have been explored in barley variety identification with acceptable accuracy. Therefore, we propose to integrate smartphone imaging and deep learning models to inspect the malt acrospire length. Our goal is to use the smartphone inspection approach to replace traditional manual inspection with higher inspection throughput and accuracy.

Project Objectives: To evaluate the quality of malt under normal malting conditions, elongation of the acrospire (coleoptile) is used to parallel the physical and chemical changes in the endosperm associated with conversion of hard vitreous barley to friable, mellow malt. As the acrospire grows under the husk of germinating barley, endosperm "modification" approaches the desired level when the acrospire approaches the full length of the kernel. In the inspection, malts are classified based on the ratio of the length of malt acrospire to the grain length: 0 to ¼, ¼ to ½, ½ to ¾, ¾ to 1, and overgrown (>1). The overgrown class, in which the acrospire extends past the full length of the kernel, is considered undesirable from the standpoint of both quality and economics. In manual inspection, human eye can identify the acrospire and estimate the ratio in boiled seeds. The time for preparation and growth inspection of one sample with 100 seeds could take up to 2 hours, which is time consuming. Human eye inspection is error-prone due to subjectivity and fatigue. In recent years, image processing with deep learning has gained popularity in various areas where image information can be used for object classification and detection. Smartphones are widely available, many of which can provide us with high quality images. The application of smartphone imaging technique is expected to replace manual inspection and reduce the inspection time to be less than half an hour (including time for seed handling. Image collection/processing itself only takes seconds). The hypothesis of this project is that smartphone image analysis integrated with deep learning models can classify the acrospire:grain ratio in malts with high efficiency. The success of this project will help the malt industry by replacing manual labor inspection with advanced imaging technology, which is both higher throughput and more accurate. Our objectives for this proposed project are to: 1) Develop a deep learning model to classify smartphone pictures of single malt. Images will be annotated with boundary boxes and labeled with class. 2) Develop a color imaging

algorithm that enhances smartphone images with multiple malts for classification and malt counting in each class. Deep learning algorithms for object detection (RCNN, fast-RCNN, Yolov4, Yolov5) will be used for detecting malts out of the background and removing outliers such as malts with broken acrospire. 3) Integrate the color imaging algorithm to a cloud computing platform so that new smartphone images can be captured from new malt samples and uploaded for seed detection and counting. 4) Maintain and share a high-quality annotated data set and aggregate the dataset by adding more labeled images from various sources to include malts from different barley genotypes, some of which have very different phenotypes. Improve the malt detection and classification model by training with the aggregated dataset.