ABSTRACT

Eggs are the most nutrient-rich and protein-dense food that is affordable and consumed by most of the population. But cracks on the eggshells can pave way for microbial contamination of the eggs posing threat to the health of the consumers. Therefore, it is crucial for the egg industries to check for the quality of eggs before reaching consumers to avoid outbreaks. Crack detection is one of the bottlenecks faced by the egg industries as it is carried out by human graders. In the recent past, many techniques have been developed to automate the process of detecting cracks on eggshells. Automatic visual inspection has gained popularity in the field of eggshell crack identification because of the advancements in the machine vision and robotic technology. However, due to the presence of microcracks, classifying eggs using entire image is challenging. Therefore, in the present study an attempt has been made to identify cracked eggs using patch level images that were acquired by pre-processing the egg images. Several Convolutional Neural Network (CNN) based techniques viz., custom CNN model, transfer learning using fine-tuning, feature extraction and training machine learning classifiers on deep features extracted from pre-trained models were used and compared to identify the best classification algorithm to identify cracks from the images of eggs. Among the classification techniques, fine-tuning using pre-trained DenseNet121 model performed the best with 98.38 % accuracy followed by linear regression model trained on deep features extracted from layer 3 of the DenseNet121 model with an accuracy of 97.77 %.

A prototype of automatic mobile-based real-time detection and grading systems to identify and remove cracked eggs from the conveyor was also developed in this study. The detection was performed using the Single Shot MultiBox Detector (SSD) algorithm with MobileNetV2 as the backbone network. The input size, feature maps and prior boxes of the MobileNet-SSD (MNet300) model were improved to enhance the performance of crack detection. The models were used to develop a mobile application to perform real-time detections on rotating eggs. The application was tested at three different conveyor speeds, which approximately rotated the eggs at 10, 20 and 30 rotations per minute (RPM). The improved model achieved the best detection accuracy at an RPM of 10.

Keywords: Egg crack detection; Convolutional Neural Networks; Transfer learning; MobileNet-SSD model; Real-time detection; Robotic technology