MACHINE VISION BASED TOMATO GRADING AND CLASSIFICATION

Abstract

Agriculture is one of the major sources in developing the economy of any country across the world. Based on the growth of world's population year by year, the necessity of the agricultural product has also increased to supply quality food to the human. Among the different agricultural products, tomatoes are a significant and famous fruit crops. Tomatoes offer numerous basic and beneficial supplements to people for example, they contain cancer-preventing agents and nutrients C and A. To increase the productivity of tomatoes and to meet the standard of supply in the market, numerous fruit grading systems have been developed in recent years. Detection of diseases in tomato is very useful in yielding high harvest. Usually, the traditional way of identification of diseases and maturity levels of fruits is not accurate, since it is based on human eye assessment and centred on the human expertise. Therefore, to improve the accuracy in detecting the quality of fruits, different artificial techniques have been suggested by different investigators. The fruit sorting and grading system is basically categorized into two types such as destructive and non-destructive methods. Due to several limitations in the destructive methods like the requirement of portable tools and the need for high cost, various non-destructive methods are widely suggested and used in grading fruits over the years. Among the different non□destructive methods of fruit grading systems, computer vision (CV)-based methods are widely used. The CV-based systems are mostly used to detect the kind of fruits, type of defects in tomatoes and ripeness level of tomatoes. This research studies the characteristics of different types of fruit grading systems such as spectroscopy-based fruit quality detection iv systems and artificial neural network (ANN)-based fruit grading systems developed over last few decades based on their characteristics like accuracy and time consumption. Based on the detailed study, it is observed that the usage of spectroscopy-based fruit grading system is limited due the major issues in the calibration of meters. So, the ANN-based fruit quality detection systems are widely suggested by different structure of ANN and by using different supporting algorithms such as image denoising, image segmentation, and feature extraction. This thesis compares the characteristics of recently developed spectroscopy-based fruit classification systems and various ANN-based algorithms used in the fruit quality identification systems. By analyzing the various ANN-based tomato sorting and grading systems developed in the last two decades, this research proposes two major suggestion to improve the accuracy of the fruit grading systems such as improving the performance of ANN-based system by using whale optimization and dual support vector machine (DSVM) classifier-based system. Further, it is also identified that the requirement of automotive systems in the agricultural fields and especially to identify the quality of fruits during post-harvest processes. By using automatic disease identification and the maturity level measurements of fruits, the time required to classify the fruits is decreased very much, and it provides accuracy in the identification of quality fruits. Thus, based on the study, this research also proposes microcontroller-based fruit sorting and grading system. To measure the accuracy level of different proposed tomato sorting and grading systems, experimental analysis by using MATLAB tools is carried out. Different quality metrics like accuracy, error rate, sensitivity, specificity, precision, and F1 score are verified. The whale optimized ANN□based fruit classification system is developed by different operating modules v such as image acquisition, pre-processing, image segmentation, feature extraction, and classification modules. The median-filter based pre□processing is used to denoise the image samples of tomatoes. The high□performance, swam-intelligence-based firefly algorithm (FA) is utilized in image segmentation process. Also, the gray-level co-occurrence matrix (GLCM)-based feature extraction module is used to improve the performance of the proposed ANN-based tomato classification system. By using these kinds of high-performance supporting algorithms, the whale-optimized ANN-based tomato classification system yields 94.11% accuracy and it outperforms any other related conventional fruit classification systems

based on accuracy. Experiments were also conducted on the proposed dual SVM based fruit classification algorithms in grading tomato fruits based on their appearance. The dual-SVM-based tomato sorting and grading system is equipped with the concepts of histogram of local features (HLFs) and super pixels (SPs)-based image segmentation. This system is used to identify the ripeness level of tomatoes and the various defects in tomatoes based on their appearance. This method operates with the precision of 94.50%. This proposed method outperforms any other related SVM classifier algorithms like fine Gaussian SVM, cosine Gaussian SVM, cubic SVM, median Gaussian SVM, and quadratic SVM. The receiver operating characteristics (ROC) is also used to demonstrate the performance of the system. To demonstrate the importance of the automotive fruit sorting and grading system, an experimental analysis on microcontroller-based tomato classification using multi-SVM classifier algorithm is also carried out. This system is constructed by using ARM7 microcontroller, IR sensor, camera, conveyor belt and a relay system. The performance of the multi SVM classifier is improved by utilizing Gabor wavelet transform (GWT)- vi based feature extraction module. By utilizing GWT, this method operated with the specificity of 99.38%. Also, this method outperforms any other conventional K-nearest neighbour (K-NN)-based classifier algorithms like weighted K-NN, cosine K-NN, cubic K-NN, and median K-NN. This proposed ARM7 microcontroller-based fruit classification is the most suitable for any real time tomato sorting and grading system. This thesis explains the characteristics of different recently developed fruit classification systems and their performance comparison. The complete design, implementation, and experimental analysis of the three proposed tomato classification methods are described with suitable comparison. Further, this thesis provides the possible improvements on the proposed systems and applications of the proposed tomato classification algorithms to extend the usage of the existing real-time fruit sorting and grading systems and to continue the research with new optimization techniques.