A circular arc approximation algorithm for cucumber classification with image analysis

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Abstract

The cucumber is one of the most important consumer vegetables, and due to high freshness and appearance standards, it must be graded according to quality. One key metric for grading cucumbers is curvature (arch height) relative to length. To date, this classification standard has not been implemented in a commercial automatic system because the curvature of the cucumber is related to its length. This paper presents and tests a circular arc approximation algorithm for measuring the curvature of a cucumber using image processing. By fitting the central axis of each cucumber to establish a curve equation, the approximate eigenvalue radius, R, and the radius of the section perpendicular to the curvature of cucumber, r, could be obtained quickly and efficiently. The curve of the cucumber was then transformed into a new characteristic, R' (R' = R − r), which was used as a threshold to classify each cucumber. The method was verified by theory and experiment, and the average error of 0.71 % corresponding to the coefficient $R^2 = 0.9958$ of the similarity index between the curve and central axis of the cucumber was verified. It was found that the fitted curve and the central axis of the cucumber were coincident. Moreover, we designed an algorithm that can detect S-shaped cucumbers based on the analysis of the contour, which can avoid the influence of S-shaped cucumbers on the results. In our tests, 148 cucumbers were classified using the circular arc approximation method, the elliptic approximation method, and a manual method. The results of the classifications were compared. According to China's standard evaluation, the classification error rate of the circular arc approximation method was 10.1 % lower than that of the elliptic approximation method. The incidence of cucumbers being classified into an adjacent grade was 0.7 % using the circular approximation method, and there were no cases of cucumbers being classified into non-adjacent grades. The classification error rate of the elliptic approximation was 10.8 %, of which 2.7 % was

classified into non-adjacent grades. Under the European standard, the cucumber classification accuracy using the circular arc approximation algorithm reached 100 %. Therefore, the proposed method offers a more accurate classifier than the elliptic approximation method, and the circular arc approximation algorithm can be fully applied in the commercial cucumber classification process.