

Retraction

Retracted: Analysis and Recognition Based on Citrus Color Grading Model considering Computer Vision Technology

Advances in Multimedia

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] J. Deng, "Analysis and Recognition Based on Citrus Color Grading Model considering Computer Vision Technology," *Advances in Multimedia*, vol. 2021, Article ID 6426163, 7 pages, 2021.

Research Article

Analysis and Recognition Based on Citrus Color Grading Model considering Computer Vision Technology

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With the continuous advancement of smart agriculture, the introduction of robots for intelligent harvesting in modern agriculture is one of the crucial methods for the picking of fruits, vegetables, and melons. In this paper, three different illuminations, including front lighting, normal lighting, and back lighting, are first applied to citrus based on the computer vision technology. Secondly, the image data of the fruits, fruit stems, and leaves of the citrus are collected. The color component distributions of citrus based on different color models are analyzed according to the corresponding characteristic values, and an exploratory data analysis process for the image data of citrus is established. In addition, 300 citrus images are selected, and the citrus fruits are segmented from the background through the simulation experiment. The results of the study indicate that the recognition rate for the maturity of citrus has exceeded 98%, which has proved the effectiveness of the method proposed in this paper.

1. Introduction

With the continuous advancement of smart agriculture, the introduction of robots for intelligent harvesting in modern agriculture is one of the crucial methods for the picking of fruits, vegetables, and melons [1]. On the one hand, it can save a lot of costs in human resources; on the other hand, it can implement intelligent management effectively. The focus of intelligent harvesting is how to identify mature fruits from the wild fruits and vegetables accurately and effectively [2]. Based on the identification results, the immature fruits are allowed to continue to grow, and the ripe ones are harvested directly. The steps of harvesting often include several aspects, such as the image collection, image preprocessing, image segmentation, feature extraction, and intelligent harvesting [3]. It should be noted that as various fruits and vegetables have different features in color and size under different environmental conditions, it is impossible to identify a clear characteristic value for independent recognition. Thus, it is necessary to select different characteristic values based on various features. As a result, the selection of a suitable model for images has become the focus and difficult point to be resolved [4, 5].

Citrus is a relatively common fruit, which also occupies a highly crucial position in our country. Although our country ranks first in the yields and planting areas of citrus, the harvesting of citrus is still completed by hand in our country, which often takes up a lot of human resources and results in a certain constrain on the speed of harvesting and the costs. Hence, how to improve the efficiency of harvesting is a problem that requires in-depth study and application [6–9]. Color is a relatively obvious feature, which can be used to determine whether fruits and vegetables are mature. Thus, scholars in the industry have tried to carry out research on the scientific classification and determination of the colors of fruits and vegetables, such as the application of exploratory data analysis methods to conduct diversified and multi-perspective statistical analysis. However, it should be noted that such statistical analysis has certain limitations; that is, the extracted features are relatively apparent, which needs to be completed by a lot of manpower [10].

Therefore, based on computer vision technology, attempts are made in this paper to analyze the colors of different parts of citrus. Through the statistical analysis and classification of the color data from the three angles, that is, the fruits, stems, and leaves, a visual model of component

images is established to measure the maturity of fruits, with the purpose to explore the intelligent implementation of color analysis of citrus.

2. Analysis Based on Computer Vision Technology

2.1. Exploratory Data Analysis Method. With regard to data statistics, from the perspective of unknown samples, how to identify the true distribution and the related patterns of data is relatively complicated. Hence, scholars have carried out research on exploratory data analysis [11, 12]. It includes several evident features. (1) No specific model is emphasized, that is, “from data to data,” and it does not deliberately apply a certain model or algorithm for calculation. (2) The originality of the data is emphasized; that is, great attention is paid to the features of the data themselves, and the relevant patterns of symmetry and constancy are identified by expressing the data on a scale. (3) The analysis is carried out in steps. Firstly, the exploratory analysis is conducted; then, data verification is carried out, where a part of the data is selected as the sample and the other part is used as the data for verification [13].

2.2. Target Recognition Technology. In the so-called target recognition, the corresponding monitoring and analysis are carried out through the system. Due to the complexity of the targets, it is necessary to identify and distinguish the characteristics of the targets. In the past, the original images are often identified and analyzed based on the traditional methods, and their characteristics are further interpreted through the steps of manual analysis before the data classifier is introduced to identify and recognize the corresponding object.

It should be noted that in the process of image recognition, it is necessary to carry out preprocessing and analysis on the images during image recognition due to the interference of light and noise. Various features are extracted for analysis based on the preprocessing methods such as grayscale binarization and filtering so as to implement the discrimination of the objects.

2.3. Target Distance Measurement Technology. At the present stage, the primary technologies applied in the driving safety-assisted system for target distance measurement are as follows: ultrasonic, laser, and machine vision distance measurement. The distance measurement method by ultrasound is mainly based on the ultrasonic transmission time to determine and measure the target obstacles. The calculation principle of this method is relatively simple and convenient. In addition, the cost is low, and it can measure the target distance at a relatively high accuracy. In the laser distance measurement methods, mainly the photon radar system is used through a type of instrument to measure the target range, which can be divided into imaging and non-imaging methods, with the advantages of wide measurement range, relatively high accuracy, and so on. In the imaging laser distance measurement method, the laser emission

direction is controlled mainly through the scanning machine, and the three-dimensional data of the targets are obtained by scanning and analyzing the entire environment, while in the nonimaging laser distance measurement method, the distance to the target is determined mainly based on the propagation time and the propagation time of the speed of light. The measurement methods for distance based on machine vision are mainly monocular distance measurement and binocular distance measurement. The monocular distance measurement method has certain advantages in cost, but it is inferior to the binocular distance measurement method in accuracy.

2.4. Citrus Recognition Based on the Principle of Color Subchannel. The principle of color recognition is to break down multiple single-channel images in color by color space components first and then represent them using the gray value images after they are binarized. The images after the gray value processing can change the existing color images to obtain the result of single-tone image segmentation, which has significantly reduced the difficulty of segmentation. After the segmentation, the overall color images are merged to form the final result [14, 15].

The research shows that in order to realize effective processing of color images, it is first necessary to select an appropriate color space. The color space refers to a subset of visible light in a certain three-dimensional space, so that colors can be easily specified in a certain color gamut, because it contains all the colors of a certain color gamut. Under normal circumstances, RGB ternary is often used to specifically represent the color space, but this method has obvious shortcomings because the Euclidean distance between two points in this method is not linearly proportional to the color distance. In other words, the color change will be subject to strong external interference, such as brightness, so this method requires independence for image processing (that is, the three components do not affect each other, and processing any one of them will not affect the other components and causes visual changes in the human eye), and uniformity (that is, the same degree of change in any one component will cause the same visual change in the human eye) is not accurate enough. However, the actual situation is that there is no color space that absolutely meets the independence and uniformity. Therefore, we can only find a color space that can meet the above two conditions in a larger range according to the actual situation.

If the effect of the segmentation of citrus color images in the wild is not satisfactory, segmentation processing on the single-channel component of the color image can improve the efficiency of segmentation processing, increase the accuracy of recognition effectively, and achieve the purpose of shorter processing time and higher recognition rate, which can meet the requirements for intelligent harvesting of mature fruits and vegetables by robot. Thus, for the field images of citrus, how to select a single-channel image to identify and distinguish various positions of the citrus is determined based on the analysis results of classification and statistics in accordance with the color characteristics.

Therefore, it is necessary to establish a color model for the fruits, stems, and leaves of citrus based on the color characteristics of the images to determine the optimal analysis amount of colors.

2.5. Process of the Exploratory Analysis of Citrus Image Data.

As the majority of the field collection sites for citrus are open field sites, there may be various influencing factors, such as changes in sunlight and weather conditions (rainy, sunny, and so on), under such conditions, which can lead to differences in lighting. Hence, even on the same day, the lighting conditions can be totally different due to the difference in time, which results in a highly complicated environment for field operations. In addition, there are also different citrus fruits growing in the same branch during the harvesting of citrus, and there can be overlaps or occlusions. These situations will have a certain influence on the recognition and discrimination of images, as well as the identification of positions. Thus, this part of the factors should also be taken into consideration.

Therefore, based on the various influencing factors described above, the process of the analysis on the exploratory data of citrus images put forward in this paper mainly includes the following steps:

- (1) According to the angle and position where the image is taken, the citrus samples are further subdivided into three types based on the acquisition of images: front lighting, normal lighting, and back lighting.
- (2) On the basis of the images acquired, citrus images are classified into a front lighting group, a back lighting group, and a normal lighting group according to the positions of fruits, stems, and leaves.
- (3) *Extraction of the Image Data.* Based on three different light conditions, the three primary color data of the fruits, stem, and leaves of the citrus are extracted.
- (4) According to the characteristic samples of the exploratory data analysis method, various components of the acquired fruit, stem, and leaf color data of the citrus are displayed based on different color thresholds.
- (5) The pattern of the fruits, stems, and leaves of citrus in different colors is identified based on the statistical quantity.
- (6) Testing and case analysis are carried out on the related results for verification. If it is correct, the verification ends. If there is any problem, proceed with Step (1), as shown in Figure 1.

3. Analysis and Recognition Based on the Color Grading Model of Various Parts of Citrus

In this paper, six different color thresholds are selected to analyze the colors of the fruits, stems, and leaves of citrus under three different lighting conditions, and attempts are made to establish a visual model for the fast identification of

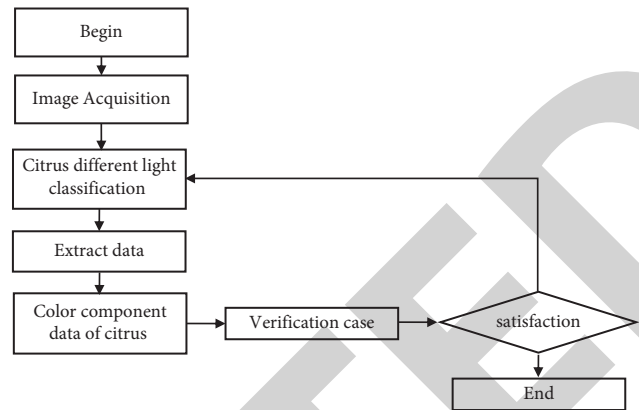


FIGURE 1: Flow chart of the exploratory analysis of citrus image data.

mature citrus and further distinguish mature fruits from the other parts of the citrus.

3.1. Acquisition of Sample Data. The sample area of the fruits, stems, and leaves is selected from 300 samples of citrus images under three illumination modes, front lighting, normal lighting, and back lighting, by using the image selection tool. According to the image information, the data of the three primary colors in the fruits, stems, and leaves of the citrus are selected. The conversion between different color models is carried out based on the conversion equation, and the color data of the color model are obtained at the same time to carry out statistical analysis accordingly.

3.2. Graphic Display in Exploratory Data Analysis. Following exploratory data analysis, the principles of its meaning and the four themes of resistance, residuals, re-expression, and graphical revelation are explained through data. In order to distinguish the patterns and characteristics of the data, box plots are selected to show the difference in citrus under different lighting conditions. The components are distributed in the 6 color models. Box plot, also known as box-and-whisker plots, is a graphical representation of some central trend measurement statistics and dispersion measurement statistics. The center position and spread range of one or more sets of continuous quantitative data distribution are described. The box plot describes the five characteristic values in the data: minimum, first quartile, median, third quartile, and maximum.

In this paper, attempts are made to visualize the graphs of each component in the six color models for various parts of citrus under different lighting conditions, as shown in Figures 2–7.

3.3. Data Analysis. From the boxplot of the color mean distribution of each component based on the 6 color models of the fruits, fruit stems, and leaves of citrus, that is, RGB, normalized RGB, HSI, YCbCr, $I_1I_2I_3$, and $L^*a^*b^*$, it can be observed that

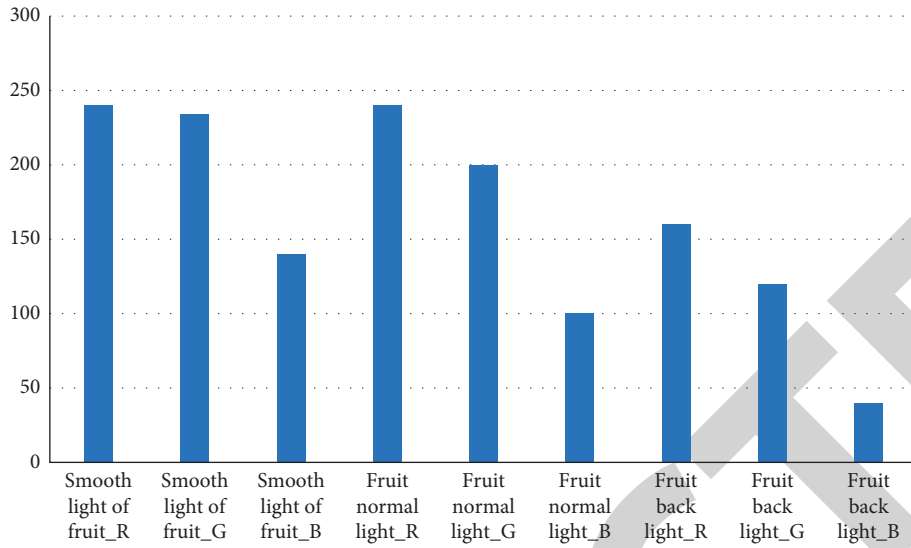


FIGURE 2: Result chart of the RGB color model under different lighting conditions.

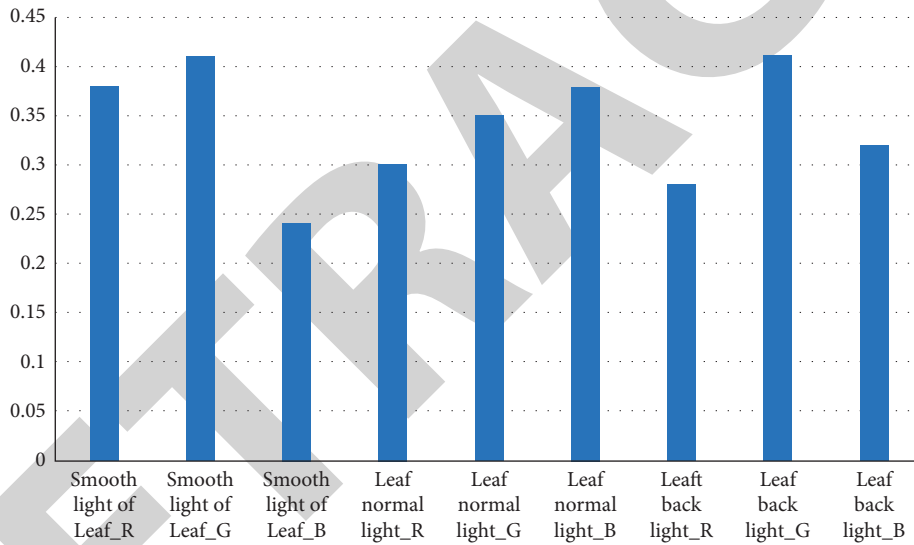


FIGURE 3: Result chart of the normalized RGB color model.

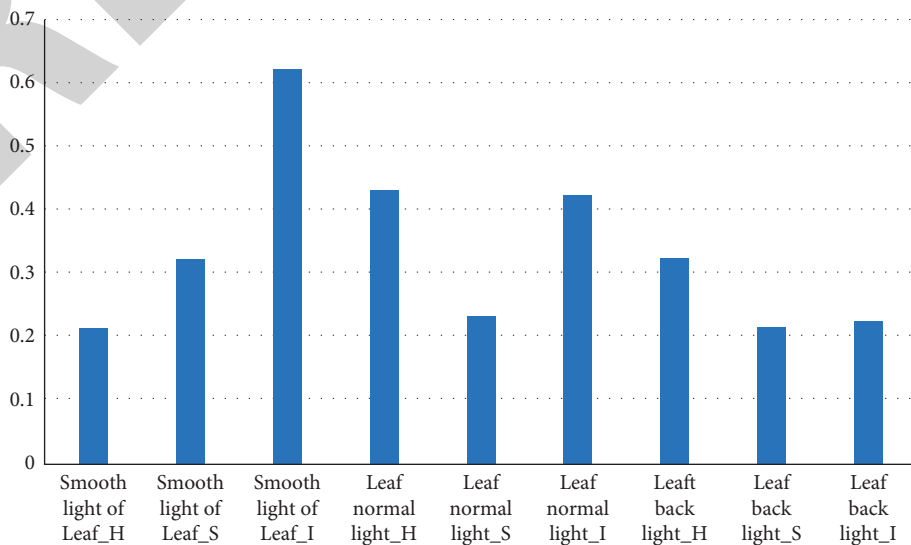


FIGURE 4: Result chart of the HSI color model.

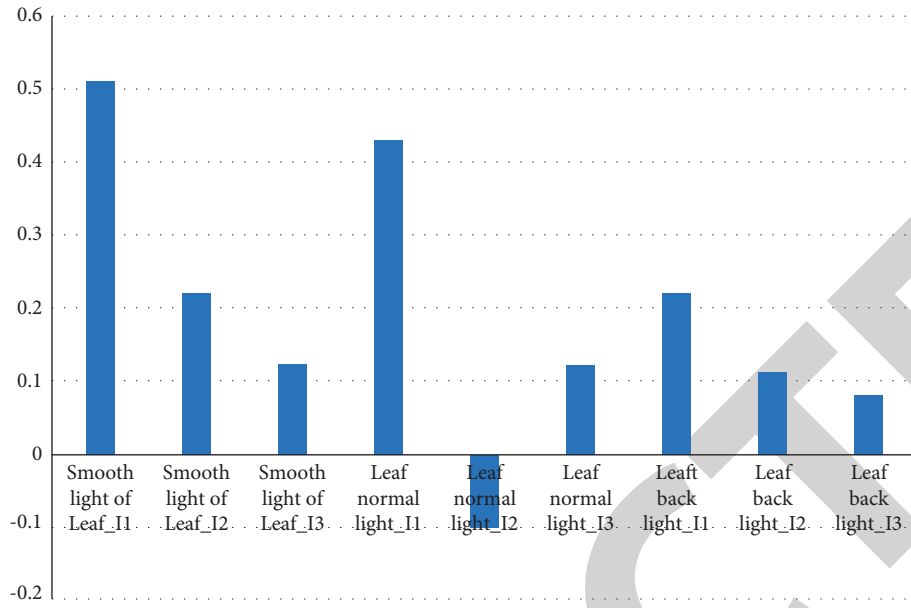


FIGURE 5: Result chart of the I1I2I3 color model.

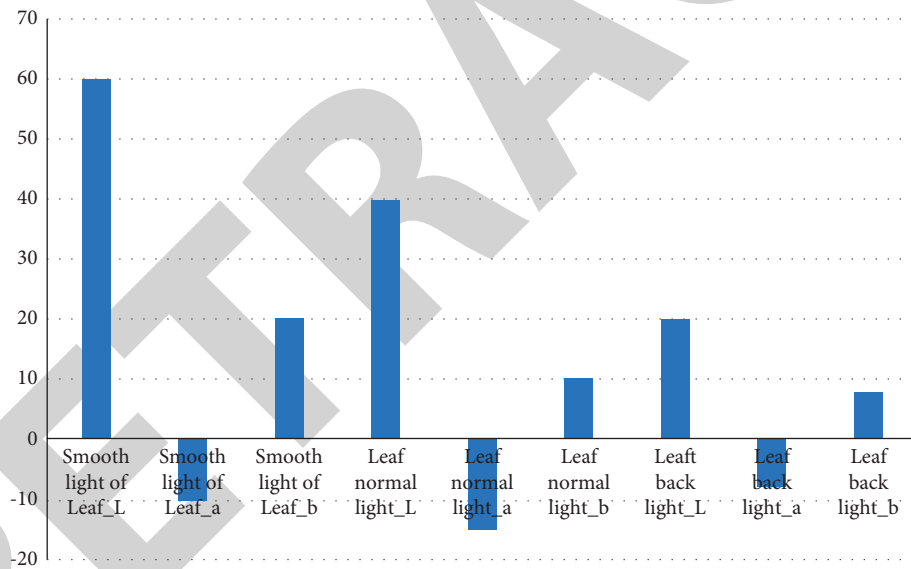


FIGURE 6: Result chart in the Lab color model.

- (1) In the normalized RGB color model, the values of the r , g , and b components under various illumination conditions are all around 0.3. The reason is that the normalization of RGB can overcome the influence of changes in the illumination conditions.
- (2) In the HSI color model, as the H components of the fruits, stems, and leaves have overlapping areas, the H component cannot be taken as the target of image segmentation and analysis.
- (3) In the $I_1I_2I_3$ color model, the I_3 components of the fruits, stems, and leaves have apparent overlapping areas under the same illumination condition, so they are not suitable to be taken as the targets of image

segmentation and analysis. There are significant differences between the fruits, stems, and leaves in the I_1 and I_2 components under the same illumination condition, so I_1 and I_2 can be taken as the identification variables. However, since the I_1 component is significantly affected by the lighting conditions and it can easily lead to misrecognition, it is not suitable either. From the figure, it can be observed that the I_2 component shows no significant changes under the influence of the lighting conditions. Hence, it is suitable to be used as an identification variable.

- (4) In the YCbCr color model, as the Y component is a brightness value, it is susceptible to changes in

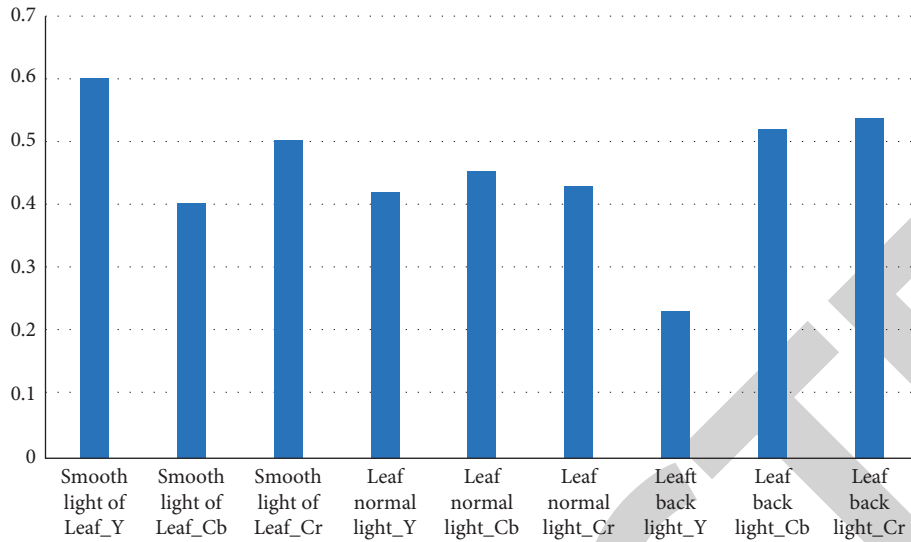


FIGURE 7: Result chart of the YCbCr color model.

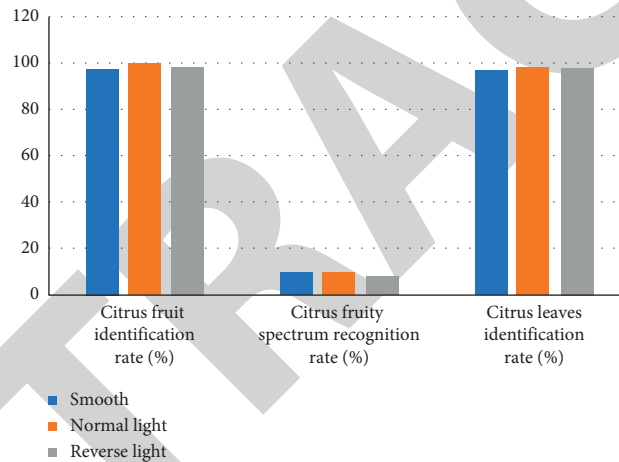


FIGURE 8: Recognition rate for each part of citrus.

illumination. Thus, it is not suitable to be taken as an identification variable.

- (5) The $L^*a^*b^*$ color model has problems such as a large amount of model conversion and long time required for computation, which is not conducive to processing in real time.

From the above analysis, it can be known that among the total of 18 color components in the 6 commonly used color models, the most suitable color component for distinguishing the fruits, stems, and leaves of citrus is the I_2 component in the $I_1I_2I_3$ color model.

3.4. Verification Test Analysis. In order to further verify the data analysis conclusions obtained above, the images of citrus samples are conditionally segmented by the components based on the color model. From the result graph of the color model, it can be seen that the color components of the fruits are all greater

than 0.3 under different lighting conditions. However, the relative component values of fruit stems and leaves are all less than 0.3 under different lighting conditions. Hence, the characteristic value of the component (0, 3) can be taken as the intermediate threshold, and the image of citrus fruits can be identified by using the fixed threshold segmentation method. From the results obtained, it can be seen that the components of the color model can isolate the citrus fruits from other backgrounds effectively.

The 300 citrus pictures selected are divided into three groups as the following: a front lighting group, a normal lighting group, and a back lighting group. The fruits, stems, and leaves of the citrus are divided into three groups based on the empirical threshold segmentation method, and the segmentation and recognition tests are carried out, respectively. Their recognition rates are statistically analyzed. Among them, the recognition rate of citrus fruits, stems, and leaves is obtained as follows:

$$\begin{aligned}
 r_f &= \frac{n_f}{n_{ft}} \times 100\%, \\
 r_s &= \frac{n_s}{n_{st}} \times 100\%, \\
 r_l &= \frac{n_l}{n_{lt}} \times 100\%,
 \end{aligned}
 \tag{1}$$

where r_f is the recognition rate of fruits, %; r_s is the recognition rate of fruit stems, %; r_l is the recognition rate of leaves, %; n_f is the number of fruits identified; n_s is the number of fruit stems identified; n_l is the number of leaf areas accessible to leaves identified; n_{ft} is the total number of fruits; n_{st} is the total number of fruit stems; and n_{lt} is the total number of areas accessible to leaves.

The recognition rates for the citrus fruits, stems, and leaves obtained are shown in Figure 8.

In the image recognition from three angles of the fruits, fruit stems, and leaves, when the relevant color components are used for effective recognition, the overall recognition rates have all exceeded 98%, which can meet the requirements for intelligent harvesting by robot.

4. Conclusions

The intelligent harvesting of mature fruits can reduce labor costs and save a lot of time effectively. In this paper, the characteristics of fruit images under three different lighting conditions, that is, front lighting, back lighting, and normal lighting, are identified based on exploratory data analysis by using the computer vision technology. The results of the experiment in the study indicate that based on the color threshold selected, the mature citrus fruits can be effectively identified, and the overall recognition rate has exceeded 98%, which can meet the requirements for intelligent harvesting.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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