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# Detection Method of Agricultural Product Defects based on Machine Vision Technology

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## Abstract

**The method of agricultural product appearance defect detection based on machine vision includes three aspects: positioning, visual measurement and defect detection. First, the algorithm determines the shape, color and texture features of agricultural products through rapid location and registration. Select gray image registration to quickly realize position offset correction. Then, K-means clustering algorithm is used to quickly separate the target pattern from the background. In this paper, geometric moments are used to extract shape features of patterns to improve the classification performance of shape features. Finally, the support vector machine classifier is used to identify the defects of agricultural product patterns, the RBF kernel function is used to classify the pattern features nonlinearly, and the cross validation method is used to optimize the parameters. Experiments show that the algorithm can improve the defect detection rate of agricultural products, and improve the detection efficiency in the detection of agricultural products such as dirt and decay.**

## Keywords

**Machine Vision; Appearance Sink Detection; Visual Measurement; Gray Image Registration; Support Vector Machine Classifier.**

## 1. Introduction

Machine vision technology is more and more widely used in surface defect detection of agricultural products. Machine vision is to use machines to replace human eyes for measurement and judgment. Agricultural products are converted into image signals through industrial cameras. Image signals are converted into digital signals by data acquisition cards and transmitted to image processing systems. The image systems calculate signals, extract image features, give judgment results through comparison databases, and control screening equipment for sorting. In the field of machine vision, agricultural product images are mainly content-based image recognition methods. Use the color, texture, shape, spatial position and combination of features of the image to extract the features of the image, and compare the detected image with the standard image.

The surface defect detection of agricultural products is to use digital image processing technology, sensor technology and automatic control technology to automatically detect whether agricultural products are damaged or deteriorated, and automatically separate qualified products from unqualified products on the production line according to the detection results, so as to improve the detection efficiency of agricultural products through the implementation of the system.

Agricultural product detection is an image recognition problem, its essence is to detect surface defects. Such surface defects are generally divided into structural defects, texture defects and color defects. Structural defects mainly include damage and defect. Texture defects mainly include texture changes on the surface of agricultural products. The color defects mainly include the color stain and abnormal color of agricultural products.

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## 2. Detection Methods for Agricultural Product Defects

There are four technical keys to this test method:

(1) Fast positioning and registration, crystal box trademark mainly has shape, color and texture characteristics. Choosing gray image registration can quickly realize position offset correction.

(2) K-means clustering algorithm is used to quickly separate the target trademark pattern from the background, and geometric moments are used to extract the shape features of the pattern to improve the classification performance of shape features.

(3) The support vector machine classifier is used to identify the defects of the trademark pattern, and the RBF kernel function is used to classify the pattern features nonlinearly, and the cross validation method is used to optimize the parameters.

(4) The algorithm is transplanted to DSP control program to realize real-time control.

The specific testing methods and procedures are as follows:

The method of agricultural product appearance defect detection based on machine vision includes three aspects: positioning, visual measurement and defect detection. This algorithm uses an industrial camera to collect images of water line products, and then converts the image signals into digital signals through A/D conversion, which is transmitted to the image processing system. The image processing system extracts the features of the image, uses the database stored in the system in advance, and then recognizes the extracted features according to the judgment criteria, makes judgments, sends out the judgment signals, and the screening equipment processes the products according to the judgment results.

(1) Positioning

The visual inspection system is required to be able to collect and save the images of six aspects of the appearance of agricultural products, so four camera systems and one flipping system are required. An industrial camera is installed on the top, bottom, left side and right side of the agricultural products respectively.

In the detection of agricultural product generation, due to the fluctuation of the conveyor belt, the position of the agricultural product image will change to a certain extent in both the direction of the conveyor belt and the vertical direction. Therefore, it is necessary to locate the agricultural product image during the detection. Because the Hough transform is applicable to the situation of high noise and discontinuous boundary points, and has strong robustness, but the amount of calculation is large, which cannot meet the requirements of real-time detection, In order to reduce the amount of calculation and improve the efficiency of the algorithm, the system uses the improved Hough transform algorithm to locate.

Hough transform detects straight lines. The input requirement is a binary image. For any pixel point in the image space, Hough transform finds the point in the Hough space through discretization, traverses all pixels in the image, and calculates the cumulative value of the straight line area in the image space. When the cumulative value is greater than a certain value, it is considered that the straight line area exists. This method requires too much calculation, so the vector closest to the line from the origin can be calculated in the form of polar coordinates. The vector is perpendicular to the line L, and the formula is:

$$\rho = A\sin(\theta + \theta_0) \tag{1}$$

Where, $A = \sqrt{x^2 + y^2}$ , $\sin\theta = x / \sqrt{x^2 + y^2}$

Hough transform is used to detect a circle. The intersection point of the center perpendicular of any two non parallel chords on the circumference is the center of the circle. The center of the circle is

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calculated by using the characteristics of the center perpendicular of the chord passing through the center of the circle. The second step is to verify the existence of the circle and calculate the radius by using the radius histogram. The algorithm requires accurate edges for binary images, so threshold segmentation and edge extraction are required before Hough transform.

(2) Visual measurement

The vision measurement of this algorithm is mainly composed of image acquisition unit, image processing unit, communication interface and human-computer interaction terminal.

The system uses a high-speed fixed-point data processor TMS320DM6437, the processor's main frequency is 600MHz, and there are eight parallel computing functional units. The maximum processing capacity is 4800 MIPS, and the bit depth is 36 bits. The size of agricultural products is 115x115x265, and the required detection accuracy is 0.1mm. Then the minimum resolution of the camera is (265/0.1) * (115/0.1)=2650 * 1150, which is about 3.24 million pixels. Therefore, a 5 million pixel camera is required.

(3) Defect detection

The agricultural product image acquisition system of this algorithm obtains the standard template image, saves it to the template library, and marks the feature area of the image. After the image to be tested is located, the image features are extracted through the K-means clustering algorithm, and then quickly compared with the standard image. The defects are identified through the support vector machine. If there is no defect, continue to detect the next one. If there is a defect, the product will be filtered out by the screening equipment, and the defect image will be entered into the defect database.

In order to calculate the shape feature description of agricultural product patterns, it is necessary to separate trademark patterns and background patterns to obtain the binary image of agricultural product patterns. Because the gray difference between agricultural product patterns and background is not obvious, K-means clustering method is needed to segment the image.

The main idea of color image segmentation algorithm based on K-means clustering is that for color pixel set S={x1, x2,..., xn}, xi=(r, g, b) T or xi=(H, S, I) T (i=1,2,., n) represented by rgb or HSI color features, K-means clustering is performed iteratively until the clustering error reaches the minimum. Clustering error is defined as:

$$E_j = \sum_{K}^{k=1} \sum_{x_i \in C_k^{(j)}} \left| x_i - z_k^{(j)} \right|^2, \quad \mathbf{i} = 1,2,\ldots,n, k = 1,2,\ldots,K \tag{2}$$

The integrity of agricultural product patterns is recognized based on support vector machine. By using RBF kernel function, the low dimensional features are mapped to the linearly separable high feature space, and the optimal classification hyperplane is solved in the high feature space. The nonlinear mapping is realized through the kernel function, which will not increase the computational complexity. C-SVC classification model and RBF kernel function are selected, so the parameters of penalty factor C and RBF kernel function are γ Cross validation method can be used to optimize and improve the performance of SVM classifier. This nonlinear transformation is realized by defining an appropriate inner product function.

The recognition steps of this algorithm are as follows:

(1) Sets the initial value of the Lagrange multiplier of the optimization variable.

(2) Starting from the first training sample, the heuristic method is applied to traverse the entire sample set.

(3) By calculating the KKT condition of the training samples, find the Lagrange multiplier corresponding to the sample points violating the KKT condition, take it as one of the two Lagrange multipliers to be optimized, and then select the first Lagrange multiplier.

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(4) The second Lagrangian multiplier is selected according to the maximum optimization steps, and the Lagrangian multiplier corresponding to the sample points meeting $\max|E_1-E_2|$ in the original training sample set.

(5) After the last sample is calculated, execute the next step, otherwise return to step (3) to calculate the next sample.

(6) A new sample set is formed, and the new training sample set is traversed to obtain the optimal solution of the new problem. So far, the optimal classification discriminant function is obtained.

## 3. Experimental Analysis

In this paper, apples, bananas and kiwifruit were selected for testing and analysis. The results of apple appearance testing and analysis are shown in Figure 1.

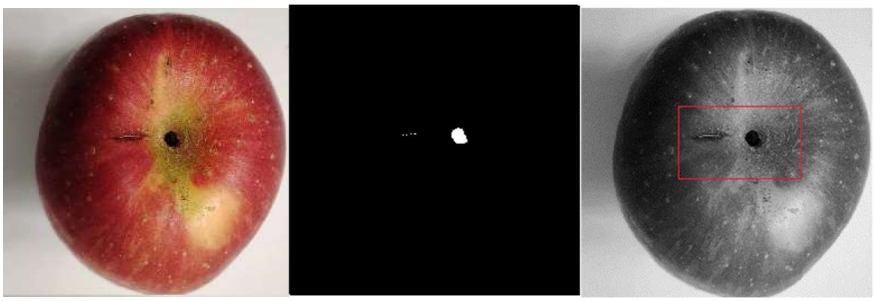

**Figure 1.** The results of apple appearance testing and analysis

The results of banana appearance inspection and analysis are shown in Figure 2.

**Figure 2.**The results of banana appearance inspection and analysis

The analysis results of kiwi fruit appearance test are shown in Figure 3.

**Figure 3.** The analysis results of kiwi fruit appearance test

## 4. Conclusion

This paper analyzes the method of agricultural product defect detection, analyzes the fast positioning registration, and chooses the registration based on gray image to realize the position offset correction.

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At the same time, K-means clustering algorithm is used to quickly separate the target pattern from the background, and geometric moments are used to extract the shape features of the pattern to improve the classification performance of shape features. Then, support vector machine classifier is used to recognize the defects of patterns, RBF kernel function is used to classify the features of patterns nonlinearly, and cross validation method is used to optimize the parameters.

The algorithm in this paper sets the initial value of the Lagrangian multiplier of the optimization variable. Starting from the first training sample, the heuristic method is applied to traverse the entire sample set. At the same time, through the calculation of KKT conditions for training samples, the Lagrangian multiplier corresponding to the sample points violating the KKT conditions is found, which is taken as one of the two Lagrangian multipliers to be optimized, and the first Lagrangian multiplier is selected. The second Lagrangian multiplier is selected according to the maximum optimization steps, and the last sample is repeatedly calculated to form a new sample set. By traversing the new training sample set, the optimal solution of the new problem is obtained. The experiment shows that the detection algorithm in this paper can effectively improve the detection efficiency of agricultural product defects.

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