A flour impurity detection system based on image processing

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Abstract. Flour plays an important role in People’s Daily consumption, and the content of impurities in flour indicates the quality of flour. At present, most domestic factories are using magnifying glass and other simple tools for impurity detection. This method is troublesome and does not meet the requirement of precision. This paper designs an automatic impurity detection system based on image processing, which not only improves the detection efficiency, but also greatly improves the detection accuracy. The basic process of this system is to grayscale the image obtained by photographing, then carry out local entropy transformation, and then map to form entropy image. Finally, the impurity detection is completed after image filtering, image segmentation and edge detection.

1. Research background and significance
With the development of economy, people pay more and more attention to the health of diet, and the content of impurities in flour directly determines the quality of flour, which is highly valued by manufacturers and consumers. However, the traditional detection methods are mostly manual and simple physical ones. In this way, the detection accuracy is not high, resulting in excessive flour impurities and other quality problems.

With the rapid development of computer system and related hardware, the detection accuracy is much higher than the traditional manual physical detection, so the detection of impurities through the computer image processing system can not only reduce the labor cost, but also improve the detection accuracy.

2. Image preprocessing
Images are usually obtained by taking pictures, so it is possible to miss some places by simply using traditional visual observation for unclear points. Before using the computer to process the image, the image should be strengthened. The purpose of doing so is to improve the image quality and facilitate subsequent processing. Image enhancement processing uses image graying, local entropy transformation and other related technologies[1].

2.1. Introduction to Digital Image
When a computer processes an image, it converts the image signal into a digital signal. Generally, the image is two-dimensional and the function f= (x, y) can be used. The x and y here represent the coordinate position in the two-dimensional array, and the function value represents the pixel value at a certain point. The image is discretized into digital image which can be processed by computer. A
matrix can be used to represent the specific pixel values of each point. This is shown in the formula below[2].

\[
f(x, y) = \begin{bmatrix}
    f(0,0) & f(0,1) & \cdots & f(0,m-1) \\
    f(1,0) & f(1,1) & \cdots & f(1,m-1) \\
    \vdots & \vdots & \ddots & \vdots \\
    f(n-1,0) & f(n-1,1) & \cdots & f(n-1,m-1)
\end{bmatrix}
\]

(1)

In order to clarify the above problems, the relevant data in this experiment were used for elaboration. The experimental data are shown in the table below. For example, \( f(4, 3) = 193 \) means that the pixel value at the pixel point \( (4, 3) \) is 193.

| x | y | 1  | 2  | 3  |
|---|---|----|----|----|
| 1 |   | 193| 192| 192|
| 2 |   | 192| 192| 193|
| 3 |   | 192| 192| 193|
| 4 |   | 194| 194| 193|

2.2. Image graying

After the completion of image acquisition, put in the MATLAB directory, and according to the path to find the load, and then the image grayscale processing. The so-called image graying is obtained by changing the gray value of the pixel by changing certain rules of the image. Since the acquired images are usually color images, it is necessary to grayscale them. Color images are composed of red, green, and blue. So it can be expressed as \((0,0,0)\) to \((255,255,255)\), where the former represents pure black and the latter pure white. The purpose of image graying is to make the light and shade of the image become the main information. So as to improve the detection accuracy. Generally speaking, there are three commonly used schemes for image gray change: the maximum method, the average method, and the weighted average method. Here are three formulas for specific algorithms[3].

\[
R_t = R_r = R_b = \max(R, G, B)
\]

(2)

\[
R_t = R_r = R_b = \frac{R + G + B}{3}
\]

(3)

\[
R_t = R_r = R_b = R \times 0.3 + G \times 0.59 + B \times 0.11
\]

(4)

This paper adopts the method of maximum value to change the gray level of the image. The reason is that a gray level image with maximum brightness can be obtained, which is more convenient for image observation and processing.
2.3. The gray entropy of the image

Entropy is a measure of the uncertainty of an event, and its value can effectively reflect the information contained in the event. Generally, the higher the entropy value is, the greater the disorder degree will be; otherwise, the smaller the disorder degree will be[4]. In image processing, the local entropy is defined according to the orderliness of the distribution of every pixel. This value reflects the richness of the image information. The entropy of an image of size \( M \times N \) is defined as follows:

\[
H = -\sum_{i=1}^{M} \sum_{j=1}^{N} P_{ij} \log P_{ij}
\]  

(5)

\[
P_{ij} = f_{ij} \left( \sum_{i=1}^{M} \sum_{j=1}^{N} f_{ij} \right)^{-1}
\]

(6)

Where, \( P_{ij} \) represents the distribution probability of point \((i, j)\), \( f_{ij} \) represents the pixel value of the midpoint \((i, j)\), \( M \times N \) is a field window centered on point \((i, j)\), and \( H \) represents the local entropy value of the field window[5].

Image gray entropy reflects the degree of pixel gray level difference, the flour in the image as a result of the existence of impurities spots, so there are big differences between the gray levels of pixels, calculated according to the difference area of gray entropy value is smaller, the greater the image the stronger the degree of chaos, and entropy value, the greater the has reflected the gray level of the region is relatively uniform. For the image of flour impurities, the background gray distribution is uniform or the fluctuation between them is small, and the entropy value can be regarded as approximately equal[6]. However, for the impurities in the flour image, its gray distribution is not uniform, and it jumps compared with the gray distribution of the background image, so the entropy value obtained also changes.

In general, entropy is calculated for an image of size \( W \times L \). First take a small window, generally take the rectangle with the same length and width. The current pixel is the center, the probability of the point in this window is calculated first, then the probability is substituted into the calculation formula of gray entropy, and the gray entropy value of each pixel is calculated in the image in turn. Then, the obtained grayscale entropy value is mapped to the \([0,255]\) image grayscale space in a certain range and reverse-color processing is carried out to obtain the entropy image. The result is an inverted, enhanced image. Compared with the previous image, the picture of entropy value of flour bran becomes clearer and brighter. The entropy value image obtained by MATLAB simulation is as follows:
2.4. Image filtering
In the process of image transmission and processing, noise interference may occur to a certain extent, which will affect the processing and observation of images and ultimately affect the detection results. In order to improve the detection accuracy and reduce noise pollution, filtering measures should be taken. The commonly used methods are median filtering, mean filtering and so on. The median filter is adopted in this paper. In MATLAB, the medfilt () function is used for filtering[7]. The resulting image is shown in the following figure.

It can be seen that the filtered image can effectively remove noise more clearly.

3. Image recognition and marking
Image is one of the most important technical template computer visual identification, is the key of image processing to analysis, on the one hand, it is the foundation of target expression, has important influence to the specific measure, on the other hand, the expression of the goal of image segmentation and image segmentation, feature extraction and the parameter measurement and convert the original image into mathematical expressions, makes the analysis and understanding of image.

3.1. Threshold segmentation
The target expression, feature extraction and parameter measurement of image segmentation and image segmentation transform the original image into mathematical expression, which makes it possible to analyze and understand the image. Since the value of grayscale image is a number between [0, 255], the so-called threshold segmentation is to determine a threshold value and compare the gray value with this number to determine the relevant background and target. A threshold value T is set, and the value within the gray range is set as f(x, y). After processing, there are only black and white colors[8]. After the calculation of gray entropy, the expression is as follows:

$$f(i, j) = \begin{cases} 255, & f(i, j) > T \\ 0, & f(i, j) \leq T \end{cases}$$  \hspace{1cm} (7)
The methods of threshold segmentation include single threshold segmentation and multi-threshold segmentation. MATLAB was used for simulation. The display threshold of query related data is set at about 95. The image after threshold segmentation is as follows:

![Threshold segmentation image](image)

Figure 4. Threshold segmentation image

The distribution of impurities can be clearly seen.

3.2. Edge detection

Image edge detection is also a kind of threshold segmentation, mainly according to the target and background, the image is divided into black and white two parts, the visual difference is that the edge detection is only on the edge of the bran star spot segmentation. The function is to extract some important feature information (texture, shape) in the image and analyze it. From a mathematical perspective, the points on the image are generally extreme points or discontinuity points, and the edge detection is generally expressed by the first derivative and the second derivative[9]. The maximum value of the first derivative represents the edge position, and the second derivative through the origin represents the edge position, as shown in the following table:

| (1) The gray value of the image changes | (2) First derivative peak | (3) The second derivative crosses zero |
|----------------------------------------|--------------------------|---------------------------------------|
| [Graph of function curve]              | [Graph of first derivative peak] | [Graph of second derivative crosses zero] |

This paper uses Sobel operator to achieve. Sobel operator is a first-order derivative detection operator, which has two horizontal and vertical 3×3 templates. It USES the template and each pixel of the image to do convolution sum operation, and finds out the appropriate threshold, so as to detect the image edge. Its calculation formula is as follows:

\[ s_x = 1 \times Z, s_y = 2 \times Z \]  

(8)

| Table 3. Horizontal and vertical templates |
|-------------------------------------------|
| -1 0 1 1 2 1                             |
| -2 0 2 0 0 0                            |

5
The gradient amplitude of Sobel operator is:

\[ M = \left( s_x^2 + s_y^2 \right)^{1/2} \]  \hfill (9)

Calculation formula of gradient direction:

\[ \alpha = \arctan\left( \frac{s_y}{s_x} \right) \]  \hfill (10)

Where, \( s_x \) represents the image of horizontal edge detection, \( s_y \) represents the image of vertical detection, and \( Z \) represents the original image. An \( \alpha \) angle of 0 indicates that there is a vertical edge, with the left side darker than the right side. Since there is a function edge of Sobel operator in the toolbox of MATLAB, we can directly use the function to detect its edge[10]. The renderings are as follows:

![Figure 5. Image after edge detection](image)

3.3. **Flour impurity mark**

Flour impurities tag occupies important role in the study of undergraduate course topic, although after segmentation image you can see, flour image points, there are a lot more obvious impurities it is only through naked eye out image binarization, want of impurities were identified through the original image, from the impurities to flour image points, some characteristics of flour impurities to extract relevant information. After some series of processing, in order to facilitate the observation of impurities in flour, the picture can be circled and processed with matlab-related toolkits to obtain the final detection picture:

![Figure 6. Final renderings](image)
4. Conclusion
The flour impurity detection system based on image processing designed in this paper is faster and more accurate than the traditional detection method. Through image graying, local entropy transformation, edge detection and other steps, the flour impurities will finally be detected and marked. These systems can also be extended to other related detection scenarios. Finally, relevant tests shall be made on whether the products are qualified.

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