

Low-temperature sausage measurement method based on machine vision

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The adaptive contour extraction of low-temperature sausage image is achieved by the predictive edge detection algorithm according to the human eye's visual characteristics, and the fitting compensation skeleton extraction algorithm is used to extract the skeleton information, and the accurate length of the low-temperature sausage is obtained by the distortion correction method. Experiment results show that the methods presented in this paper can achieve automatic measurement of the length of the low-temperature sausage's casing.

Keywords: edge detection; distortion correction; automatic measurement.

1. Introduction

In recent years, corn hot dogs won the majority of consumers, it is produced by edible pig casing as the first layer of the wrapper, since the pig casings are natural casings, after filling and sterilization processing, there will be greater product shape and bending deformation, resulting that the pig casings yield is uncertain while the yield is an important factor to measure the pig casing price.

Therefore, to solve business problems of pig casing reasonably priced, the urgent need for corn hot dog casings is automatic measurement and defect detection system to achieve accurate measurement of the effective length of the finished product, and accurately obtain each batch of finished casing length by means of statistical analysis, such casings pricing system can achieve transparent price and truly pricing according to quality.

The measurement accuracy requirement of corn hot dog is 3mm, and the detection speed is 3 pieces per second. In order to achieve statistical

measurement casing length, low-temperature sausage effective length measurement methods is discussed in this paper.

2. Segmentation and edge detection algorithm

The first step of image processing is the segmentation of the target, and the target image feature extraction is achieved, such as contour, texture, circumscribed rectangle, and other characteristics etc. According to the features, the target measurement and defect recognition are achieved. Location and segmentation algorithm are the basis of subsequent body measurements and defect recognition. The segmentation is the basis of object expression, and has important implications for measuring characteristics. After the original image is converted by the segmentation algorithm, the identification of the image is possible[1].

The measurement system working process is conducted as following steps.

Step1: Capture the sausage image.

Step2: Adaptive threshold coarse segmentation by the projection of main color.

Step3: Edge detection by the prediction method.

Step4: Skeleton extraction by fitting compensation.

Step5: Skeleton length measurement.

2.1. Coarse segmentation based on main body color projection

In general, when human beings are viewing an image, they are good at grasping the interior of the main color[2]. Colors of sausage outer casing are composed of several main color and auxiliary color. Main colors occupy the most sausage images pixels, so color quantization should be carried out.

According to the color quantization method proposed in citation[2], quantified hue histogram of sausage image can be obtained, the colors are sorted in descending order by the number of each pixel containing, the maximum color is chosen as the main color, a binary image treatment results can be obtained by the main color. Then according to the main color binary image projection data analysis, the threshold is selected by the projection of the main color of sausage continuous presence characteristics, and the occupied sausage area can be quickly determined as further segmentation and feature extraction treated area, by this way, reducing the amount of computation to improve the real-time can be achieved.

2.2. Prediction edge detection based on human visual characteristics

In this paper, edge detection is carried out by the prediction edge detection algorithm. The basic principle of the algorithm is that an edge pixel is the result of discontinuous gray level, there must be an edge between the distinct gray levels. The edge pixel can be detected by calculating the mean of the current pixel and the first two pixels and the gradient, and the next pixel's gray value can be predicted, if the gray value falls below the specified range, the next pixel is considered belong to the same gray level, and it is not the boundary points, if not within the scope of the provisions, the pixel is considered to be in a different gray levels and the pixel may be an edge[3]. Compared with the traditional differential edge detection algorithms, the algorithm has a large advantage on the real-time on the condition of meeting the detecting premise requirements.

In the building process of the visual system, different types of lighting mode are tried, and the camera's exposure time are also observed by the designer through image forming compliance testing requirements, the features of the measured object contour should be more prominent, so the visual characteristics of the human eye plays an important role in defining the vision system lighting and camera imaging process.

The human visual system is less sensitive to noise in bright area and structured region or edge. The same gray-level differences in different regions are considered to be edge or not. In the white area, the human eye resolution about gray is the lowest, followed by the black area, and then the gray level region about 127. The human eye is more sensitive to gray level region about 48 and 206, so the sensitivity of the human eye is not as gray value varies linearly. Based on the visual characteristics of the human eye, different decision threshold t is set according to different sensitive areas. The edge of the main image sausage for monochrome casing can be detected by this method with high segmentation accuracy and computational efficiency.

3. Length measurement algorithm based on skeleton extraction

Due to the irregular deformation of corn hot dog's nature casing, the skeleton length of the corn hot dog is measured as the actual length by the measurement method.

3.1. Skeleton extraction

Skeleton extraction algorithm can be simplified as a region, and is a kind of important structural shape representation. The refinement technique is axis transformation which can be described as follows: B is the edge of area R , if the

point P in R can be found on B more than one nearest neighbor, then P is belong to the skeleton of R[4].The above description is a schematic skeleton extraction.

3.2. Fitting Compensation skeleton

As can be seen in Fig.1(a), the length and shape of the body portion of the sausage is clearly exhibited by the skeleton, and it is very favorable for the calculation of the length of sausage. Due to the inherent flaw of the skeleton principle, for a slimmer body, more information are shown by the skeleton, for the thick and short body, the less information are shown by the skeleton. For the inherent flaw, the skeleton points of sausage at both ends of skeleton region are difficult to get, the skeleton should be fit for further compensation.

By the analysis of the sausage's shape, the casing end points are generally corresponding to the contour points from the farthest end of the skeleton. The fitting process can be carried out in accordance with the following steps.

Step1: Select skeleton endpoint D and a point K as the control point which distance to the end point is L.

Step2: Determining a straight line M from the two control points.

Step3: For the line between control point P in the sausage's edge and D, if the angle with M is within a certain range, the point P may be a candidate point

Step4: Select the farthest candidate point from the end point as the final endpoint of skeleton.

Skeleton fitting compensation result is shown as Fig.1(b).

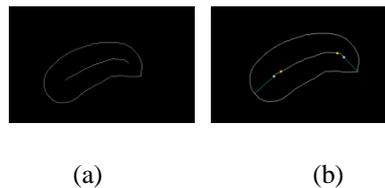


Fig. 1. Skeleton fitting compensation result

3.3. Skeleton length measurement

Because the imaging system inevitably involves distortion, a certain influence about measurement accuracy is inevitable. Therefore, skeleton point coordinate should be corrected before the measurement. The system resource of the skeleton point calibration is far less than the whole image calibration. Considering real-time and accuracy, dual homogeneous polynomial method is adopt about the skeleton coordinate correction. The skeleton coordinates before correction is (u, v) , the corrected coordinates is (x, y) , then there is Eq. (1).

$$\begin{cases} x = \sum_{i=0}^n \sum_{j=0}^{n-i} a_{i,j} u^i v^j \\ y = \sum_{i=0}^n \sum_{j=0}^{n-i} b_{i,j} u^i v^j \end{cases} \quad (1)$$

After correction for distortion, a new skeleton distance between the points and the adjacent pixel coordinates is obtained as the sum of the length of the skeleton. According to the proportion of 0.4mm / pixel, the actual length value is measured.

4. Measurement results

According to the proposed length measurement method, we collected a lot of sausage images, the length measured by machine vision and the actual measured data were compared by Table. 1. Experimental results show that the method meets the length measurement accuracy requirement. The original sausage images are shown in Fig.2 , and the final skeleton sausage images for measurement are shown in Fig. 3.

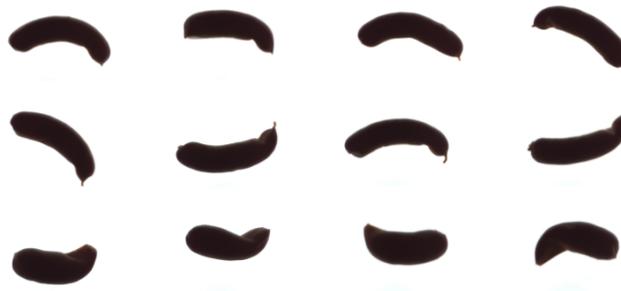


Fig. 2. The original sausage image

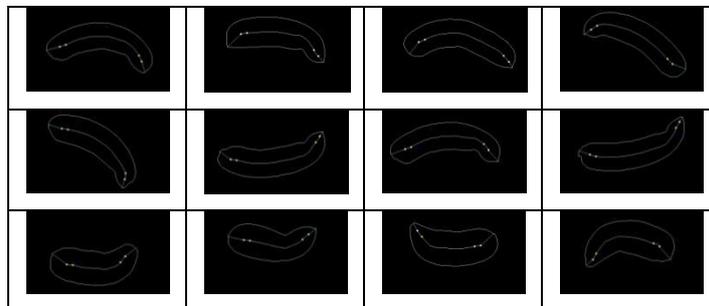


Fig. 3. The final skeleton sausage image for measurement

Table 1. Length measurement compared results

No.	Actural Length(mm)	Measured Length(mm)	Difference (mm)	No.	Actural Length(mm)	Measured length (mm)	Difference (mm)
1	90.4	92	1.6	7	90.9	92.5	1.6
2	82.2	83.9	1.7	8	94.5	93.9	-0.6
3	93	94.3	1.3	9	73.4	75	1.6
4	86	85.4	-0.6	10	73.1	74.6	1.5
5	85.3	87.1	1.8	11	75.8	75.6	-0.2
6	89.7	91	1.3	12	74.4	76	1.6

5. Conclusion

In this paper, casing length measurement scheme based on machine vision for irregular corn hot dog sausage is proposed, The adaptive threshold segmentation and edge detection method based on prediction are adopt in the scheme. After the extracting, fitting and correction of the skeleton, the length of corn hot dog casing is accurately measured. The real time and detection accuracy reach the design requirements.

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