Positioning and Tilt Correction of Milk Production Date Based on Mathematical Morphology

Fei Lei¹, Kang Sun¹, Kang Sun¹, b and Xueli Wang¹
¹Beijing University of Technology, Beijing, China
²myislj@126.com; bskang0502@163.com

Abstract: Milk is one of the most common drinks in people’s lives. Its quality is related to people’s health and safety. Therefore, food regulatory authorities and milk manufacturers are increasingly strict with milk. The production date on the packaging is an important part of milk testing. One. Aiming at the problems of long time and high cost of manual detection, this paper proposes a method based on mathematical morphology for milk production date location and tilt correction based on computer vision related technology. The method firstly preprocesses the collected milk image, then uses the mathematical morphology method to obtain the candidate region of the milk production date, then analyzes the candidate region, extracts the accurate milk production date region, and finally uses the least squares principle. The straight line is fitted to calculate the tilt angle of the milk production date, and the milk image is tilt corrected using the rotation formula. In order to verify the comparison with the Hough transform method, the experiment proves that the proposed method can accurately predict the milk production date and tilt correction.

1. Introduction
With the development of social economy, the dairy industry has become an important part of China’s modern agriculture and food industry, and the variety of dairy products represented by milk has become an indispensable food in the daily life of Chinese people.

Therefore, the requirements of the national food regulatory authorities and manufacturers for the detection of milk have become more and more strict. The visual identification and analysis of the milk packaging production date is one of the important means of milk detection. As a kind of computer vision, visual inspection is used in milk production date character recognition [1], which can effectively improve production efficiency and reduce defective rate. It is of great significance in terms of efficiency and reliability of milk production date detection. Therefore, this paper combines advanced computer pattern recognition and digital image processing technology and other related theoretical knowledge, combined with mathematical morphology edge detection to have the ability to suppress noise and facilitate regional extraction. Based on the analysis of connected regions, a mathematics-based approach is proposed. Morphology and regional analysis of milk production date localization method, and the disadvantages of computational complexity and poor stability of Hough transform. This paper proposes to use the least squares principle to fit the straight line to calculate the milk production date tilt angle, and finally use bilinear interpolation. The milk image is rotated for correction.

2. Positioning of milk production date
2.1. Pretreatment of milk image
In the process of collecting milk, the image quality is degraded due to illumination changes, printer vibration and other factors, which is not conducive to accurate positioning of production date. In order to improve the image quality and improve the accuracy of milk production date positioning, it is necessary to pre-process the milk image.

2.1.1. Grayscale. The process of converting a color image into a grayscale image is the grayscale of the image. A color image refers to an image in which each pixel is composed of red, green, and blue, where R, G, and B are described by different gray levels. A grayscale image refers to an image in which each pixel is described by one quantized gradation. There are many methods for graying out color images. In this paper, the milk image is grayed out according to formula 1.

\[ G = 0.299R + 0.587G + 0.114B \]  

The result of the grayscale processing is shown in Figure 1.

2.1.2. Binarization. In order to improve the accuracy of milk production date positioning and recognition, the target and background should be separated, so that the entire image shows a clear black and white visual effect. The process of transforming a grayscale image into a binary image is the binarization process of the image. In this paper, the Otsu algorithm is used to binarize the image [2].

2.1.3. Edge detection. Edge detection is a method of highlighting the edges of an image, weakening the image area outside the edge, and highlighting the outline of the image. It can greatly reduce the amount of processed data while preserving the useful structural information about the boundary of the object, thus simplifying the analysis process of the image [3].

Commonly used edge detection operators are: the Roberts edge operator [4], Prewitt edge operator [4] and Sobel edge operator [4].

The Roberts edge operator is an operator that uses the local difference operator to find the edge. The edge of the processed image is not very smooth. The Prewitt edge operator uses the gray level difference between the pixel points up and down and the left and right adjacent points. The extreme value detection edge is reached at the edge; the Sobel operator is improved based on the Prewitt operator, and the 4-neighbor domain is weighted to calculate the difference. There are two Sobel operators that detect horizontal and vertical edges, respectively. This operator introduces a similar local average operation, which can suppress the noise well and is better than the Prewitt operator and the Roberts operator.

Therefore, this paper uses the Sobel operator to convolve each pixel in the image. The Sobel operator uses a directional template for convolution to add edge features in one direction. The Sobel operators in different directions are shown in Figure 2.

\[ G_x = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix} \quad G_y = \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix} \]

Figure 2. Horizontal and vertical templates for Sobel edge operators
The effect after the Sobel operator detection is shown in Figure 3. It can be seen from the figure that the contour information of the milk production date area can be well preserved after the Sobel operator edge detection.

![Figure 3. Results of Sobel edge operator processing](image)

2.2. Morphological processing

Mathematical morphology is currently a commonly used subject of image processing and analysis [5]. Its principle is to use a certain structural element to measure and extract the corresponding shape in the image to satisfy the analysis and recognition of the image. Mathematical morphology algorithms can improve the speed of image analysis and processing. Its basic operations are four, namely: expansion, corrosion, open and closed operations.

Dilation: The structural element $B$ is translated to the $x$ to obtain $B_x$. If $B_x$ and $A$ are not empty, then the $x$ is recorded. All the sets of $x$ satisfying the above conditions are called the result of the dilation of $A$ by $B$. Expressed as:

$$D(A) = \{x \mid (B_x \cap A) \neq \emptyset\} = A \oplus B$$

Erosion: can be regarded as an expanded dual operation, that is, the structural element $B$ is translated to the $x$ to obtain $B_x$. If $B_x$ is included in $A$, the $x$ is recorded, and all the sets of $x$ satisfying the above conditions are called the result of $A$ being erosion by $B$. Expressed as:

$$E(A) = \{x \mid B_x \subseteq A\} = A \ominus B$$

Opening: $A$ is first eroded by $B$ and then dilated to be called $A$ is opened by $B$. Expressed as:

$$O(A) = D(E(A)) = (A \ominus B) \oplus B$$

Closing: $A$ is first dilated by $B$ and then eroded is called $A$ is closed by $B$. Expressed as:

$$C(A) = E(D(A)) = (A \oplus B) \ominus B$$

In this paper, the milk image after edge detection is first closed, that is, the milk image is first expanded, the production date is filled into a connected area, and then the etching operation filters out some smaller areas. Then the milk image is opened. Through the previous closing operation, although the image basically conforms to the production date area, the image leaves a part of the thin line, first performs the etching operation, filters it out, and then expands to restore the size of the connected area. Smooth the image. After the above treatment, most of the interference area is removed, and the rest may be the milk production date area. The processed image is shown in Figure 4.

![Figure 4. Morphological processing results](image)

2.3. Analysis of connected areas

After the previous step, multiple candidate areas for milk production date are obtained, which need to be analyzed and the parameters of different areas are compared to locate the milk production date area. Specifically, it is based on the method of positioning such as license plate [6-8]. Firstly, the height and
width of the minimum circumscribed rectangle of each candidate area are obtained, and then the height, width and aspect ratio of the production date area are within a certain range. Geometric features to get the real milk production date area.

The algorithm for extracting the milk production date region based on the region analysis is as follows:

- Marking each candidate area in the image;
- Successively scanning the marked candidate domains to obtain the height, width and coordinate values of the minimum circumscribed rectangle of each marked area;
- Using the nature of the milk production date is a fixed value, combined with the height of the milk production date, extracts the milk production date area.

The height and width of the same milk production date area in China are fixed. For example, the milk production date used in this experiment is 4 mm in height, 19 mm in width and about 4.75 in aspect ratio. Because of the possibility of tilting, etc., after experiment, the aspect ratio threshold interval of the milk production date area is [4, 5], and the candidate areas that do not satisfy this condition are eliminated during the analysis. At the same time, considering the single condition judgment error, this paper selects the milk production date height as the second judgment condition. After two screenings, the area that satisfies the aspect ratio and height conditions is the real milk production date area. The extracted milk production date area is shown in Figure 5.

![Figure 5. Milk production date positioning results](image)

### 3. Tilt correction

The image after the milk production date is positioned may be skewed, and the character segmentation may be directly performed, which may result in inaccurate segmentation results and affect subsequent recognition operations. Therefore, it is necessary to perform a tilt correction process on the milk production date.

#### 3.1. Calculate the tilt angle

Let the coordinates of the vertical edge points of the milk production date area be \((x_i, y_i) (i = 1, 2, \ldots, n)\), where \(n\) is the number of vertical edge points, and the principle of least squares fits the set of data with a smooth curve \(y = f(x)\) and makes the curve has the smallest sum of squared deviations from all vertical edges, and the curve reflects the tilt direction of the production date [8].

Let the linear exponential equation be:

\[
y = ax + b
\]  

(6)

In the above formula, \(a\) represents the slope and \(b\) represents the intercept. For each \(x\), there are two corresponding \(y\), one is the measured value \(y_i\) and the other is the value \(y_i'\) obtained by fitting the equation. The difference between the measured value \(y_i\) and the fitted value \(y_i'\) is recorded as a deviation:

\[
\delta_i = y_i - y_i'
\]  

(7)

The principle of the least squares method described above is to find the minimum value of the sum of the squares of the deviations, to find the value of \(\min(\delta_i^2)\), and the definition is:

\[
\phi = \sum_{i=1}^{n} \delta_i^2 = \sum_{i=1}^{n} (y_i - ax_i - b)^2
\]  

(8)

It can be seen from Equation 8 that the value of \(a\) and \(b\) when the demand \(\phi\) takes the minimum
value. First, let the first-order partial derivative of \( \phi \) for \( a \) and \( b \) be equal to 0; then find the second-order partial derivative of \( \phi \) for \( a \) and \( b \). When the second-order partial derivative is greater than 0, the obtained values of \( a \) and \( b \) can make the square of the error. The smallest, get:

\[
\begin{align*}
\frac{n \sum_{i=1}^{n} x_i y_i - (\sum_{i=1}^{n} x_i)(\sum_{i=1}^{n} y_i)}{n \sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2} & = a \\
\frac{\sum_{i=1}^{n} x_i^2 y_i - (\sum_{i=1}^{n} y_i)(\sum_{i=1}^{n} x_i)}{n \sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2} & = b
\end{align*}
\]

(9)

Therefore, the inclination \( \alpha \) of the characteristic line is:

\[
\alpha = \arctan(a)
\]

(10)

In this way, to calculate the inclination, the inclination can be calculated simply by multiplying the coordinates of the vertical edge points by simple multiplication and summation.

After obtaining the \( \alpha \), it is only necessary to rotate the picture according to the rotation formula. The tilt correction matrix is of the form:

\[
\begin{bmatrix}
\cos \alpha & -\sin \alpha & 0 \\
\sin \alpha & \cos \alpha & 0 \\
0 & 0 & 1
\end{bmatrix}
\]

(11)

Where \( X \) and \( Y \) represent the \( x \) and \( y \) coordinate matrices of the oblique image, respectively, representing the \( x \) and \( y \) coordinate matrices of the corrected image, respectively.

3.2. Milk production date correction

The tilt milk production date correction is divided into horizontal direction correction and vertical direction correction. According to the method of the above section, the inclination angle \( \alpha \) in the horizontal direction of the milk production date and the inclination angle \( \beta \) in the vertical direction are respectively calculated.

The bidirectional interpolation method is used to correct the horizontal tilt. If \( \alpha > 0 \), the clockwise rotation is performed. Otherwise, the transposition is performed to obtain the corrected image.

For vertical tilt correction, it is necessary to shift the pixel offset between the same line to determine the coordinate point of the corrected pixel. The specific formula is as follows:

\[
y_{\text{new}} = y + (x + 1)\tan \beta, \beta > 0
\]

(12)

\[
y_{\text{new}} = y + (h - x)\tan \beta, \beta < 0
\]

(13)

After the corrected pixel point coordinates are calculated, the grey value is calculated by bilinear interpolation.

4. Experimental results and analysis

In this experiment, we not only used this method for the tilt correction of milk production date image, but also realized the Hough transform method for milk production date image tilt correction. The tilt correction results of the two methods are shown in Figure 6.

![20170521](a) Tilt image (b) Hough transform corrected image (c) Least squares corrected image

**Figure 6.** Tilt corrected contrast image

The milk image containing the date of manufacture produced by the random manufacturer of the pixel was tested, and the accuracy and running time of the least square method and Hough transform in calculating the inclination angle were analysed in matlab7.11. The specific analysis results are shown in Table 1.
Table 1. Algorithm comparison

|                | Correct rate (%) | Time (s) |
|----------------|------------------|----------|
| Hough          | 83.3             | 0.2934   |
| LSM            | 96.7             | 0.0643   |

The experimental results show that the accuracy and speed of the calculation of the milk production date tilt angle by the least squares method are better than the Hough transform.

5. Conclusion
In this paper, a method based on mathematical morphology for milk production date location and tilt correction is designed. Firstly, the milk production date candidate area is obtained by edge detection and mathematical morphology processing. Then, the milk production date aspect ratio analysis is used to remove the interference. The connected domain is tilt corrected for the milk production date by fitting the line based on the least squares method. The experimental results show that the positioning and tilt correction method is simple, fast and accurate, which can lay a good foundation for the next step of milk production date segmentation and recognition.

References
[1] Ni C X. A review of computer vision research [J]. Electronic world, 2018(01):91+93.
[2] Chen S. Binary Image of License Plate Image Based on Otsu Algorithm and Its Matlab Realization [J]. Journal of Changchun Teachers College, 2012, 31(03):33-35.
[3] Wei W B, Rui X T. Research on Image Edge Detection Method [J]. Computer Engineering and Applications, 2006(30):88-91.
[4] Guan H R, Ding H. A Survey of Edge Detection in Image Processing [J]. Journal of Capital Normal University (Natural Science Edition), 2009, 30(S1):66-69.
[5] He D J, Geng N and Zhang Y K. Digital image processing [M]. Xi’an University of Electronic Science and Technology Press, Xi’an, 2008.
[6] Chen L, Chen W. Method for license plate location and tilt correction based on mathematical morphology [J]. Science & Technology Vision, 2015(23):10+50.
[7] Wang Y. A Mathematical Morphology Based on Algorithm for Elevator Registration Number Locating Process [J]. China elevator, 2018, 29(08):42-46.
[8] Xue D. Research the algorithms of license plate location and slant correction under the complicated conditions [D]. Zhengzhou University, 2013.