Tobacco box character sticker extraction technology based on machine vision

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Abstract: With the introduction of the smart factory, the tobacco industry is facing an upgrade in the way of reading and verifying the package number in the process of material entry and exit. This paper proposes a method based on mechine vision to extract and recognize the characters on the surface of the tobacco box during the in and out of the warehouse. The proposed method uses image processing algorithms to perform a series of processing on the tobacco box image. Firstly, the target box and the background area are completely separated. Then the character printing type on the surface of the box is recognized, using vertex fitting and correction algorithm for complex distorted images, as well as overlapping sticker segmentation algorithms. The proposed method can efficiently locate and extract various different types of character regions from the tobacco package image to provide precise character lines for subsequent character recognition.

1. Introduction

In recent years, major economies around the world have vigorously promoted the revival of manufacturing. Under the upsurge of Industry 4.0, Industrial Internet, Internet of Things, and Cloud Computing, many excellent manufacturing companies around the world have carried out smart factory construction practices.

Currently, our country's manufacturing enterprises are facing tremendous pressure for transformation. On the one hand, factors such as the rapid increase in labor costs, overcapacity, fierce competition, and increasing individual needs of customers have forced manufacturing companies to shift from low-cost competition strategies to establishing differentiated competitive advantages. At the factory level, manufacturing companies are facing tremendous pressure from recruitment difficulties and lack of professional technicians. They must reduce staff and increase efficiency, and there is an urgent need to promote the construction of smart factories. On the other hand, emerging technologies such as the Internet of Things, collaborative robots, additive manufacturing, predictive maintenance, and machine vision have sprung up rapidly, which provided good technical support for manufacturing companies to promote the construction of smart factories. Coupled with the strong support of the state and local governments, more and more large and medium-sized enterprises in various industries have started the journey of smart factory construction.

The transportation of material resources, as one of the important links in the production of tobacco factories, also urgently needs adjustments in technological upgrading. During the transportation of materials in and out of the warehouse, there are two batch number marking methods on the surface of the tobacco leaf packaging box:

1) Pasting the barcode which can be read by a scanning device at a fixed position on the surface of the box

2) Pasting the sticker with the character number or printing the character number directly on the surface of the box.

In the traditional transportation link, there is only one way of barcode recognition to quickly identify the code of the packaging box. Verifying the correctness of the barcode only relies on manual spot checks to compare with the printed characters on the surface of the packaging box. A large number of manual operations lead to low efficiency, and the accuracy of the comparison cannot be guaranteed.

Therefore, a chatacter recognition algorithm for stickers on tobacoo boxes based on machine vision is proposed to quickly and accurately identify whether the bar code matches the box number, which can significantly improve the efficiency of the tobacco box in and out of the warehouse and reduce the potential risks of material allocation errors in the subsequent production process.

The overall machine vision system includes the image capture device and image processing system. The image capture device converts the optical signal of the captured target into an image signal, which is transmitted to a dedicated image processing system, where the image signal is converted into a digital signal according to the pixel distribution, width, color and other information. Then the image system performs various operations on these signals, extracts the characteristics of the target, and finally controls the actions of the equipment on the spot based on the results of the discrimination.[3] The main goal of machine vision is to enable computers to recognize three-dimensional environmental information through two-dimensional images, as well as to perceive and process geometric information such as the shape, position, posture, and movement in the three-dimensional environment.

2. Extraction of the sticker character on the surface of the tobacco box

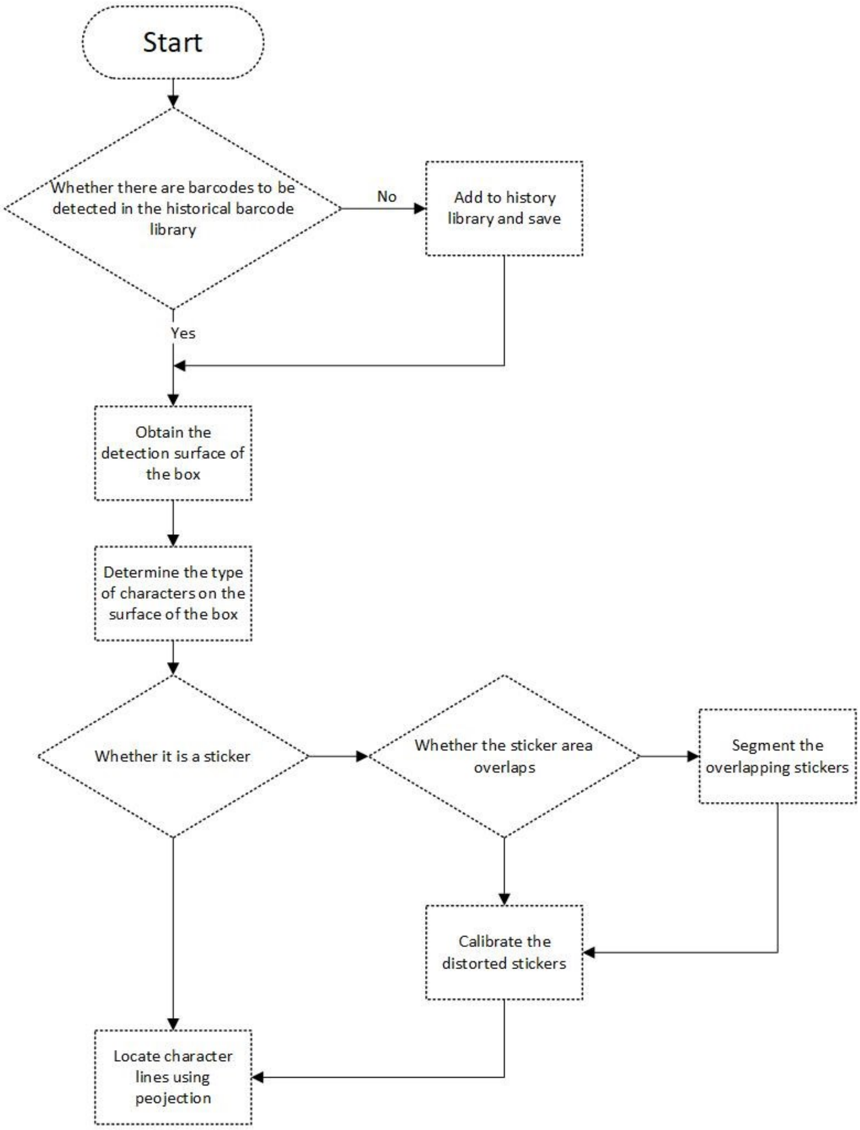

Figure 1 Character area extraction flow chart

The main difficulty in positioning the character area on the surface of the box is the extraction of the sticker area on the surface of the box. The difficulty of extracting the sticker area lies in the sticker image distortion caused by the randomness of the sticker position and the overlap of multiple sticker positions. In this paper, a special algorithm is proposed to calibrate the distortion of the stickers and segment the overlapping stickers of the tobacco boxes.

2.1 Extract region of interest

Figure 2 Original image

In order to highlight the color characteristics of the stickers, the HSV[1](Hue, Saturation, Value) color space is used, which is a color space created by A. R. Smith in 1978 based on the intuitive characteristics of color, also known as the Hexcone Model.

Hue: Hue is measured with an angle ranging from 0-360 degrees, counting from red in counterclockwise direction. 0° for red, 120° for green, and 240°for blue. Their complementary colors are: 60° for yellow, 180° for cyan, and 300° for magenta；

Saturation: Saturation indicates how close the color is to the spectral color. A color can be seen as the result of mixing a certain spectral color with white. Among them, the greater the proportion of the spectral color, the closer the color to the spectral color, and the higher the saturation of the color. With high saturation, the color is deep and brilliant. The white light component of the spectral color is 0, and the saturation reaches the peak. Usually the value range is 0%～100%, the larger the value, the more saturated the color.

Value: Value indicates the brightness of the color. For the color of the light source, the value is related to the brightness of the luminous body; for the color of an object, this value is related to the transmittance or reflectance of the object. Usually the value range is 0% (black) to 100% (white).

$$h = \begin{cases} 0^\circ & \text{if } max = min \\ 60^\circ \times \frac{g-b}{max-min} + 0^\circ, & \text{if } max = r \text{ and } g \geq b \\ 60^\circ \times \frac{g-b}{max-min} + 360^\circ, & \text{if } max = r \text{ and } g < b \\ 60^\circ \times \frac{b-r}{max-min} + 120^\circ, & \text{if } max = g \\ 60^\circ \times \frac{r-g}{max-min} + 240^\circ, & \text{if } max = b \end{cases}$$

$$s = \begin{cases} 0, & \text{if } max = 0 \\ \frac{max-min}{max} = 1 - \frac{min}{max}, & \text{otherwise} \end{cases}$$

$$v = max$$

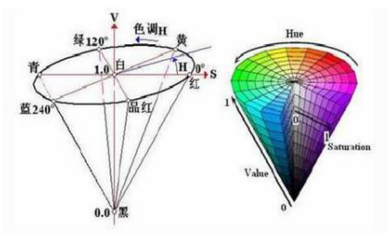

Figure 3a) HSV Calculation formula b) HSV Six Prism

Figure 1 HSVImage

The goal is to locate the detection surface of the tobacco box, and separate the region of interest (ROI) from the background. In the HSV color space, a special multi-channel gray value independent processing algorithm is used to segment the box and the possible character sticker area. Then the multi-channel image calculation is superimposed, and the image of the to-be-detected surface area of the packing box with the background removed is segmented.[2]

The main pseudo code for image processing is as follows

```
matThBox = threshold_Box(matSrc);    // Locates the box
matThLabel =threshold_Label(matSrc);    // Locates the sticker
matMultiply=matThBox + matThLabel;    // Image superposition:
matRoiBox = ExtractRoi(matMultiply);    // Extract ROI of the packaging box
```

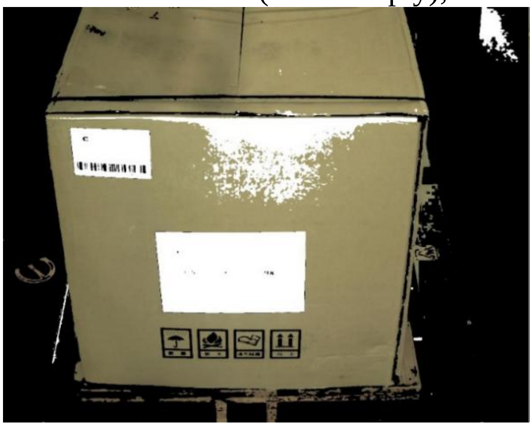

Figure 5 Multi-channel image overlay

Figure 6 Extracting box Images

2.2 Determine the type of characters

Due to the different origins of tobacco leaves used by tobacco factories, each production area has its own standards for the recognitionofthetobacco box number. Some products print the batch number directly on the surface of the packaging box, while others print the batch number on the sticker, and paste the sticker on the surface of the box。In the actual material entry and exit environment, the boxes with two different labeling methods are randomly transported on the production line, so special procedures are needed to classify the character types on the surface of the boxes.

This paper proposes a special feature confidence judgment method to classify the character types on the surface of the tobacco box. Firstly, a special algorithm is used to extract features of the sticker from the image of the tobacco box. Then the percentage of the surface of the tobacco box occupied by the sticker features is caculated. Finally, the type of characters on the surface of the tobacco box is classified by the specified percentage threshold.

Figure 7 a) Surface printed characters b) Surface sticker character

3. Special process for character stickers

3.1 Sticker image distortion correction

Due to the difference in the production area and the production process of the tobacco leaf, the number of some tobacco boxes is printed on the stickers, and the stickers are fixed on the surface of the packaging box by manual pasting. Therefore, the position and angle of the sticker are quite different. The more serious situation is that due to the limitation of manual pasting process, some stickers are not completely regular quadrilateral rectangles after pasting. Coupled with the influence of the installation angle of the shooting equipment itself, the sticker will produce relatively serious distortion in the final captured image. This paper specifically designs a corresponding calibration algorithm for the distorted sticker image.

First segment the original sticker area from the box surface image.

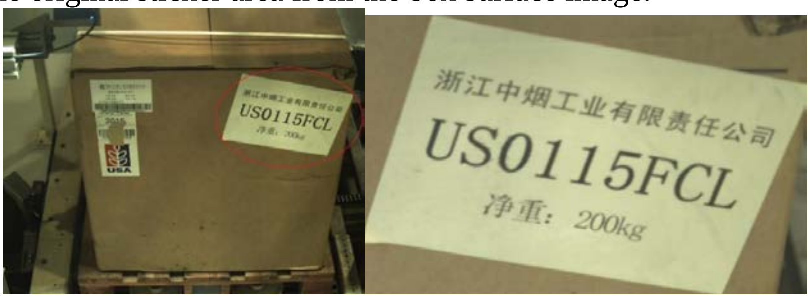

Figure 8 a) Distorted sticker Position b) Positioning distortion sticker

Find the contour of the sticker area and generate a set of vertices circumscribing the sticker contour (Pointpeak).

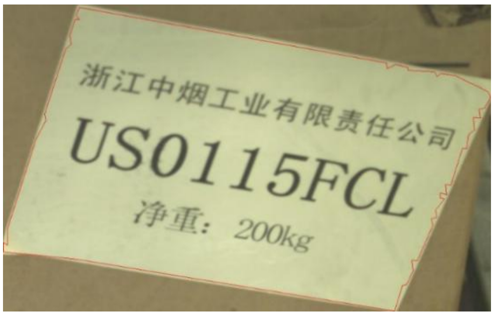

Figure 9 Sticker Outer Contour Polygon

Then use the virtual vertex fitting algorithm designed in this paper for the distorted image of the sticker to calculate the four virtual vertices of the sticker area.

Virtual vertex fitting algorithm:

Point set classification is performed on the polygon vertices(Pointpeak) circumscribing the sticker outline , and four sets of reference points are sifted out: PointLeft, PointRight, PointTop, and

PointButtom:

$$\begin{cases} \{Point\ Left\} = Point\ Classify(\{Point\ Peak\}) \\ \{Point\ Right\} = Point\ Classify(\{Point\ Peak\}) \\ \{Point\ Top\} = Point\ Classify(\{Point\ Peak\}) \\ \{Point\ Buttom\} = Point\ Classify(\{Point\ Peak\}) \end{cases}$$

Point set filtering is performed on the coordinates (x, y) of the four sets of reference points to calculate the virtual vertex matrix of the sticker area(matCorner):

$$\begin{bmatrix} (x_{LT}, y_{LT}) & (x_{RT}, y_{RT}) \\ (x_{LB}, y_{LB}) & (x_{RB}, y_{RB}) \end{bmatrix} =$$

$$Point\ CornerFilter\left(\begin{bmatrix} (\{Point\ Left\},\{Point\ Top\}) & (\{Point\ Right\},\{Point\ Top\}) \\ (\{Point\ Left\},\{Point\ Buttom\}) & (\{Point\ Right\},\{Point\ Buttom\}) \end{bmatrix}\right)$$

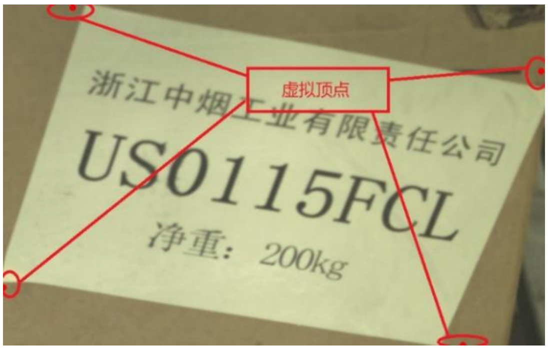

Figure 10 Virtual vertex

After obtaining the virtual vertex (matCorner), perspective transformation is used to correct the distorted sticker image.

According to the four pairs of pixel coordinates corresponding to the four virtual vertices (matCorner) and the given perspective transformation (regular rectangle), the perspective transformation matrix can be obtained, and the perspective transformation is used to correct the image.

Perspective transformation refers to the transformation which uses the three-point collinear condition of the perspective center, the image point, and the target point to rotate the projection surface (perspective surface) around the trace (perspective axis) by a certain angle according to the perspective rotation law, destroying the original projected light beams and still maintaining the projection geometry on the projection surface.

$$[x' \quad y' \quad w'] = [u \quad v \quad w] * \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

(u,v) is the original coordinate of image pixels, and(x=x'/w', y=y'/w') is the transformed coordinate.

The use of virtual vertices can effectively avoid the large offset of the pixels of the original vertices of the sticker image caused by image distortion; eliminate the abnormal reference points caused by the damage, warping, and irregular cutting of the sticker which affect the location; as well as correct the irregular shape of the sticker image due to process reasons.

After the distorted sticker is corrected, the projection method can be used to locate each complete character line area from the corrected image.

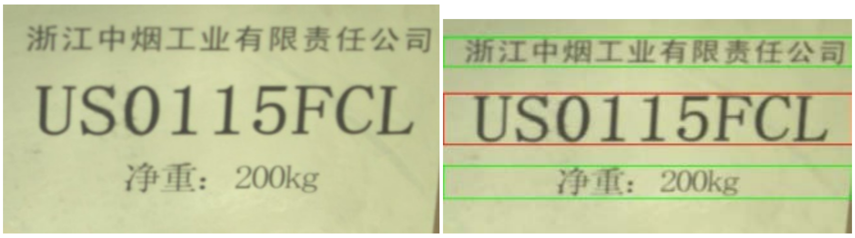

Figure 11 a) Corrected sticker image b) Positioning character lines

3.2 Overlapping sticker segmentation

Since the sticker on the surface of the box contains a variety of different contents, currently a variety of different stickers are often used for identification. On the surface of some boxes, stickers printed with box numbers will overlap with other stickers. This paper has designed a special area searching algorithm to locate the entire area of the overlapping stickers to ensure that the entire sticker image containing the tobacco box numbers are segmented.

First of all, the entire overlapping sticker area image is divided from the surface of the box.

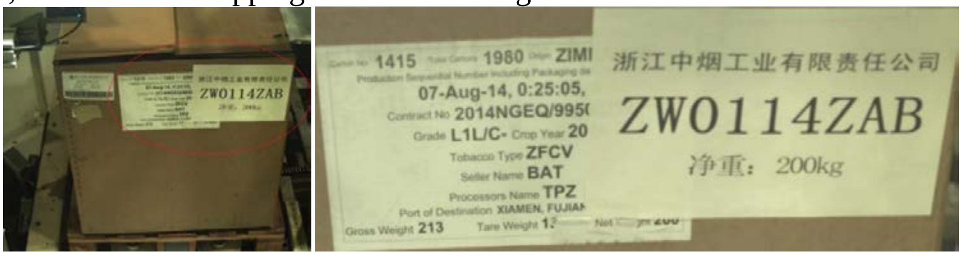

Figure 2 Box surface overlap sticker

The overlapping relationship of stickers is mainly divided into the following two types:

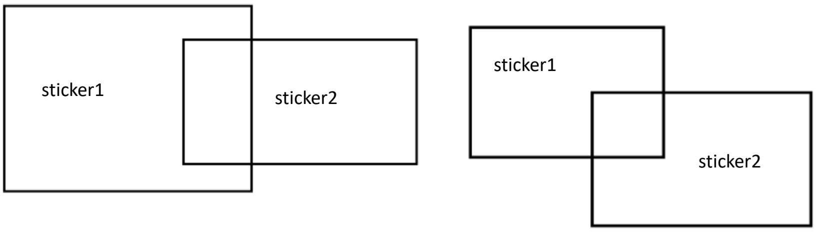

Figure 33 Overlapping sticker relationship (1) Overlapping sticker relationship (2)

This paper proposes a multi-layer overlapping sticker area locating algorithm for overlapping sticker image.

Overlapping sticker area positioning algorithm:

Take the overlapped sticker relationship (2) as an example. According to the relative position relationship of the overlapped stickers, find the outer contour part of the two stickers, and calculate the virtual vertices of the non-overlapping part of the sticker according to the set of circumscribed convex polygon vertices of the outer contour ({Pointpeak}):

$$\{VirtualPeak\} = PointVirtualFilter(\{Pointpeak\});$$

Based on the virtual vertices of the non-overlapping part, the remaining vertices are calculated symmetrically to achieve accurate positioning of each sticker position:

$$\begin{bmatrix} (x_{LT}, y_{LT}) & (x_{RT}, y_{RT}) \\ (x_{LB}, y_{LB}) & (x_{RB}, y_{RB}) \end{bmatrix} = PointCornerFilter(\{virtualPeak\});$$

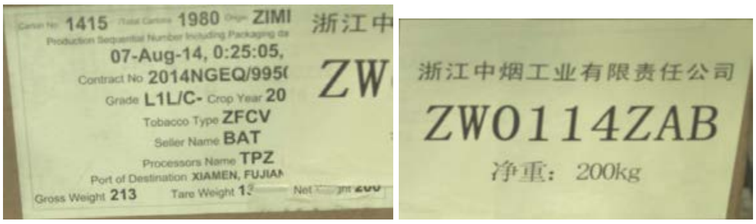

Figure 44 a) Overlapping sticker lower layer b) Overlapping sticker upper layer

After segmenting each independent sticker, the perspective transformation algorithm is used to calibrate each sticker.

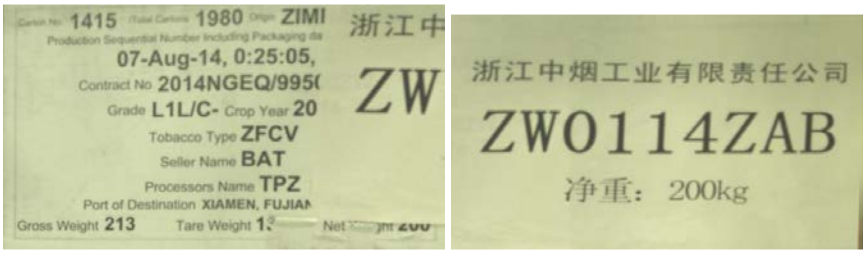

Figure 5 Corrected overlapping stickers

Finally, each character line area is located by the projection algorithm.

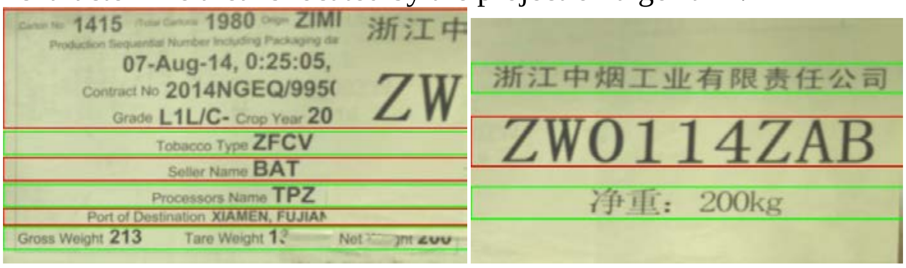

Figure 6 Projection method locates whole line of characters

4. Conclusion

The application of the virtual vertex fitting algorithm successfully eliminates the effects of sticker damage, warping, angle transformation and image distortion. The overlapping sticker area locating algorithm ensures that characters can be extracted even when the stickers overlap。

The use of virtual vertex fitting algorithm and overlapping sticker area locating algorithm ensures that the sticker character recognition accuracy is above 99%. After the extracted character lines are processed by OCR, they are compared with the reading code of the bar code, and the inefficient manual comparing process replaced by an efficient and stable recognition system reduces the probability of tobacco packaging errors and effectively improves the warehouse exit-and-entry efficiency.

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