Intelligent method of customs inspection platform based on machine vision

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Abstract. In the existing customs inspection, the inspection of outbound goods includes recording the arrival time of containers, opening and closing of containers, and the departure time of containers. This method takes a lot of time to manually record the relevant information of each container and manually input it to the server. This paper presents an intelligent method of customs inspection platform based on machine vision, through the analysis of collected video information processing, the inspection of each node in the process of time, behavior, such as digital processing, database, automatically record each inspection position of the box, opening time, sorting, inspection, packing, closing time, leaving time, behavior, compliance and other information. It greatly improves the efficiency and safety of container inspection and avoids the random and uncertain behavior of manual record. This system can automatically record the dynamic changes of containers in the storage yard in real time without anyone participating, improve the digitization and accuracy of the information of container state changes, reduce the working intensity of customs personnel, and reduce the working risks of personnel in the storage yard.

1. Introduction

With the rapid development of international economy, the demand of logistics and transportation is increasing. The port economy that forms a complete set with it is taken more seriously by people place. Containers are the most important means of loading goods in international ports. However, due to its large size and large cargo load, inspection is very difficult. According to statistics, 80% of the smuggling crimes are carried out by means of containers, which seriously endangers the economic and security interests of the country. Therefore, the customs side is in urgent need of efficient container inspection methods. Since China's accession to the world trade organization, the total volume of foreign trade has been increasing, and the number of containers entering and leaving ports has also been increasing. Customs plays a particularly important role in the inspection of import and export goods. The traditional method of opening containers manually by customs inspection not only requires a large number of staff, but also has low efficiency, which cannot meet the requirements of modern container inspection.

With the rapid development of image recognition technology, it is feasible to digitize the inspection process by image recognition technology. Zhu shengnan [1] et al. detected containers with super-pixel level context features; Chen chao [2] et al. identified containers through template matching and feature matching; zhang shaoming et al. Identified deformed containers with large perspective. There are also many corresponding researches on the identification of moving containers. Literature [4-9] USES different algorithms to detect moving objects and identify moving objects. Wang xue et al. [10] used
binocular to locate containers. Due to the influence of application environment and other factors, the video-based container status detection has not been applied to the container inspection platform in the storage yard.

This paper presents an intelligent inspection method for the customs inspection platform, which is to use the camera to collect the information of the inspection platform and monitor the time of the container falling, opening, closing and leaving in real time, so as to display the monitoring information in real time and upload it to the server.

2. Algorithm
The overall algorithm of the system is shown in figure 1. After reading video into the inspection platform, the current status of containers, whether there are containers and the number of containers are judged first. Identify the identified container status. Then real-time monitoring of container status changes at the inspection platform. The whole monitoring system algorithm is mainly divided into four parts: to determine the location and color of the container, the dynamic change of the container in video, the judgment of the container dropping and taking and the judgment of the container opening and closing state.
Figure 1. General arithmetic chart of system.

This algorithm has the following preconditions in special applications:
1) determine the ratio of length to width of the container;
2) each camera can monitor no more than 6 inspection platforms;
3) the container shall be placed in a specific line drawing area.
2.1. Container location and color identification

The difference between containers and other environments lies in the consistent color, fixed shape and fixed aspect ratio. Based on the above features, the container can be located and identified in video. Locate the container and identify the color according to the following steps:

2.1.1 RGB to HSV color space conversion. The RGB color model works by varying the red (R), green (G), and blue (B) channels and superimposing them on each other to produce a wide variety of colors, including almost all colors that can be perceived by human eyes. HSV color model is a color space divided according to the intuitive characteristics of color. In this model, color contains three parameters: hue (H), saturation (S) and brightness (V). Hue is represented by an Angle, and the value range is 0° ~ 360°; saturation means the degree to which the color is close to the spectral color; brightness means the degree to which the color is bright.

The image read by the camera is in RGB format. In terms of image color differentiation, RGB color is often converted into HSV color, different areas are distinguished by saturation, and different colors are distinguished by hue.

The transformation formula of RGB color space and HSV color space is:

\[
\begin{align*}
R' &= R / 255 \\
G' &= G / 255 \\
B' &= B / 255 \\
C_{\text{max}} &= \max(R', G', B') \\
C_{\text{min}} &= \min(R', G', B') \\
\Delta &= C_{\text{max}} - C_{\text{min}} \\
H &= \begin{cases} 
0^\circ & , \Delta = 0 \\
60^\circ \times \left( \frac{G' - B'}{\Delta} \right) & , C_{\text{max}} = R' \\
60^\circ \times \left( \frac{B' - R'}{\Delta} + 2 \right) & , C_{\text{max}} = G' \\
60^\circ \times \left( \frac{R' - G'}{\Delta} + 4 \right) & , C_{\text{max}} = B' 
\end{cases} \\
S &= \begin{cases} 
0 & , C_{\text{max}} = 0 \\
\frac{\Delta}{C_{\text{max}}} & , C_{\text{max}} \neq 0 
\end{cases} \\
V &= C_{\text{max}}
\end{align*}
\]

2.1.2 Container positioning. In the s-channel image, different color areas are clearly distinguished. The shape of the container, the aspect ratio of the container, the approximate position of the container in the image and the number of pixels of the container in the image are known in advance. Through the threshold, different color areas are distinguished to get the contour of different areas. For objects with different contours, the contour moment is calculated by the following formula:

\[
m_{p,q} = \sum_{i=1}^{N} I(x_i, y_i) x^p y^q
\]

Where, \( m_{p,q} \) represents the sum of all pixels in the object, where the pixel value of each pixel \( x, y \) is multiplied by a factor \( x^p y^q \). When dealing with the contour of, calculate the length of the contour, if dealing with the set of regional points, calculate the number of points.

To calculate the center of the region, the central moment can be obtained by calculating the central moment. The calculation formula of the central moment is:
\[ \mu_{p,q} = \sum_{i=1}^{N} I(x_i, y_i)(x - \bar{x})^p (y - \bar{y})^q \]  

(7)

Where, \( \bar{x} = \frac{m_{10}}{m_{00}} \), \( \bar{y} = \frac{m_{01}}{m_{00}} \)

Find the contours of different areas, calculate the shape, aspect ratio, center of each area and the number of pixels occupied by the area, and determine the location and number of containers in the image.

2.1.3 Container color. Once the location of the container is determined, an area in the upper right corner of the container serves as the area of interest. In the corresponding area of H channel, the average value is calculated, and the hue range is used to determine the container color with S channel and V channel as auxiliary.

Since there are many letters and numbers of other colors on the container, when calculating the color of the container, select an area without alphanumeric. Generally, the upper right corner of the container is pure color.

2.2. Container dynamic state change
In video, background elimination modeling (BSM) model [11] can be used to track changes in container states. The moving object is tracked in video. Morphological operation is carried out on the image after the background is removed. Structural elements are created according to the shape and size of the container, the foreground interest area is extracted, and objects other than the container are removed.

2.3. The judgment of dropping the box and taking the box off
Container loading and unloading are two opposite processes, but the judgment algorithm is similar, so the judgment algorithm of these two states is introduced together. The following detailed description of the algorithm steps of the box.

- In the lower part of the container placement area, select the area of interest and monitor the change of its S channel.
- When the S channel image changes, check whether the previous position has been marked with containers. If it is marked as none, then proceed to judge by the drop-off algorithm; otherwise, proceed to judge by the drop-off algorithm;
- If there is no container before, select the area where the change occurs, and calculate the area in the image according to its width and the aspect ratio of the container;
- In this area, calculate the mean square error of pixels. If the mean square error is less than a certain threshold, the color of this area is consistent; otherwise, it is interference.
- Threshold the s-channel image of the whole image to determine whether the area in step d is an area with similar pixels;
- If this area is an area, calculate the average value, judge the color of the container, and mark a container here.

The process of taking the box is similar to that of taking the box off.

2.4. The judgment of opening and closing the box
After determining the location of the container, judge the switch state of the container. In order to exclude the influence of personnel and vehicles on the state of switch box, the upper half of the container is selected as the area of interest. The judging steps are as follows:

- Vertical Sobel edge extraction was performed for the region of interest;
- Conduct corrosive operations;
- Conduct expansion operation;
- Binarization;
6.

- Count the number of white pixels. If the threshold value is reached, it means that the column of the container exists, that is, the container is in the closed state; otherwise, it means that the container is in the open state.

3. Experimental results
According to the algorithm proposed above, the experiment is carried out on the actual scene.
Perform histogram normalization of video images to remove light and other influences. As shown in figure 2.

![Image histogram normalization](image1.png)

Figure 2. Image histogram normalization.

Dynamically track the image and find the outline to determine the container.
Track dynamic objects using background-based elimination modeling. The running program is:
Mat kernel = getStructuringElement(MORPH_RECT, Size(4, 4), Point(-1, -1));
Ptr<BackgroundSubtractor> pMOG2 = createBackgroundSubtractorMOG2();
vector<vector<Point>> contours;
vector<Vec4i> hierarchy;
findContours(ROIThreshold, contours, hierarchy, CV_RETR_EXTERNAL, CV_CHAIN_APPROX_SIMPLE);
drawContours(roiImg, contours, -1, Scalar(0, 255, 0), 1, 8);
Figure 3. Container determination.

The first image is the original image, the second image is the detection of the tracking dynamic image, and the third image is the location of the container determined according to the aspect ratio of the container after contour detection.

After determining the container area, select the area of interest according to the location of the container. The column on the container is edge extracted, and the final calculation result is shown in figure 4.

Figure 4. Judgment of container closing.
Among them, the first image is the original one, which selects the area of interest from a container. The second figure shows the vertical results of sobel post-corrosion. The third image is the result after expansion, and the fourth image is the result after threshold processing. Then, according to the number of white pixels in the image, the column is judged to determine the switch state of the container door.

4. Conclusion
The intelligent inspection method of customs inspection platform based on machine vision proposed in this paper can complete the inspection of containers in real time and realize the automation and intelligence of the inspection process. Makes the workers and supervisors visualization in the whole process of supervision of container logistics process, the formation of standardized data inspection information, improve customs clearance efficiency and improving the quality of the goods inspection, to further expand areas for reform, enhance the level of supervision business site information construction, so as to improve the efficiency of customs clearance, reduce business operating costs; Realize real-time grasp of the panoramic visualization of container clearance logistics, improve the management level of containers, improve the rigor of law enforcement; It can provide information support for macro decision-making and serve local economic development and social stability.

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