Research on elevator hydraulic buffer detection system based on intelligent image recognition

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Abstract: As a kind of vertical transportation device, elevator is widely used in the production field and daily lives. In order to detect the reset time of the elevator hydraulic buffer, this article first analyzes the shortcomings of the existing detection methods, then provides a design of detection system for the elevator hydraulic buffer based on intelligent image recognition. This system can detect the reset time and reset distance, and grasp the dynamic compression and reposition process of the elevator hydraulic buffer. Besides, this system can also bring lots of advantages, such as wide universality, easy installation, high degree intelligence, less influence of human factors and no risk for the inspectors in measurement process.

1. Introduction
As a kind of vertical transportation device, elevator is widely used in the production field and daily lives. There are many elevator accidents in the world every year, some of them are due to the elevator car falling into the pit. In May 2012, an elevator in Lianyungang City fell from the 18th floor to the 1st floor. In October 2012, an elevator in Beijing suddenly fell from the 4th floor to the 1st floor. In March 2013, all four wire of an elevator ropes broke in Hong Kong. The elevator fell straight from the second floor to the ground floor. Seven passengers were all injured.

In order to alleviate the impact of the elevator car falling into the pit, a buffer will be set in the pit of the well. For elevators with a speed greater than 1m/s, a hydraulic buffer with better buffering effect will be set. When the car exceeds the terminal landing, the kinetic energy and potential energy of the car will be converted into the thermal energy of the hydraulic oil through the buffer, so that the car will stop with low speed to protect the passengers. Among all the safety protection measures of the elevator, the buffer is the last safety protection. It is like a fire-fighting device in people's daily life. Although it is not usually used, it must be ensured that its function is good so that it will work in an emergency. Therefore, the detection of hydraulic buffers is very important.

2. The existing detection technology of hydraulic buffer
2.1. Detection requirements
The monitoring of the elevator hydraulic buffer is mainly to monitor the reset time after its action. According to the general requirements, the elevator cannot move until the hydraulic buffer return to its original position. The maximum time limit for the buffer to fully reset is 120s.
2.2. The existing detection methods
At present, the existing detection methods include: (a) short-circuit the limit switch (if any) and the final limit switch, lower the no-load car at the inspection speed, compress the buffer, and observe the operation of the electrical safety device; (b) short-circuit the limit switch (if any), final limit switch and related electrical safety devices, lower the no-load car at the inspection speed, fully compress the buffer, and measure the time from the start of the car until the buffer returns to its original position. This method requires the inspector to squat in the pit and measure time until the buffer returns to its original position.

2.3. Shortcomings of the existing detection methods
This detection method has the following shortcomings: (a) judgment of the reset start position, reset stop position, reset start time, and reset end time of the buffer by manual observation is too subjective, and the data obtained are lack accuracy; (b) using a stopwatch for manual timing causes manual errors; (c) the pit space is very small, and the inspectors squatted in the pit during the inspection process, which is a serious threat to the safety of inspectors. This detection method cannot meet the needs of the rapid development of elevators. It is urgent to research more advanced devices to detect buffer.

3. The detection system of hydraulic buffer based on intelligent image recognition

3.1. The design of whole scheme
Based on the principle of intelligent image recognition, the detection technology of hydraulic buffer is designed[1-2]. The whole scheme is shown in figure 1.

3.2. The collection of information
The movement process of the hydraulic buffer is acquired by the camera[3]. The whole movement process is: (a) the elevator car slowly descends from a certain distance from the top of the hydraulic buffer, and gets closer and closer to the buffer until it is pressed onto it; (b) the car continues to descend, and the buffer is also compressed until to the end, the traction wire rope slides in the rope groove, and the car cannot move downward; (c) the car is operated to move upward to leave the buffer, and the buffer starts to reset automatically without external pressure; (d) the buffer is completely reset, and the entire movement process ends. The cameras like eyes are observing and recording the movement of the buffer all the time. When does the buffer begin to be compressed by the car? When is it compressed to the end? What is the compressed distance? When does the reset begin? When does the reset end? What is the reset distance? This information is captured and stored by the camera.
3.3. The transmission of information

The exchange of information in and out of the well is realized by wireless transmission technology[4]. In order to avoid injury, the inspectors stand outside the well during the inspection, and the camera is placed in the floor of the pit. On the one hand, the inspector remotely controls the camera; on the other hand, the information collected by the camera is transmitted to the computer outside the well, so that the inspector outside the well can always know the moving process of the buffer.

3.4. The processing of information

After obtaining the video and image of the buffer movement process, the image is processed to obtain the result. As shown in figure 2, the steps of calculating the compression amount of the hydraulic buffer include image sharpening, color threshold filtering, effective interval calculation, edge feature extraction, and compression amount calculation[5].

![Image processing flow](image)

Figure 2. Image processing flow

The buffer image must first be sharpened to enhance the edge features, and then the area of the hydraulic cylinder is selected by color filtering. At the same time, the gradient value filtering is performed to extract the edge features of the image for preparation for subsequent calculations. As shown in figure 3.

![Figure 3. Edge features of the hydraulic buffer](image)

(a) The original image  (b) The result of color filtering  (c) The result of edge extraction

Figure 3. Edge features of the hydraulic buffer

There is still a lot of interference in the binary map obtained after color filtering, and these small features need to be removed by image erosion. The base of the hydraulic buffer will also cause interference. It is necessary to select the middle part of the image to calculate. Judging the "middle part" of the image, the binary image can be accumulated in the x direction to obtain the distribution of the binary image with respect to y. As shown in figure 4.
It can be seen that a peak appears in the middle of the distribution map, corresponding to the "middle part" of the binary map. The threshold value is 100, and the y-axis coordinates corresponding to the points with ordinates higher than 100 are filtered out, and the ones that meet the conditions are found the minimum value of ymin and ymax, then [ymin, ymax] is the valid interval. After the valid interval is calculated, the edge binary maps within the valid interval are summed along the y direction to obtain the distribution of the binary map with respect to x, as shown in figure 5. The x-coordinates of the two peaks circled in the figure represent the position of the boundary between piston rod and cylinder.

In this way, the length of the piston rod exposed from the cylinder can be calculated. Calculate the length of each frame in the video and compare them to get the distance the piston rod moves. After the image processing and recognition are completed, it is displayed on the computer through a simple interface to realize human-machine interaction[6].

4. Major innovations

The detection system based on intelligent image recognition can record all the movements of elevator hydraulic buffer. The main innovations are as follows:

(a) This system can detect the reset time and reset distance, and grasp the dynamic compression and reposition process of the elevator hydraulic buffer.
(b) The exchange of information in and out of the well is realized by wireless transmission technology, without the need for electric wire, which facilitates the on-site arrangement and operation of the instrument.
(c) The inspectors are located outside the well to ensure personal safety, which can overcome the shortcomings of existing detection methods.
(d) This system can also bring lots of advantages, such as wide universality, easy installation and high degree intelligence, human factors can be educed to a small extent in the inspection; and risk is free for the inspectors.

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