

Research and Comparison of Horizontal and Vertical Installation Proposal for Anti-lifting System Based on Laser

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Abstract: As to meet the requirements of automatic detection of the separation status of the container and truck body which can prevent the body lifted in wrong operation in Thailand, two different implementation proposal are taken out. By detailed analysis of truck type and characteristics of the truck body in port, we study the main factors which influence the success of each proposal. Each proposal is verified on-site respectively in Thailand, we compare the advantages and disadvantage of the proposal, then select the vertical installation proposal more feasible to success, and play a decisive role in the automatic detection of truck body lift, provide a reliable technical support for other project application and promotion.

Keywords: *Laser; container; truck body; separation detection.*

1. INTRODUCTION

With container transportation becoming the main mode of logistics transportation, more and more cranes work in ports, docks, railways and other logistics hub for container loading and unloading operations. How to ensure the safety of crane operation has become a hot research direction, which is an important part of equipment automation and intelligent operation.

The yard crane is used to realize the container exchange and transfer between the truck and the yard, or put the container from the truck to the yard (unloading), or from the yard to the truck (loading). There are internal and external car types. The external truck has a long driving distance and bumpy road surface during transportation. In order to prevent the container from dropping accidentally, locks are installed around the car body to fix the lock holes at the bottom of the container. In general, the internal truck only runs in the port, and the container is fixed by the baffle around the body.

Before the unloading operation of the external truck, the truck driver needs to unlock the lock around the car body in advance. If the driver forgets to unlock or the unlocking is not complete, the truck body will be lifted by the container together during the lifting process of the spreader locking, causing a safety accident. At present, there are many schemes to realize the separation detection of body and container. Some of them are monitored and processed by crane driver through real-time video; some of them are processed by multiple detection devices.

The crane in the storage yard of Hehuang Thailand project needs to raise an alarm for the abnormal body of the truck under the unloading condition. By installing a two-dimensional laser on the side of the electrical room close to the operation lane, it can detect the separation of the truck and the box. In the process of implementation, two different laser installation schemes (vertical installation and horizontal installation) are adopted, and the research and comparison are carried out. Finally, a conclusion is drawn. Shanghai University invented a detection method for truck anti-lifting used in RMG. The system is equipped two laser scanners to scan the container and truck trailer to find the relative position through the geometric constraints, while send IO signal to electrical control system of crane. Another way to achieve truck anti-lifting detection is to use machine vision. Huang Wei proposed a truck anti-lifting method which uses two cameras to collect real-time trailer images. The system will capture an image as the reference before crane picks up the container, and then extract the feature points from the image every 500ms by using the ORB(Oriented FAST and Rotated BRIEF) algorithm, using FLANN algorithm to match the feature points between the real-time image and reference image to judge whether truck is lifted up by threshold. This method has been tested in Shanghai Yangshan automation terminal.

2. SCHEME INTRODUCTION

The laser installation position is close to the operation lane of the crane. During the unloading process, a large number of scanning data points can be collected. By analyzing these data points, we can detect whether the body is lifted. Once there is an abnormal situation, the lifting mechanism will be forbidden to continue to rise, and the crane driver will intervene manually. In addition, the yard crane of the project is exposed to the internal and external collecting cards. When the internal collecting cards are working, the alarm caused by false detection shall be avoided. Different installation methods affect the range of data collected by the two-dimensional laser, the judgment method of separation detection, and play a decisive role in the realization of the final automatic detection function.

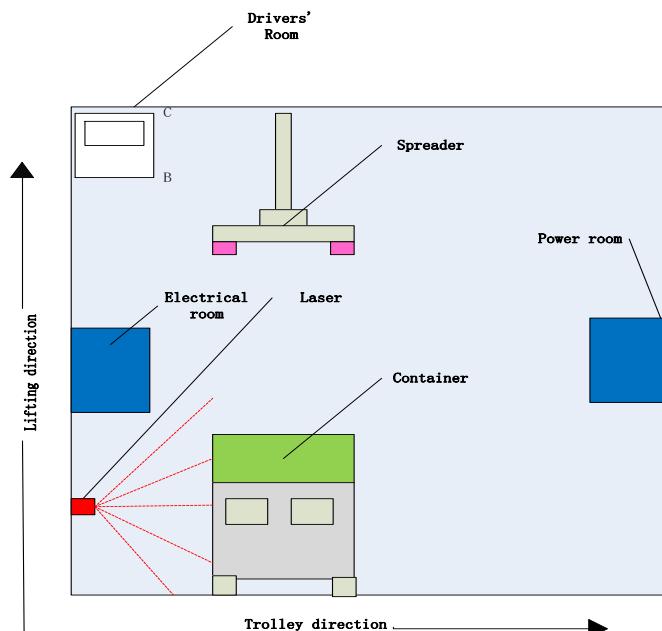


Fig. 1 Front view of laser vertical installation

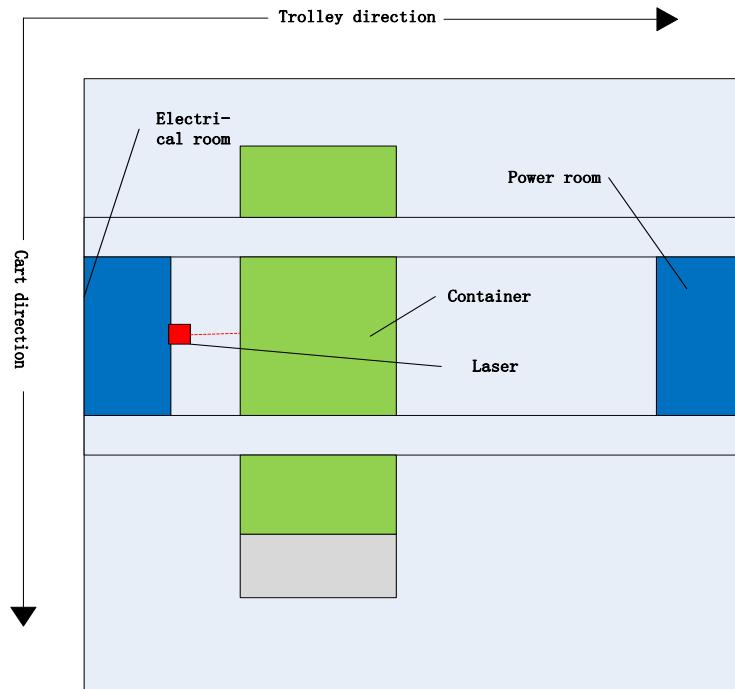


Fig. 2 Top view of laser vertical mounting

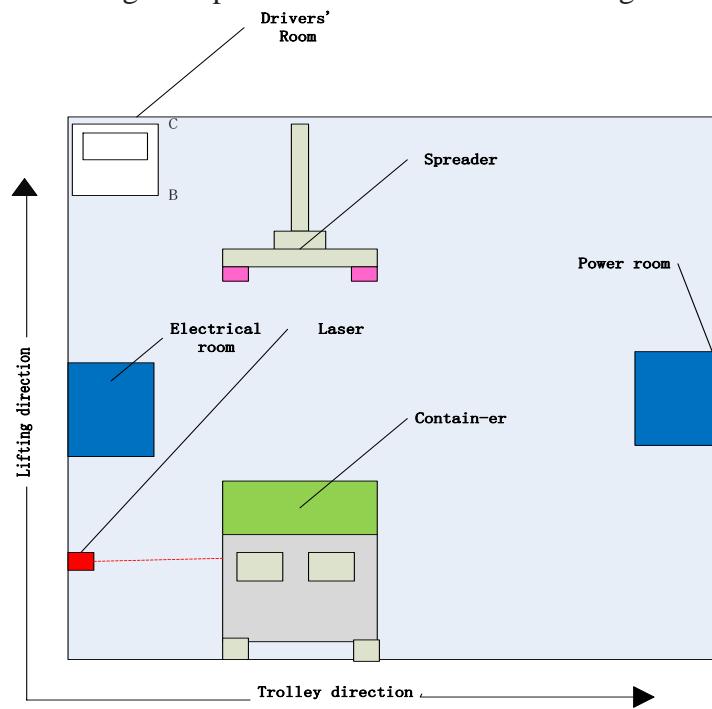


Fig. 3 Front view of laser cross mounting

3. SCHEME STUDY

3.1 Characteristics of truck body

The exterior truck body is complex and has the following characteristics.

There is a height drop in the length direction of the body of the same external truck, which is significantly higher near the front part than the rear part. The difference of body height and tire pressure makes the body height of each truck different. Part of the exterior frame of the exterior car is hollowed out, only the lock head is reserved. The body length is different, usually it can carry 20 foot or 40 foot containers; however, some simple external trucks can only carry 20 foot containers. There may be a baffle around the lock head of the car body. The height of the baffle is about 2 ~ 4cm.

There are wide baffles around the car body, which are inclined or straight up. The front of the body is also slightly higher than the rear. The height difference of the trucks in the same port is not big.

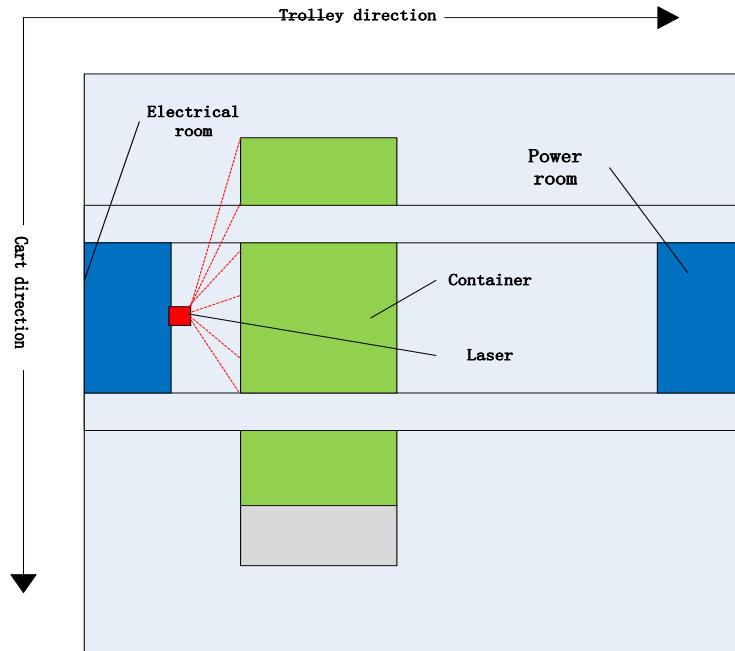


Fig. 4 Top view of laser cross mounting

3.2 Transverse installation plan

In the transverse installation mode, the laser scanning surface is approximately parallel to the ground, and each scanning data point is arranged in sequence along the direction of the cart, which can basically cover the whole body length. Normally, when the container is lifted, there is no scanning data point in the gap between the container and the body. If an appropriate detection area can be selected, anti lifting detection can be realized by judging whether there are data points in this area after lifting (the abnormally lifted body will enter the detection area).



Fig. 5 Field drawing of laser cross mounting

Based on the working principle of the transverse mounting mode, the height of the laser from the ground, the detection area and the threshold value of the data point are the important factors affecting the success.

1) Ground clearance of laser

The installation height should be greater than the height of the truck body, so that when the container is lifted, the gap area can be detected. The height of inner and outer truck is different, but it can be regarded as fluctuation in a certain range. If the installation height is too small, the lifting detection cannot be carried out under the condition of high body (the laser will always hit the side of the body, and there are data points in the detection range); if the installation height is too large, the lifting detection speed is sacrificed, especially for the working condition of low body, the lifted truck body will lag into the detection range, thus delaying the alarm time.

In addition, the installation height has a great influence on the recognition of inclined type of internal card baffle. Ideally, the laser line is in the middle of the inclined angle, and the most obvious feature is in the figure. If the scan line moves up, it is difficult to separate the features from the data points on the side of the container. In different conditions, the position of the internal card baffle relative to the laser is different. If the baffle is close to the laser, the characteristics will be much more obvious; otherwise, it will be reduced. All of these make it difficult to recognize the characteristics of the inclined type of the internal card baffle.

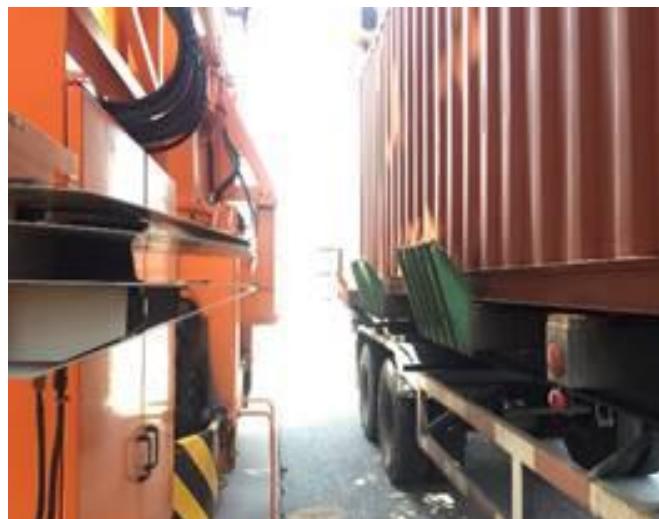


Fig. 6 Inner card of laser cross mounting detection



Fig. 7 Laser cross mounting test external card

2) Selection of detection area

Assuming that both the body and the test area are parallel to the ground, the test area can be easily selected. As long as it is ensured, the width of the area shall accommodate the truck body; the length direction can be appropriately relaxed. However, the height of the front and back of the truck body is not the same, which will make the normal working body plane intersect with the detection area after lifting the container and trigger the false alarm. Therefore, the detection area should be appropriately reduced in the length direction to avoid the intersection with the body plane. Similarly, a small number of body types also incline in the width direction, further reducing the detection area in the width direction. If the convex baffle plate of some external cards is too high, it will enter the detection area. It is necessary to divide the detection area into several pieces to eliminate the influence of the baffle plate. Because of the above reasons, it is difficult to select the detection area, which can not be applied to the changeable working environment.

3) Data point threshold

It is difficult to answer how many scan data points exist in the detection area to trigger the alarm. If the value is too small, the alarm will not be given; if the value is too large, the alarm will be given by mistake. In addition, the impact of rainwater should be considered, and raindrops may also enter the detection area.

3.3 Vertical installation plan

In the vertical installation mode, the laser is placed on the side of the container truck, and each scanning data point is arranged in order along the lifting direction. A large number of data points on the side of the truck can be collected at the same time, such as the truck body, container, and ground. In the process of lifting upward normally, the container and the body are gradually separated. Because the data points of the container and the body can be obtained at the same time, if the body is lifted upward, it can be prohibited to lift upward.

Based on the working principle of the vertical mounting mode, the height from the ground and the displacement threshold of the laser are important factors affecting the success.

1) Ground clearance of laser

According to the above discussion, although the body height of each type of truck is different, it fluctuates in a range. The average value can be selected as the actual installation height of the vertical mounted laser, which is much simpler than many limitations of the horizontal mounting process. In the installation process, the laser mirror should be perpendicular to the ground, and the mirror should not rotate around the cart direction. Of course, there is also a defect in this installation. The laser mirror will be directly exposed to the outside, which is easily affected by raindrops. Therefore, an additional rain shield needs to be installed on the upper part of the laser.

2) Displacement threshold

When the truck body is lifted, the displacement of the car body in the trolley and lifting direction can be detected as the alarm basis. From the test situation, there will be several basic actions such as overall lifting, front and rear length direction tilting, left and right width direction tilting. In the actual environment, the displacement is easier to obtain than the number of scanning points.

4. CONCLUSION

From the field application effect, the laser cross mounting scheme is greatly affected by the truck body, and the defects are obvious. The front and rear transverse and left and right longitudinal inclinations of the vehicle body will have adverse effects on the selection of the detection range. The front and rear inclinations make the length of the area greatly reduced; the left and right inclinations make the area only consider the side close to the laser body. Because of the uncertainty of the body height, the installation height of the laser cannot be too low. Under the low body condition, it may lag the trigger of the detection signal; the characteristics of the internal card baffle are not easy to be detected. Therefore, the superposition of the above causes eventually results in the abandonment of the cross mounting scheme.

The vertical installation scheme solves the problems of the former. First of all, the vertical mounting mode is not sensitive to the mounting height, and the scanning data points are arranged in the lifting direction, so the actual mounting position can be determined by referring to the height of most of the truck body. In addition, the laser can sample a large number of data points at the same time, such as container, truck body, frame, ground and so on. It can detect the separation of truck body and container after lifting up after locking. In the same way, because of the richness of data points, in the process of recognition of baffle features, it is not limited to a certain shape of baffle, but also the inclined or vertical type of baffle can be detected.

The two installation schemes proposed in this paper are tested on site in the project of Hehuang Thailand tire crane, and the vertical installation scheme is finally selected. In the mixed operation environment of on-site internal and external truck, the function of anti lifting detection is realized to avoid the occurrence of false alarm. The expected effect is achieved, the user's approval is obtained, and valuable experience is accumulated in the field of crane equipment safety operation.

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