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Item detection inside shared car based on Image processing and Infrared

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Abstract: By browsing a lot of data in recent years about shared car in China market, we had come to a conclusion that although the pertinent fields of Car Sharing market in China have already made a great process especially compared to its original circumstances, it's still suffering from tremendous loss due to poor management. In order to make it possible for improving the current situation and reduce the huge amount of loss, we have devised a set of detection equipment which can be used to detect the anomalous items inside the shared car automatically by referring to some existing algorithms of the Image processing and Infrared ray, with which we could cut down the number of necessary cleaning workers needed to check and clean the shared car after being used.

1. Introduction of the whole system

For most of the time, the cleaners will have to check up the interior of shared car including the surface of Steering Wheel, Seat and Carpet and so on so as to let the vehicle become neat and tidy again for the next client each time due to their ignorance of whether the previous user have messed up the car or not. This kind of behavior can result in huge amounts of unnecessary manual work of cleaning because not all the shared cars are polluted by the previous users in general. Thus, a large sum of money has been used for hiring workers to clean the car, which is deficient and will turn into the loss of profits before long. To improve this, we have designed a set of automatic detection equipment which can be used to check cleanliness of surface inside the vehicle based on a series of algorithms including DHash, Color histogram similarity and Image subtraction and Infrared ray, etc. After several test analyses, we firmly believe that this set of tools should be able to figure out items larger than wallet in size basically.

2. The structure of the whole system

Aiming at collecting data more stably and precisely, an experiment system has been constructed based on the Network transmission, including camera, Android pad, infrared sensor and computer. Camera was used to photograph some specific areas inside the vehicle. Android pad was used to acted as if an Automobile console to in charge of data transmission. Infrared sensor was used to detect some specific illegible areas like the storage box located nearby the front passenger seat which was hard for a camera to discover. Computer was used to compute the image data and finally draw a conclusion.

The basic system was showed in Figure 1.

Figure 1: The structure of whole system

3. The process of Data Analysis

3.1 The basic principle of whole process

Collected the data from the vehicle, then transferred them to computer by internet, finally calculated them and drew a conclusion to show whether it was necessarily needed for cleaning. The process was showed in Figure 2.

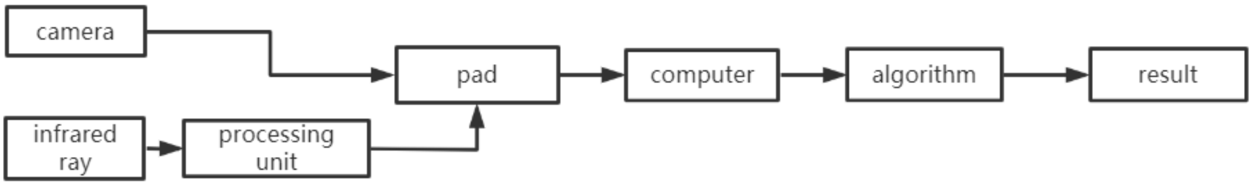

Figure 2: The basic principle of whole process

3.2 The process of Image Detection

The main procedure of Image Detection was mainly about a three-step strategy. First, to scan the image stored in the designated folder and put it into the image detection program automatically. Second, to start the Different hash Algorithm [1] and wait for the calculated value, only when the value satisfies the threshold could we move on to the next step to Color histogram similarity Algorithm [2], otherwise we would start the process of Image subtraction directly and get the result. Third, if we go into the Color histogram similarity Algorithm successfully, then we continue to compute it and wait for the calculated value, only when the threshold is satisfied could we report the 'good' signal to user, otherwise the process of Image subtraction would be started. The legible process was showed in Figure 3.

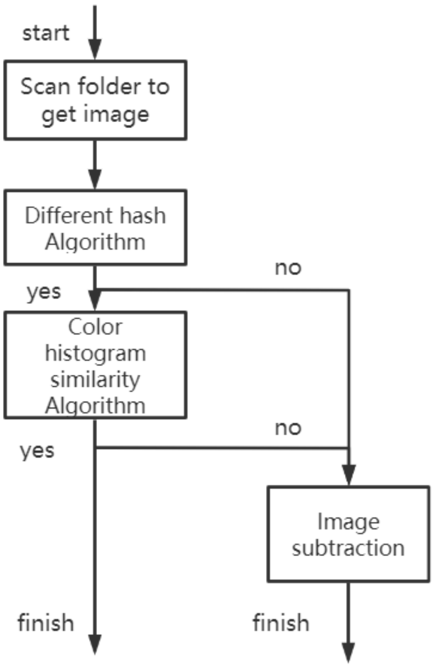

Figure 3: The process of Image Detection

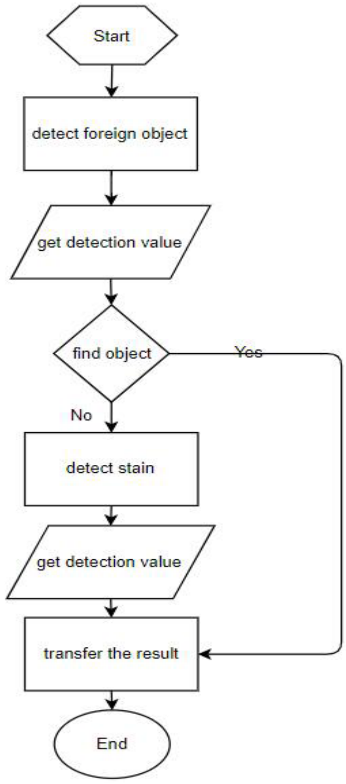

Figure 4: The process of Infrared Sensor

3.3 The process of Infrared Sensor

The processing of the Infrared detection part was mainly to collect the infrared sensor data from the sensor, then process the collected data and compare it with the standard value.

There were two main steps in this process. First, to detect the foreign items, the result would be returned if there was a foreign item. Otherwise, the second step would be carried out to detect the stain, and finally return the result. The process was showed in Figure 4

4. The principle of Algorithms

4.1 The principle of Different hash Algorithm

The kernel point of this Different hash Algorithm was to differentiate the adjacent parts of image in order to create a 'fingerprint', then we told the difference from test image and standard image by comparing these fingerprints. Here were the details of how we did it. First, to resize the input image to a general size of 9*8, then we converted the 9*8 image to Gray Image by using formula (1). Second, we calculated the difference between adjacent pixels within 9*8 image, then we compared the difference with a threshold to create the value of hash. Finally, we got the value of Hamming distance by comparing these values of hash.

$$Gray = 0.299R + 0.587G + 0.114B \tag{1}$$

R, G, B represented the color value in RGB channels

4.2 The principle of Color histogram similarity Algorithm

In order to get the similarity of images, we need to take the following steps. First, to calculate the frequency distribution of pixels of the image in R channel. Second, to calculate the similarity of histogram by using formula (2) and formula (3) and dividing Degree by the length of frequency distribution of pixels. Third, we need to repeat the above steps so as to get the similarities of histogram in G, B channels. Lastly, to get the average of the above results as the similarity between test image and standard image.

$$Degree_i = \begin{cases} 1 - \frac{|a_i - b_i|}{\max(a_i, b_i)}, a_i \neq b_i \\ 1 \quad\quad\quad\quad\quad , a_i = b_i \end{cases} \tag{2}$$

$$Degree = \sum_{i=0}^{n} Degree_i \tag{3}$$

Degree referred to the similarity in one color channel.

4.3 The principle of Image Subtraction

Image subtraction should be the last procedure in the Image processing. In order to locate the outline of detected items more accurately in the end, we should resize and convert both the test image and original image into Gray image. If needed we could even apply a filtering algorithm on the image. And then, we subtracted these images and binarized the processed image with OTSU Algorithm. Finally, to locate the target within the test image.

4.4 The principle of Infrared Sensor

4.4.1 Structure of the Infrared Sensor

The infrared sensor contained two pairs of infrared tubes to detect foreign items and dust respectively.

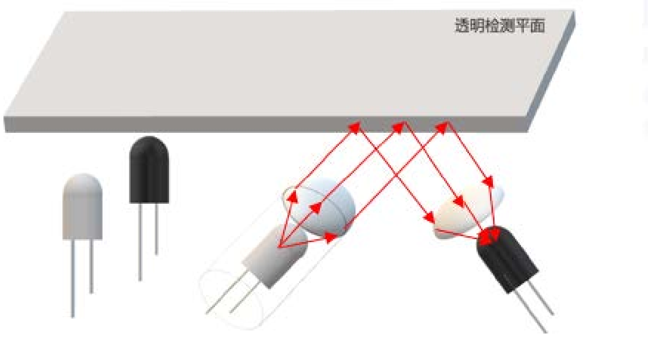

Figure 5: Structure of Infrared Sensor

As shown in the Figure 5, the first pair of infrared pairs of tubes was perpendicular to the transparent detection plane, and the infrared rays were reflected by the foreign items and received by the infrared receiving tube to complete the foreign item identification. The second pair of infrared pair tubes were placed obliquely with respect to the transparent detection surface, and the stains on the detection surface would reflect infrared rays to the infrared receiving tube, so the stain content on the detection surface could be judged through the collected receiver data [4]. A convex lens was set on the optical path of the infrared pair tube to converge infrared rays in order to enhance the infrared receiver signal and improve the sensitivity of stain detection.

4.4.2 Infrared sensor data processing

Collected 30 data continuously and selected the mode as the measured value to reduce random errors. In order to weaken the influence of infrared rays in sunlight on detection, the measured value of the sensor when the infrared emission tube was working and the measured value of the sensor when it was not working were obtained respectively, and the difference was taken as the final measured value.

5. The result of Data Analysis

5.1 The result of Image Detection

In this experiment, we used some items including wallet, umbrella, pad and bag as the detected objects which would cover the range of easy-losing items of passengers. The experiment had been done under ordinary circumstances with the random lighting conditions and vehicle location, which could fully simulate the daily using conditions.

5.1.1 Hamming distance and Image similarity

By using computer to process the images received from Automobile console with the help of Network transmission, the value of Hamming distance and Image similarity had finally been calculated. And in order to detect the items inside the shared cars more precisely, we had set the threshold of Hamming distance algorithms and Color histogram similarity algorithms as the value of 1.5 and 0.9, with which the items larger than wallet in size could be checked up successfully. The values of Hamming distance and Image similarity were showed in Table 1.

Table 1: Values of Hamming distance and Image similarity

	wallet	umbrella	pad	bag
Hamming distance	1	0	1	6
Image similarity	0.8440973	0.76762325	0.7945047	0.83357626

Table 1 has indicated the manifestation that DHash algorithm had a better performance than Color histogram similarity algorithm for detecting large substances. Or to put it in another way, DHash algorithm did not good at dealing with small items in this experiment. In order to make up its defect, a Color histogram similarity algorithm was necessary to raise the possibility of success and it did perform very well. The comprehensive application of these two algorithms has successfully checked up all the items above.

5.1.2 Image subtraction

After the process of computing Hamming distance and Image similarity, an indication should be given by the program to show whether the test image satisfied the threshold of executing the process of Image subtraction and if the requirement was satisfied, the location of extrinsic items we were interested in would be marked. Once the value of Hamming distance algorithm was higher than 1.5 or the value of Color histogram similarity algorithm was below 0.9 then we started the process of Image subtraction.

Here we would show the result of wallet detection in Figure 6, from which we could see even a wallet inside the vehicle was big enough for our comprehensive process of detection to identify whether it was extrinsic substance needed cleaning and this program has made it possible for us to figure out whether the shared car is needed to be cleaned from a long distance, sitting in front of the computer desk rather than go inside the car to see by ourselves. Although the last image in Figure 6 has showed that sometimes the procedure for marking target would be affected by its surrounding conditions such as the cushion we saw, it still worked excellently so long as we use binary graph to highlight the foreground as we saw in Figure 7.

Figure 6: The result of wallet detection

Figure 7: The binary graph of pad, umbrella, bag

5.2 The result of Infrared Sensor

5.2.1 Object detection

It could be seen in Figure 8 that the output voltage of sensor was positively correlated with the distance between the sensor and detected item, which has indicated that the farther away an item from the sensor was, the lower value it would get.

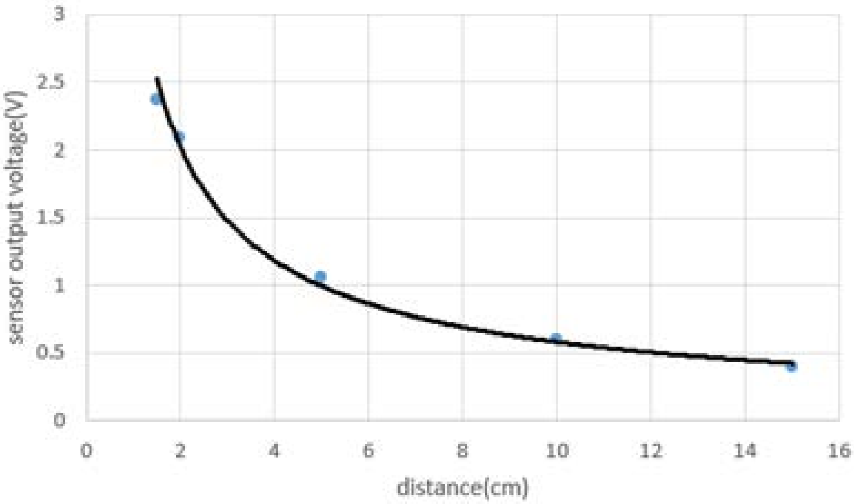

Figure 8: the relationship between output voltage and distance

5.2.2 Stain detection

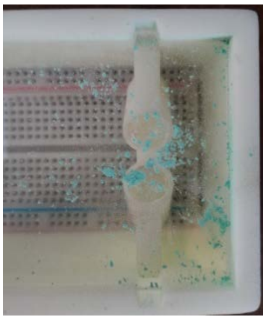

Figure 9: Fewer stain

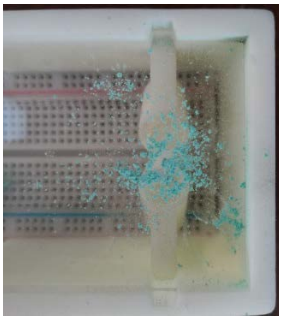

Figure 10: More stain

Table 2

Detection object	Environment value (V1)	Total value (V2)	Actual value (V=V2-V1)
Fewer stain	0	98	98
More stain	0	164	164

Environment value referred to the value that was got in no infrared situation, while the Total value referred to the value that was got in infrared situation which meant the infrared emitter was working then.

The output value of the sensor ranged from 0 to 166. The more dust there was, the greater the output value of the sensor.

6. Conclusions

From above on, the following conclusions were obtained.

(1)By using the comprehensive procedure of image detection, a foreign item which was not belong to one part of the vehicle inside originally and with a size larger than a small wallet could be detected successfully. However, as we saw in the Figure 6, the result would be disturbed by its surrounding conditions, especially when the item's environment is complicated in texture such as the wooden cushion showed in Figure 6. Therefore, in order to elevate the accuracy of the process of Image detection, the surface environment inside the vehicle should be simple.

(2) The infrared sensor can accurately identify the extra objects in the storage box and convert the amount of stains into the corresponding detection value, but the quantitative standard for the detection value has not been established, and the detection value is not intuitive enough.

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