A Quick Detecting Method Based on The Least Square Method for Missing and Damage of Manhole Cover

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Abstract: In this paper, a high-speed condition based on the least square method covers defects and damage detection methods, this method can through visual road surface shape characteristics, fracture characteristics of the cover quickly identify and make analysis and processing.The road image in front of the detection vehicle is obtained at high speed through the two CCD cameras fixed at the top of the locomotive.The image acquisition card converts analog signal to digital signal transmission to the upper computer. The processing center uses the algorithm to preprocess the image and the least square ellipse fitting of the processed image to realize the shape feature recognition, using the calculated pixel area, pixels horizontal and vertical projection, calculation methods of rectangular degree, realize the manhole cover crack identification;The location of the well cover can be indirectly reflected by rotating encoder and GPS location detection vehicle.This method is simple, fast, safe and cost effective for the existing well cover detection technology. It can effectively recognize the loss and damage of the surface well cover and provide support for road safety.

1 INTRODUCTION

With the development of urban transport system and vehicle ownership continuing increasing sustainability, more and more people pay attention to road traffic safety. In the method of investigating the condition of the damaged road manhole cover, the most widely used method are manual visual inspection and installing the sensor in the manhole cover, but they are time-consuming and inefficient. The number of manhole covers is large, the method of installing the sensor in the every manhole cover costs hugely and is error-prone, there is a certain degree of instability in this method. There is not an ideal method for detecting of damaged road manhole covers automatically (Xinyu Kou, 2002). The method should be able to identify a variety of road covers, including manhole covers' cracks and missing, etc, under various driving speeds and environmental conditions (Jain A.K, 1989).

At present, there are many kinds of road condition detection vehicles which are mainly for road damage, roughness, rutting and other road safety hazards detection of highways, municipal roads, airport runways , but there is not the study for vehicle type on the detection of damage and defect of the manhole cover on the road surface. In this paper, a method of detecting missing and damage of high-speed on-board manhole covers based on image processing is proposed (M.Mendelsohn, 1968).

2 OVERALL FRAMEWORK

The whole system includes image acquisition unit, image storage and transformation unit, image processing unit, manhole cover positioning unit and auxiliary unit. The image acquisition unit comprises two parts of image acquisition and auxiliary illumination. Image acquisition part is two CCD cameras which were fixed in front of the top of the detection vehicle and used to obtain road images.Auxiliary lighting part is the auxiliary lighting which is fixed on the bracket and located in the middle of the two cameras and it is used to provide uniform lighting conditions to ensure the image quality ; image storage and transformation converts analog signals into digital signal transmission to the computer for the next step through the image acquisition card (Jain A.K, 1989). The image processing unit uses the image processing technology to preprocess the image by the algorithm program and

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analyze and judge the processed image to realize the identification of the shape characteristic of the manhole cover, the identification of the fracture characteristic of the manhole cover, and the evaluation of the manhole cover condition. Manhole cover positioning unit reflects the specific location of the manhole indirectly through the rotary encoder and GPS positioning detection vehicle position.Auxiliary unit includes testing vehicles, support and power supply and other auxiliary equipment.

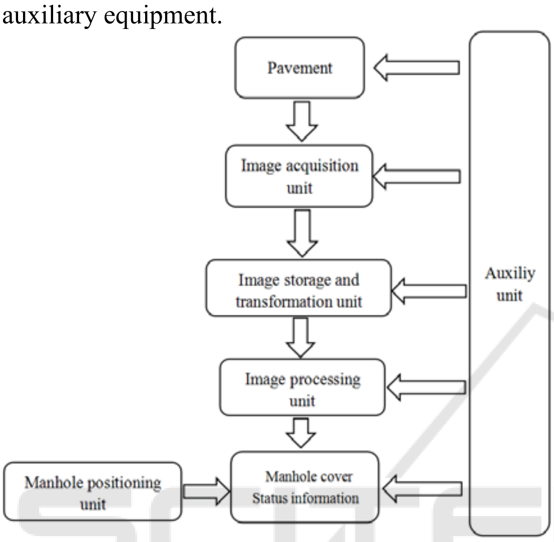

Figure 1: Chart of system's untis

3 MANHOLE COVER FEATURE IDENTIFICTION

It is necessary to preprocess the image of the road ahead which is collected by the CCD camera in order to identify the characteristics of manhole covers.The preprocessing includes grayscale processing, filtering, edge detection and binarization (Zhang Xuegong, 2000).

In the image, the object to be recognized has a target feature.Target feature is its unique attributes which is the basis for distinguishing the target type (E.R. Darvis, 1968). These characteristics may be the natural properties of the object such as geometric features. It can also be attributes provided for the convenience of computer processing such as statistical properties. Target feature extraction is the category of image analysis (Radim H, 1998). Target feature extraction is a technique of changing data from image, that is, the input form is the image form .A set of data that reacts object attributes and characteristics are output.The target feature extraction is used to digitize the target information in the image, which can describe the target feature more accurately and objectively and lay a foundation for the target recognition (Qu Wen-tai, 2005).

Because there is a certain angle between the camera and the road, the manhole cover will be taken to the oval state,the ellipse fitting is performed by the least square method.The following is the identification of the manhole cover feature step:

(1) Use the least squares method for ellipse fitting,the general equation of the ellipse is:

$$x^2 + bxy + cy^2 + dx + ey + f = 0 \quad (1)$$

b, c, d, e, f are fitting parameters.

(2) Use the least squares method, the variance of the coordinates of the edge points on the image is:

$$s^2 = \sum_v (x_v^2 + bx_v y_v + cy_v^2 + dx_t + ey_v + f)^2 \quad (2)$$

(x_v , y_v) Is the coordinates of the ellipse boundary point.

(3) Solve the partial differentials of b, c, d, e, f :

$$\frac{\partial s^2}{\partial d} = \sum_v 2x_v(x_v^2 + bx_v y_v + cy_v^2 + dx_v + ey_v + f) = 0 \quad (3)$$

$$\frac{\partial s^2}{\partial c} = \sum_v 2y_v^2(x_v^2 + bx_v y_v + cy_v^2 + dx_v + ey_v + f) = 0 \quad (4)$$

$$\frac{\partial s^2}{\partial b} = \sum_v 2x_v y_v(x_v^2 + bx_v y_v + cy_v^2 + dx_v + ey_v + f) = 0 \quad (5)$$

$$\frac{\partial s^2}{\partial f} = \sum_v 2(x_v^2 + bx_v y_v + cy_v^2 + dx_v + ey_v + f) = 0 \quad (6)$$

$$\frac{\partial s^2}{\partial e} = \sum_v 2y_v(x_v^2 + bx_v y_v + cy_v^2 + dx_v + ey_v + f) = 0 \quad (7)$$

(4) Use the Gaussian elimination method to solve the above equations (16) - (20), then obtain value of b, c, d, e, f . The fitting elliptic coefficient is obtained.

(5) For the ellipse, the variance of the coordinates of each edge point (s^2) is very small, If $s^2 \leq$T (threshold value)，it can be judged that the image is an ellipse.Then the manhole cover is recognized in the image.

(a)

(b)

Figure 2: Ellipse recognition result

4 TO DETERMINE WHTERMINE WHETHER A MANHOLE COVER MISSING AND BROKEN

After locking the manhole cover area. When the manhole cover is missed and broken, the gray value on the image is not the same as the gray value when the manhole cover exists or complete. Through the gray value of the size, set a reasonable threshold and the manhole cover missed and broken can be judged. As shown in Figure 3 and Figure 4, it's the test result.

(a)

(b)

Figure 3: Manhole cover loss detection results

(a)

(b)

Figure 4: Manhole cover rupture test results

5 WELL COVER CRACK IDENTIFICATION

(1) Judge the existence of cracks in the manhole cover surface.If there is a crack, there is a need to further determine the type of fracture. It can judged whether there are cracks on the cover by calculating the crack pixel area, the calculation of the fracture area is actually calculating the number of the cover area f (i, j) = 0, that is the number of pixels whose gray value is 0.

$$W = \sum_{i=0}^{P-1}\sum_{j=0}^{Q-1} f(i,j) \tag{8}$$

W represents the crack pixel area, f (i, j) represents the crack binary image, and P and Q denote the total number of rows and columns of the image respectively. When X = 0, there is no crack in the manhole cover (Qu Wen-tai, 2005).

(2) Transverse longitudinal crack identification: according to different geometric shapes and direction of the cracks, and these differences in the horizontal and vertical projection are fully reflected:

$$Y(j) = \sum_{j=0}^{Q-1} f(i,j) \qquad i = 0,1,.....P-1 \tag{9}$$

$$Y(j) = \sum_{j=0}^{P-1} f(i,j) \qquad i = 0,1,.....Q-1 \tag{10}$$

X represents the horizontal projection, Y represents the vertical projection, f (i, j) represents the manhole cover binarization image. Pixel value of the crack part of the 0, the rest is 255, P is the total number of manhole covers the region, Q is the total number of covers area.

The projection value of the crack image is integrated into the data parameter,set the parameters are:

$$X_s = \sum_{i=0}^{Q-2} | X(i) - X(i+1) | \quad (11)$$

$$Y_s = \sum_{i=0}^{P-2} | Y(i) - Y(i+1) | \quad (12)$$

When X_S is larger and Y_S is smaller, this is a longitudinal crack, when X_S is smaller and Y_S is larger, this is a transverse crack.

(3) Network crack identification: Because the contour of the crack is determined, the minimum circumscribed rectangle of the crack portion can be obtained.Calculate the maximum and minimum values of the boundary coordinates of the fracture in the horizontal and vertical directions respectively, to obtain a range of horizontal and vertical spans. Solve the rectangle of the crack what is the ratio of the area of the cracked pixel to the area of the smallest circumscribed rectangle, representing the proportion of the object in its minimum circumscribed rectangle. Let A be the squareness, S be the area of the crack pixel, S1 be the minimum circumscribed rectangular area of the crack portion.

$$A = \frac{S}{S1} \qquad 0 \le A \le 1 \quad (13)$$

When $0.6 \le A \le 1$, this is a mesh crack. The characteristic parameters of the three cracks are shown in Table 1

Table 1: Comparison of characteristic parameters of three types of fractures.

Type of fracture	W	X_S	Y_S	A
Lateral cracks	smaller	smaller	larger	smaller
Longitudinal cracks	smaller	larger	smaller	smaller
Mesh cracks	larger	modera te	moderate	larger

6 CONCLUSION

In this paper, the identification method based on visual analysis of the loss and damage of the well under high speed condition is proposed. On the basis of image processing, the method of ellipse fitting by least square method is introduced, which can effectively identify the area of manhole cover in the image. Judge whether the lack of cover and a wide range of rupture clearly by setting a reasonable threshold; the existence of the cracks on the cover shape can be intelligently identified, locate covers with missing or damaged conditions simultaneously and summarize the situation by calculating the pixel area method, pixel vertical projection method, the calculation of rectangularity and other methods (Haykin s, 2011).

Experiments show that this method has a strong practicality.This method can detect the hazardous situation of road covers in advance and provide data support to the relevant departments. Compared with the existing manhole cover detection technology, this method is simple, fast, safe, cost-effective and provide support for road safety.

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