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Development of Coordinate-machine of the Scene of Road Traffic Accident based on Binocular Stereo Omni-Directional Vision Sensors

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Abstract

On the basis of analyzing flaws of the traditional means of traffic accident scene survey and inadequate of the existing photogrammetry technique, this paper presents a panoramic stereo photogrammetry technology applying to traffic accident survey. By employing the result of photogrammetry, the drawing module can automatically draw traffic accident scene diagrams for the accident analysis and reconstruction, so as to quickly achieve the purpose of measurement and drawing. Experiments show that the presented accident scene coordinate-machine can measure the distance and the azimuth of all the relevant objects on the accidental scene, and enjoys the advantages of high precision in measurement, convenience in operation and carry, no necessity in calibration, etc. So it can meet the traffic police’s needs of the measurement and drawing of the traffic accident scene.

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1. Introduction

With the continuous increasing of the number of cars, traffic accidents happen with high frequency. Therefore, how to achieve an accurate and effective investigation traffic accident scene rapidly has been an urgent issue that calls for solving.

Nowadays, the main means for traffic accident scene investigation are tape, laser [1], total station [2], Global Position System (GPS) and photographic surveying. Besides, the photographic surveying includes...
stereoscopic and common camera measurements. The former has advantages of high quality of imagery as well as high speed of restoration of the spot.

This paper comes up with a Binocular ODVS to apply to scene investigation of traffic accidents. It combines the panoramic vision technology and stereoscopic vision technology. Therefore, it can bring out high-precision space distance and position detection within the panoramic scope at the same time.

The significance of this paper lies in innovation in photographic surveying technique of the traffic accident scene. It improves the efficiency and accuracy of the traffic accident scene mapping, which can achieve 80%. In addition, the collected data of panoramic stereo-pictures can restore the accident scene and stereoscopical figures to guarantee the integrity of collected evidences.

Fig.1 BODVS Traffic Mapping System Diagram

2. The design of the accident scene mapping instrument based on BODVS

Based on BODVS, the goal of the accident scene mapping instrument is to quickly measure the objects at the accident scene in an all-round and real-time way, with high precision. Fig.1 shows the systematic structure we design which is based on BODVS accident scene mapping instrument, whose hardware consists of a portable computer and a BODVS.

3. Measuring principle of BODVS

Because of the due parallax of the different imaging of the same object pointed on the two separately-located Binocular ODVSs [3], the incidence angle of the corresponding object point of the image can be figured out through the marks on ODVS. Then the triangle calculation model can be formulated. The detailed information of measure point can be calculated by the method of binocular ranging.

3.1. Structure of BODVS

The document [4] presents three different designs of the BODVS structure. They combine the two single-view-point ODVSs with same imaging parameters vertically in three different ways, namely, face to face, face to back, and back to back. All of the three designs can make sure that the spindles of the two ODVSs are on the same line while forming a BODVS. Considering the investigation instruments on the spots of traffic accidents, this paper adopts a BODVS design with wide baseline and large stereoscopic imaging range. Fig.2(a) is a face-to-face design with wide baseline. Fig.2(b) is the real object of this design. Fig.2(c) is the stereoscopic imaging of this design in a rectangular coordinate system. The slashed part of Fig.2(d) is the stereoscopic imaging range of this design.
The advantages of the BODVS design above are as follows: (1) the two ODVS viewing fields won’t shade each other; (2) the possible measuring range is relatively large; (3) it allows a wide baseline.

In this paper, the mid point (the central eye) of the two ODVS viewpoints up and down are regarded as the original point of the Gauss plane coordinate system, as illustrated in Fig.3. The measuring points of the scene of the accident are located on the spheres of different radiuses. The spatial position of every measuring point is expressed by the Gauss coordinate \((r, \phi, \beta)\).

3.2. Calculation of the point’s depth information and azimuth.

Fig.4 shows the depth of measurement points P, it can be calculated by the principle of binocular vision. A, B points represent the point of view of ODVS in Fig.4. Point O is the central eye. DC is the distance of baseline. \(\Phi_1\) and \(\Phi_2\) represent the same measurement point P’s angle of BODVS. According to the principle of BODVS imaging, the distance between the measuring point and the central eye points can be calculated, as long as the incident angles of BODVS (namely \(\Phi_1\) and \(\Phi_2\)) and the length of the baseline AB are known. The measuring point is within the binocular stereo imaging scope. From section 3.2, it is known that the \(\Phi_1\) and \(\Phi_2\) Angle can be calculated through the Eq.1.
\[
\tan \varphi = \frac{f}{u} = \frac{\alpha_0 + \alpha_1 u^1 + \alpha_2 u^2 + \cdots + \alpha_n u^n}{u^p}
\] (1)

From the length of the baseline AB, DC has been set in the design of Omni-Directional Vision Sensors (ODVS) structure. The distance of point O and point P which represents r can be calculated according to the trigonometric formula.

The panorama of the pixels on the coordinates, according to the Eq.2 we can easily find out the azimuth \( \beta \).

\[
\beta = \begin{cases} 
\varphi, 0 \leq \varphi < \frac{\pi}{2} \\
\pi + \varphi, \frac{\pi}{2} \leq \varphi < \frac{3\pi}{2} \\
2\pi + \varphi, \frac{3\pi}{2} \leq \varphi < 2\pi
\end{cases}
\] (2)

In the formula, \( \varphi = \arctan \frac{y_p - y_{center}}{x_p - x_{center}} \), \( x_p \) and \( y_p \) represent the pixel coordinates of the image, while \( x_{center} \) and \( y_{center} \) represent the pixel coordinates of the central point.

4. Automatic generation of the accident scene graph

This graphic symbol library of road traffic scene is constructed according to the national standard of The Graphic Symbol of Road Traffic scene of the PRC. Part of graphic symbols are illustrated in Fig.5. Every graphic symbol in the library can be dragged, translated, zoomed and rotated [5], and the drawing model will draw the graphic symbol, according to the measurements, on the base map, i.e. generate the graph of road transportation trouble spot automatically.

![Fig.5 Graphic symbol of road transportation accident spot](image)

![Fig.6 Definition of model symbol](image)

The properties of the graphic symbols include the vertex coordinate, the center coordinate, coordinates of every feature point, the width and the height of the model, the azimuth angle of a feature point relative to the center coordinate, the scaling factor, the rotation angle and the distances between the center to every feature point. The model will generate the graphic symbols by searching the relevant models in the library according to the different traffic elements and measurements of different feature points (the feature points of a car are the center coordinate of the four wheels and the four vertices, for example). For the car model as illustrated in Fig.6, it is necessary to define the vertex \( p_1 \), the coordinate of center \( C(x_c, y_c) \), the coordinates of other feature points \( (p_2, \text{etc}) \), the width \( \text{imgWidth} \) and the height \( \text{imgHeight} \) of the car model, the azimuth angles \( (\varphi_1, \varphi_2, \text{etc}) \) of every feature point relative to the coordinate of center \( C \), the scaling factor \( \text{scale} \), the rotation angle \( \text{rotate} \) and distances \( (d_1, d_2, \text{etc}) \) of every feature point to the center coordinate. After defining the internal points and their correlations, the drawing model will draw the symbols on the base map coordinate by means of zooming, translating, dragging and transferring according to different measurements.

5. Experimental studies on the coordinate machine of the scene of road traffic accident
We will use the coordinate machine of the scene of road traffic accident based on BODVS to survey a simulated scene of road traffic accident.

The whole mapping process is as follows: The coordinate machine based on BODVS is first placed in the centre of the simulated scene of road traffic accident, drawing the accident scene sketch in the current time; as shown in the left of fig.7, the top left shows the panorama taken by the upper ODVS, while the bottom part is the panorama collected by the lower ODVS. Then, click the mouse to get feature points, such as the left front wheel and left rear wheel of the red car, between which the distances and directions can be figured out automatically by the program through using trigonometric formula. And choose the graphic symbols and corresponding feature points in the Model Database on the human-computer interface, then pick the Add buttons below the graphic symbols; thus, corresponding graphic symbols, according to the measurement results, can be automatically spotted on the base map, labelling the distances and azimuths. Fig.8 is an application of a simple accident scene plan drawn by the coordinate machine presented in this paper. The whole process of measuring and drawing is finished in three minutes.

6. Conclusions

The surveying and mapping machine presented in this paper have the following characteristics: A. Compared with the present manual method and stereo photogrammetry technology, the measuring accuracy can be improved by almost 50%; B. It is able to survey and map quickly disregarding the weather condition; C. In the way of processing the measuring data and restoring the scene, it is convenient to do the quadric information extraction of the accident scene; D. When drawing the accident scene sketch, it is an automation technology; E. For the convenience of storing, filing and searching the on-site information, it can offer systematic, complete and visual grounds while dealing with serious and complex traffic accidents.

In the future research, the BODVS technology will be combined with Virtual Reality technology and 3D Animation technology to achieve a high level of the visual restoration of the accident scene and digital stereo representation.

References