# Research on the Application of Reverse Technology in Traffic Accident Treatment

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Abstract: In recent years, frequent traffic accidents have led to the decline or even interruption of traffic capacity, which has brought huge economic and life and property losses to the society, which has higher requirements for traffic survey. It is found that the traffic jams will be reduced by about 5 minutes every 1 minute fast in dealing with traffic accidents, thus indirectly reducing economic losses. Therefore, using advanced technology to deal with the traffic accident scene quickly is of great significance to solve the problems in traffic accident scene investigation. In this paper, how to quickly and effectively explore the scene of major traffic accidents is the goal. On the premise of accurate investigation and proper disposal of traffic accidents, reverse technology is introduced to restore the scene of traffic accidents.

## 1 RESEARCH SIGNIFICANCE

Traffic accidents are imbalances caused by roads, vehicles and people in the designated environment, and the impact is a global public safety problem. According to the report on the current situation of global road safety 2018, road traffic accidents cause about 1.35 million deaths every year in the world, and it is expected that by 2030, traffic accidents will rise to become the fifth largest cause of death in the world. During the same period the number of vehicles worldwide has steadily increased, while death rates declined from 135 deaths for every 100,000 vehicles in 2000 to approximately 64 deaths for every 100,000 vehicles in 2016 (Figure 2). This represents a reduction of more than 50% in the last 15 years suggesting some progress in mitigating the adverse effects of increasing motorized transport. Although progress has been made, these data show that it has not occurred at a pace fast enough to compensate for rapid population growth and increasing motorization worldwide. (Global status report on road safety 2018)

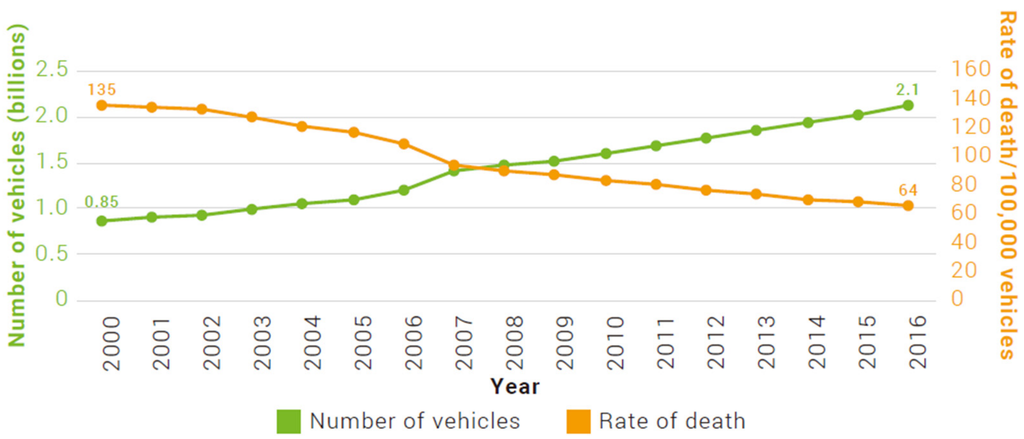


Figure 1: Number of motor vehicles and rate of road traffic death per 100,000 vehicles: 2000–2016.



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Table 1: Statistics of road traffic accidents in China from 2011 to 2016.

| Particular year | Number of accidents (Times) | Number of injured (Person) | Death toll (Person) | Direct economic loss (RMB 100 million) | Death rate per 10000 vehicles (%) |
|---|---|---|---|---|---|
| 2011 | 210812 | 237421 | 62387 | 10.78 | 2.80 |
| 2012 | 204196 | 224327 | 59997 | 11.70 | 2.50 |
| 2013 | 198394 | 213724 | 58539 | 10.38 | 2.30 |
| 2014 | 196812 | 211882 | 58523 | 10.75 | 2.22 |
| 2015 | 187781 | 199880 | 58022 | 10.37 | 2.08 |
| 2016 | 212846 | 226430 | 63093 | 12.10 | 2.14 |

The economic losses caused by road traffic accidents account for 1% - 3% of the world's GDP every year, about 518 billion US dollars. According to the statistics of national economic and social development in 2016 by the National Bureau of statistics of China, the number of civil vehicles in China reached 185.7million, including 28.1million private vehicles. With the rapid growth of China's civil vehicle ownership, the number of drivers is also growing significantly, with an average annual growth rate of 12.42% between 2007 and 2016. By the end of 2016, the number of motor vehicle drivers in China has reached 303 million. According to the analysis of relevant data by the traffic police department, drivers with driving age less than 3 years have the most traffic accidents, accounting for 39% of the total number of accidents (Qiang Chen, 2017).

The increase in vehicle ownership and the relatively weak safety awareness of drivers have led to a increase in the number of traffic accidents in China. According to the road traffic safety development report (2017), in 2016, there were 8.643 million road traffic accidents in China, an increase of 659 thousand on a year-on-year basis. Among them, there were 212846 road traffic accidents involving casualties, 226430 injuries, 63093 deaths and 1.21 billion RMB of direct property losses (Ministry of transport, 2017). In 2016, the death rate caused by traffic accidents was 2.14, 2.9% higher than that in 2015. The statistics of road traffic accidents in China from 2011 to 2016 are shown in Table 1.

If the traffic accident is not handled in time, it will easily lead to chain reaction, resulting in more economic losses and adverse social impact. The losses mainly include the cost of treatment, rehabilitation, rehabilitation, work delay, on-site rescue, traffic jam, insurance and other costs. Therefore, it is necessary to use advanced technology to deal with the traffic accident scene quickly. Research shows that every 1 minute fast in dealing with traffic accidents, traffic jams will be reduced by about 5 minutes, thus reducing economic losses (Lidong Tan, 2009).

# 2 RESEARCH METHODS

The main method of this paper is to use the reverse technology to obtain the three-dimensional point cloud of the traffic accident scene in a short time, record all the information of the accident scene completely, so as to deal with the traffic accident quickly and reduce the traffic jam time.

In this paper, taking the UAV as a platform, equipped with a three-dimensional laser scanner used in reverse technology to record the scene information of traffic accidents. According to the statistical data at home and abroad, the traffic accident rate at night is 2-3 times larger than that in the day, and the principle of the full-color laser scanner itself determines that it must work in the day with sufficient light, so in order to improve the data accuracy, this paper adopts the modeling method of laser scanner + tilt image, and then after the post-processing, the traffic accident scene model data is output. The three-dimensional model can also be used for later accident analysis or as a kind of evidence.

## 2.1 Information Collection Technology of Accident Site

The basis of reverse technology is to obtain high-precision data, and the three-dimensional laser scanning technology and artificial intelligence algorithm developed in recent years is such a new technology, which can quickly and accurately obtain the three-dimensional data model of the object.

### 2.1.1 Introduction of 3D Laser Scanning Technology

3D laser scanning technology is a kind of technology developed from surveying and mapping technology. It has the advantages of high precision and high efficiency. It can give precise coordinates for points in space. Such technical products mainly include CMM, total station and laser tracker. The 3D laser scanner records the 3D coordinates of the whole or part of a given target.

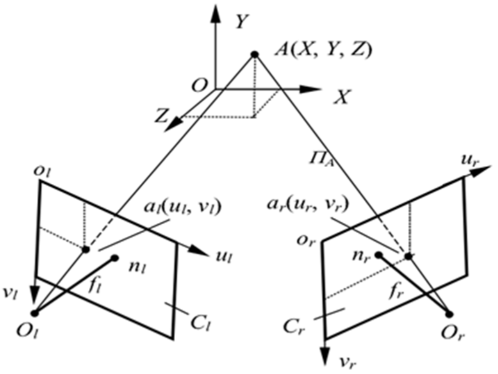


Figure 2: Schematic diagram of laser scanner.

The principle of 3D laser scanner is to send infrared beam to the center of rotating lens through the front end, rotate the laser around the detection environment, once it contacts the measured object, the beam will be reflected back to the scanner, and then calculate the rotation angle and horizontal angle of laser by computer according to the change of infrared position, so as to obtain the X, Y, Z coordinates of point A (Housheng Huang, 2014). The calculation method is shown in Fig. 2, and the corresponding parameters of left and right cameras are marked with l and r respectively. The image points of point A (X, Y, Z) in the three-dimensional space on the image plane$C_l$and $C_r$ of the left and right cameras are $a_l(u_l, v_l)$ and $a_r(u_r, v_r)$, respectively. These two image points are called "conjugate points". They are respectively connected with the optical centers $O_l$ and $O_r$ of their respective cameras, that is the projection lines $a_l O_l$ and $a_r O_r$ , and their intersection points are obtained to obtain the coordinates of the object points A (X, Y, Z) in the three-dimensional coordinate system. One type of laser scanner is shown in Figure 3.

Figure 3: A type of laser scanner.

Suppose that the coordinates of the two CCD cameras are $O_l x_l y_l z_l$ , $O_r x_r y_r z_r$ , respectively; the focal lengths of the two CCD cameras are fl,fr, respectively. The coordinates of the measured object point P in the measurement coordinate system of the CCD cameras are $(x, y, z)$ , $(x_r, y_r, z_r)$ , and the relationship between them can be expressed as follows:

$$\begin{bmatrix} x_r \\ y_r \\ z_r \end{bmatrix} = M_{lr} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} R & T \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \qquad (1)$$

In Formula 1, $M_{lr}$ is the space conversion matrix, R is the rotation matrix, indicating the rotation relationship of two CCD camera coordinate systems; T is the translation transformation, indicating the translation relationship of two CCD camera coordinate systems. Among them:

$$R = \begin{bmatrix} r_1 & r_2 & r_3 \\ r_4 & r_5 & r_6 \\ r_7 & r_8 & r_9 \end{bmatrix}, T = \begin{bmatrix} t_x \\ t_y \\ t_z \end{bmatrix} \qquad (2)$$

The coordinates of the space measured point and the corresponding point in the CCD camera coordinate system are $(x, y, z)$ and $(x_r, y_r, z_r)$ , respectively. The relationship between them can be expressed as homogeneous coordinates:

$$\rho \begin{bmatrix} X_l \\ Y_l \\ 1 \end{bmatrix} = \begin{bmatrix} f_l & 0 & 0 \\ 0 & f_l & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$
$$\rho \begin{bmatrix} X_r \\ Y_r \\ 1 \end{bmatrix} = \begin{bmatrix} f_r & 0 & 0 \\ 0 & f_r & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_r \\ y_r \\ z_r \end{bmatrix} \qquad (3)$$

Where ρ is the scale factor (ρ is not 0). The spatial three-dimensional coordinates of the surface points of the measured target can be obtained by combining formula (1) and formula (3):

$$\begin{cases} x = \frac{X_l}{f_l} z \\ y = \frac{Y_l}{f_l} z \\ z = \frac{f_l (f_r t_x - X_r t_z)}{H} \end{cases} \qquad (4)$$

Where, $H = Y_r(r_7 X_l + r_8 Y_l + r_9 f_l) - f_r(r_4 X_l + r_5 X_l + r_6 f_l)$
$= X_r(r_7 X_l + r_8 Y_l + r_9 f_l) - f_r(r_1 X_l + r_2 X_l + r_3 f_l)$.

After obtaining the three-dimensional coordinates of the spatial target points, various three-dimensional measurement tasks can be completed. These are the basic principles of laser scanners. In the actual measurement, the main factors that affect the measurement accuracy are: calibration error, matching error, and camera optical system error.

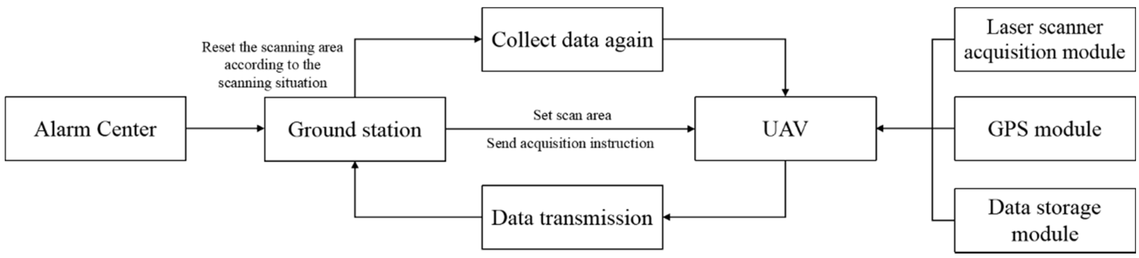


Figure 4: Data acquisition flow chart of UAV.

### 2.1.2 The Data Collection Process of UAV

After receiving the alarm, the UAV will arrive at the scene of the traffic accident according to the GPS positioning and send back the scene image, and then manually set the scanning area and scanning route to ensure that there is a certain overlap rate in the scanning process, which is generally set to 35%, and the heading overlap rate is 60%. The UAV will scan the root set area independently, and the scanned data will be sent back to the base station in real time through the network. Figure 4 shows the data acquisition flow chart of UAV.

The UAV sends the data back to the ground station in sections for data splicing, which can not only effectively prevent data loss, but also save time. After the collection, the manual data verification shall be carried out, and the unqualified area shall be supplemented until the qualified data is scanned.

## 2.2 Processing of Traffic Accident Scanning Data

### 2.2.1 Introduction of Geomagic Software

Geomagic ® software is a professional engineering software brand under 3D systems c®. Geomagic software is used for computer-aided design, focusing on 3D scanning and other non-traditional design methods, such as tactile input modeling based on point cloud. Geomagic wrap software, formerly known as Geomagic studio, is a professional reverse software developed by Geomagic company in the United States. It has advanced algorithm and surface construction capabilities, and can quickly organize point cloud data, automatically generate meshes, and construct complex and accurate digital models. The re grid function of Geomagic wrap software can generate the disordered scanning data into regular polygon mesh data, and also can adjust the mesh surface accurately (Hongming Wang, 2015).

### 2.2.2 Data Processing

The Geomagic wrap (Geomagic studio) software splices data through a variety of commands, and the operation interface is shown in the figure below.

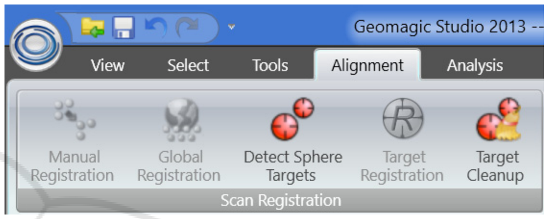


Figure 5: Data splicing operation interface.

After the global registration command dialog box pops up, set the software, click the "application" command to splice all point clouds, and then click the "OK" command to exit the current dialog box and enter the "point" menu. Use the merge option on the points menu to merge the aligned point clouds into a single point cloud.

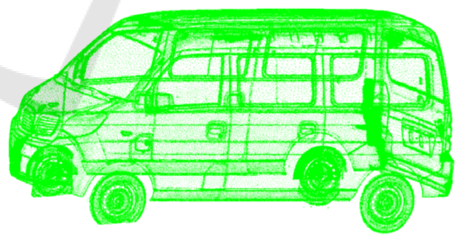

Figure 6: Data splicing results.

The final data can be obtained through a series of processing steps, such as point cloud sampling, noise removal, encapsulation, and deletion of spikes, which can be used for later use.

### 2.2.3 Using Tilt Photography to Make Up for Missing Data

The tilt photogrammetry technology of UAV can improve the modeling efficiency of 3D model. Using UAV tilt photography technology, it takes only three to five months to complete the scanning task which needs one or two years to complete manually, which reduces the time of obtaining 3D model data and saves manpower.

The 3D model obtained by ordinary laser scanner does not have color after processing, which makes it inconvenient to observe, and the model will have some holes, overlaps or gaps, so it is necessary to synthesize a complete 3D model with the help of photographic image. If we use the full color laser scanner, we can get the color data directly, but there are still holes in the data. The existing UAV tilt photography technology only needs to set the ground coordinate point (or even no ground coordinate point) for positioning, then it can quickly obtain high-precision 3D scene and build a digital model. This technology is widely used in 3D model acquisition.

UAV tilt photography technology first uses UAV to obtain all images, and then transmits the images to the computer for relevant option settings. After setting the output format, grid quality and other operations, the renderings as shown in Figure 7 are obtained.

Figure 7: Final renderings.

# 3 APPLICATION OF DATA IN TRAFFIC ACCIDENTS

Using reverse technology to get the three-dimensional model of traffic accident scene is a new method to deal with traffic accidents, and also an important step to shorten the time of dealing with traffic accidents. Some studies show that the use of the new method can reduce the time of investigating accident scene to one-fifth of the original, and the time of later investigation to about one-third of the original.

In general, the data from section 2 can be used to create scenes and measure the relative positions of objects. Law enforcement officers can measure the distances and angles needed on the digital model as an effective basis to determine the cause of the accidents.

# 4 ADVANTAGES OF UAV IN COLLECTING TRAFFIC ACCIDENT DATA

When a traffic accident occurs, the scene of the accident should be cleaned up as soon as possible to reduce economic losses, but the scene data of the traffic accident must be recorded first, which brings great pressure to the traffic police department. Using UAV in traffic accident reconstruction can record the scene data of traffic accident quickly and accurately, so this technology has great potential in law enforcement (Hongming Wang, 2015).

At present, emergency personnel often use laser scanner, total station or photography to record traffic accident data, or use them together to collect field data and generate three-dimensional point cloud. However, it is necessary to close the road or reduce the traffic flow to record the scene of the traffic accident; in some cases, there may be a second accident, which will threaten the life safety of the first responders, police and firefighters. For the above situations, the use of UAV in the scene of traffic accident treatment came into being. UAV can record the scene of accident quickly and accurately, which is an ideal choice for lack of manpower or equipment limitation, and has less risk. UAV can easily cover a wider range of accidents. The larger the accident area, the more efficient the UAV data collection. Drew jurkofsky, an expert in traffic accident reconstruction, has found that the time used by UAV to record traffic accidents is about one fifth of the time used by traditional methods.

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