Three-dimension Point Cloud Technology and Intelligent Extraction of Trace Evidence at the Scene of Crime

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Abstract. Three-dimensional (3D) point cloud technology is a kind of high-tech for the extraction of trace evidence from crime scenes. It is also an artificial intelligence technology for criminal justice investigation and diagnosis with great development prospects. It is one of the frontier issues in the field of criminal science and technology research. The purpose of this paper is to explore and analyze how to use 3D point cloud technology to extract trace evidence of crime scenes on the basis of understanding 3D point cloud technology, and to discuss the intelligent features of 3D point cloud trace evidence extraction. The principle and characteristics of 3D point cloud technology are introduced and described by the method of comparison and example. According to the technical characteristics of laser scanning, the methods and steps of extracting trace evidence from crime scenes are designed, and the overall workflow is given. This paper analyzes the intellectualization of 3D point cloud technology for trace evidence extraction from the perspective of the fusion of technology and perception, and draws some conclusions through simple practical description. Research shows, trace evidence extraction based on 3D point cloud technology is the full embodiment of digitalization and intellectualization of crime scene investigation. Doing a good job in information collection, data sample database construction, human-computer interaction platform design, and the data and knowledge of crime scene diagnosis experience are the basis for the development of this intelligent technology. In addition, with the different characteristics of different crime scenes, the improvement and innovation of the 3D laser scanning method is also an important work in the future.

1. Introduction
Traces on the scene are signs and images that reflect the characteristics of material and environment. The extraction and analysis of trace material evidence at crime scene shows that the completeness of trace material evidence extraction is the premise and important guarantee of crime investigation and criminal proceedings, and the credibility of trace material evidence analysis is the core of the whole criminal case. According to Lockard's principle of material exchange, "there is no scene without traces, and there is no seamless disguise." [1] The famous detective Dr. Li Changwei said: “For criminal forensic work, anything can happen at the scene, and no conclusion can be drawn before the facts are clarified. Let the evidence speak, how much evidence is there and how much can you say. ” [2] The core issue in this field of research is how to discover and extract trace evidence and obtain information on criminal suspects through trace evidence. Although trace evidence researchers and criminal investigation experts have established some effective techniques and methods in the extraction and analysis of trace evidence at crime scene through long-term exploration and practice which have provided valuable experience for the discovery of criminal acts. However, how to find out the existence of trace evidence on the crime scene, how to obtain the complete information of the trace
evidence, how to obtain reliable clues and to achieve the purpose of criminal case investigation through the trace evidence analysis are an unsolved problem in the field of criminal investigation.[3]

The purpose of this paper is to analyze the 3D point cloud data of trace evidence, and to explore the intelligent extraction method of trace evidence from the perspective of mutual integration of perception and technology.

The content of this article is composed as follows: Section 2 introduces the research status of 3D point cloud technology in obtaining criminal information, and gives a brief review. Section 3 puts forward the intelligent extraction method and basic process of crime scene trace evidence based on 3D point cloud technology. Section 4 introduces an intelligent fusion system based on 3D point cloud technology and perception. Section 5 gives the conclusions of the study.

2. Research Status and Review of Domestic and Foreign Research

From the existing research literature, 3D point cloud technology is a high-end information technology, although the generation time is not long, it is developing rapidly, which has been widely used in various fields. In the field of crime scene information acquisition and crime detection assistance analysis, foreign countries started earlier, especially in the field of trace material evidence extraction has entered the practical application stage. With the development of information technology in the field of criminal science and technology and criminal investigation, after the wide application of police GPS, foreign police began to introduce 3D point cloud technology into criminal case detection and achieved great success. Thali et al. (2008) proposed how to use 3D laser scanning technology to obtain new data in crime cases. At the same time, they use the principle of virtual 3D reconstruction to assist investigators identify an incident is an accident or a criminal case. [6] Subke J. (2002) used 3D point cloud technology to simulate the suspect's model in the crime scene. In fact, it is a crime portrait simulation system based on 3D scanning. The technical feature of this simulation system is an intelligent calculation based on 3D point cloud data set. [7]

Buck U. et al. (2013) discussed how to reconstruct the crime scene using 3D laser scanning technology in the process of crime detection through two real crime cases, and simulated the actual crime process on the basis of obtaining the real crime scene data, thus determining the nature of the crime case.[8] Crime scene reconstruction is a hot issue in the field of criminal investigation, and it is also an important research direction for criminal investigation technology to be informationized and intelligent. However, as far as the current research is concerned, there is still a long distance from the real target.

Puentes et al. (2009) used 3D laser scanning and point cloud data to analyze the trajectory of the bullet and model it, so as to analyze the cause of the victim's gunshot wounds.[9] Cavagnini et al. (2009) studied the role of 3D data in crime detection. Here, they describe how to use cameras to extract, record and automatically reconstruct the crime scene from the scene photos.[10] Agosto et al. (2008) studied how to combine a 3D laser scanner with photography, and established a geometric analysis method of crime scene based on 3D point cloud data.[11] In fact, from the research and application status of foreign countries, it can be found that the3D point cloud technology is not only the information acquisition technology, but also the information analysis technology in resolving the problems of extracting evidence from the crime scene and rebuilding the crime scene. Moreover, while information technology be used to get information, people's experience perception should also be integrated.

Chinese scholar Liu Jin et al. (2017) discussed the classification of 3D laser scanning equipment in information acquisition of crime scene, and put forward the basic methods and steps of using laser scanning technology in view of the actual crime scene. Cai Nengbin et al. (2011) scanned the crime scene with a 3D laser scanner to obtain the point cloud data of the crime process. Then, based on the point cloud data describing the crime, the scene was modeled and the dynamic behavior was simulated. Zhu Fuquan et al. (2014) studied 3D reconstruction of crime scene based on Virtools technology (Virtools is a kind of computer software, it has interactive function, can carry out space simulation in 3D real environment), moreover, they have made a detailed analysis of the3D reconstruction process
of the crime scene, the results show that the 3D laser scanning plays an important role in the detection of criminal cases, although the operation process and technical analysis are too complex, the application is more difficult, his research will promote the rapid development of this problem. In the research of quantitative criminology, Chinese scholar He Ping (2003) puts forward the principle of mapping and inversion of crime relation for the problem of information reconstruction of crime scene, and establishes an intelligent reasoning model for point cloud data analysis, which embodies the theory and method of artificial intelligence in criminal investigation from a certain angle.

3. Intelligent extraction of trace evidence in crime scene

3.1. Using 3D scanning to extract the significance of the scene trace material evidence

Due to the non-contact characteristic, the extraction of evidence on the crime scene has great advantages. For example, when footprints on snow are used as suspected traces of a crime scene, the traditional method is to use sulfur to mold footprints on snow. Usually, when collecting evidence of a suspect's footprints, sulfur is used when the traditional method of overturning the footprints on the snow is used. Once the sulfur is injected into the snow print, it quickly cools and forms a crystal of the footprint flip mold, which will damage the original footprint on the scene to some extent. Another way to get footprints is to take photos, but the information obtained by taking photos is incomplete, such as the angle and depth of the footprints. In this way, the non-contact nature of 3D laser scanning technology shows its effectiveness. Using 3D scanner can accurately obtain the characteristics of the traces, and do not damage the scene traces, which is precisely difficult to achieve by traditional methods. As shown in Fig. 1.

![Fig. 1 Extracting snow footprints with 3D laser scanning](image)

Fig. 1 shows the scene of using 3D scanner to extract footprints in snow. In order to get complete footprint information, 3D scanning is required from different angles, and a data file is obtained according to the triangulation principle. In the actual 3D scanning process, the measuring head projects light and shadow on the shoe print on the snow, and then analyzes the change of light and shadow on the shoe print on the snow through the detector. The light and shadow of these changes is the geometric information about the shoe prints on the snow.

3.2. Method of extracting evidence from crime scene

3.2.1. The basic framework for the extraction of evidence on crime scenes

The basic framework of the crime scene evidence extraction based on 3D scanning technology is shown in Fig. 2:
Determine the Position of the crime scene trace evidence and place reflectors

Collecting raw data

Registration of photos and point cloud data

Human-computer interaction to remove useless data and noise points

Calculate multi-viewpoint clouds for each scan location

Triangulation

Data modeling

Raw data collection

Fig. 2 The basic framework for the extraction of evidence on crime scenes

3.2.2. Point cloud data collection

In the process of using point cloud data to carry out 3D modeling of crime scene evidence, the data collection of trace evidence is the premise of the whole process, and it is also an important link, which directly affects the quality of the 3D model of trace evidence. After the criminal investigator arrive at the crime scene, the representative criminal activity area is selected to set the scanning target object, and selects the scanning equipment according to the different scanning target object. In order to obtain high precision and low redundancy point cloud data, it is necessary to avoid the errors caused by unreasonable target selection and artificial error in the scanning process. [12] The basic process of point cloud data acquisition is shown in Fig.3.

Fig. 3 Crime scene point cloud data collection process

4. Intelligent fusion system based on 3D point cloud technology and perception

4.1. From 3D point cloud to criminal investigation digitization

It is an important step for criminal science and technology to move towards artificial intelligence through the 3D laser scanning method to transform crime scene information from traditional picture form and semantic description of criminal record to digital form. In fact, the basic task of artificial intelligence research is to make machines (computer-based object processing systems) have human intelligence. However, in the study of the theory and application of artificial intelligence, information collection is the key to the success of intelligent system development. In the past, in the process of police information construction, the identification and analysis of evidence on the crime scene based on computer has been applied in the actual criminal investigation work. For example, the fingerprint recognition system, the footprint recognition system, and the bullet mark recognition system. These independent trace evidence identification systems are based on image acquisition, feature extraction, coding and conversion into data form by computer software, and then compared with the original sample records of the database to achieve the purpose of trace evidence analysis. In the actual scene investigation, due to the incompleteness of information collection of trace evidence, incomplete image formats will lose information in the process of feature extraction and coding. Although the image
information extracted from the scene is relatively complete, it still gives up a lot of information which cannot be reflected in the two-dimensional image, such as spatial information, dynamic information and environmental information. In order to realize the completeness of information, it is necessary to be able to extract the trace information and the data information of the crime scene space, and transfer the complete data of the crime scene into the intelligent system with crime analysis, which can reproduce the criminal process, determine the evidence of the crime scene, and even it can also serve as a testimony in the court and can play a key role in the analysis of the case. Therefore, this is the real meaning of 3D point cloud data to criminal investigation digitalization.

4.2. From trace evidence data to intellectualization

From the perspective of data description of information, the digital form of trace evidence extraction from crime scenes is a 3D point cloud data measurement, which is also a description of spatial distance points. When physical traces are measured by point cloud data, the traditional trace evidence sample space must also be a 3D point cloud data space. In this way, cloud defamations of trace evidence points is a basic work of trace material management. For example, converting traditional criminal forensics and evidence into digital records, using 3D scanners with 3D printers can quickly produce copies of important material evidence, easy for court display or teaching. Therefore, on the basis of the 3D point cloud data extraction of various typical trace evidence samples, the establishment of the trace evidence card cloud database is the premise of intelligent trace evidence analysis. In addition, in the past crime scene investigation process, on the basis of discovering and extracting the trace material evidence information, it is also necessary to semantically describe the crime time and behavior state based on a certain physical space and possible happen, that is, the so-called crime scene can reflect the information statement of crime time, space and behavior. However, these semantic descriptions are based on assumptions, and their credibility depends on the experience of criminal investigators. It is certain that the hypothesis of experienced criminal investigation experts has a high degree of credibility and this is the criminal investigation intelligence behavior. Therefore, the point cloud dataset formed by the 3D scanning of the crime scene is actually the data meaning of the semantic description. If the relationship between the two is established and has the learning function, then the extraction of trace evidence and the analysis of crime on the spot can be truly from data to intelligence.

In the process of realizing the intelligent extraction of traces evidence of crime scenes, it is also necessary to integrate various information. In the process of realizing the intelligent extraction of traces of crime scenes, it is also necessary to integrate various information. For example, the point cloud analysis combined with on-site photography and photography. First, get photos (static or video) from the crime scene surveillance lens. Then, a photo is attached to the 3D point cloud data, and the photo is projected onto a silver plate standing perpendicular to the ground of the crime scene. According to the analysis of the 3D point cloud data, the height of the suspect can be directly measured on the identified photo, and the correctness of this measurement can be verified by comparing the measurements (the height of the gate). Another example is that through the 3D point cloud data extraction of the bloodstains at the crime scene, the point cloud data analysis intelligent software can measure the location of the suspect's bloodstaining, as shown in Fig. 4.
5. Conclusion

Based on the analysis of the application of 3D point cloud technology in the field of criminal investigation, this paper studies the method of 3D point cloud technology method for extracting evidence from crime scene. Research shows that the application of 3D point cloud technology to extract trace evidence from crime scene is a progress of criminal science and technology, and it is also a full embodiment of intelligent extraction of trace evidence. The traditional extraction of trace evidence can only solve the problem from physical characteristics to physical characteristics, from a single phenomenon to local conclusions, but can not explain the uncertainty of the crime situation and the incomplete trace evidence. Using the 3D point cloud technology to extract the evidence of crime scenes can not only solve the difficulties that traditional methods can't overcome, but also realize the intelligence of trace material evidence extraction to a certain extent.

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