Research on Comprehensive Analysis and Intelligent Reconstruction Technology of Criminal Investigation Traces at Crime Scenes

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Abstract: With the constant escalation and sophistication of criminal methods, traditional criminal investigation techniques are facing increasing challenges. Based on the extraction and analysis of traces of physical evidence and biological information left at the crime scene is an important part of criminal investigation. In order to improve the efficiency and accuracy of crime scene investigation, it is necessary to conduct comprehensive analysis and intelligent reconstruction of criminal investigation traces at the crime scene with the help of advanced physical principles and intelligent technologies. This paper systematically describes the discovery, extraction and fixation techniques of trace physical evidence, and discusses the application of advanced technologies such as image edge detection technology and neural radiation field (NeRF) in crime scene reconstruction. Through the simulation of 3D reconstruction techniques for physical evidence such as footprints and shooting scenes, the crime scene can be objectively and accurately restored, providing strong evidence support for case detection and court proceedings. Meanwhile, this paper proposes a new criminal investigation technology framework integrating trace extraction, analysis and intelligent reconstruction, aiming to improve the efficiency and accuracy of crime scene investigation. The results of this study will provide an important reference for the progress and application of criminal investigation technology.

1. Introduction

Along with criminal activities, the scene of a criminal offense often leaves behind various traces and physical evidence, becoming a huge crime information base. Due to the different manifestations of crime scene trace information, the amount and content of the information carried are different, and trace information itself exists universality, timeliness, sharing and other characteristics, so the public security organs are urgently required to strengthen the research on the comprehensive extraction of trace information from the scene of the crime, so as to be able to scientifically select the extraction method in the process of extracting information from the scene of the crime, and objectively, completely and efficiently extract the traces of the information contained therein to provide strong support for the investigation and litigation stages. The information contained in the traces can be objectively, completely and efficiently extracted to provide strong support for the investigation and litigation stages.

Crimes scene traces of physical evidence of the discovery, extraction and fixation is crucial to record and accurately restore the scene of the crime is the core work of criminal technicians, the current stage of the scene using the image and record data form, there are limitations in the portrayal of the space of the crime process, the physical evidence of the form, type, location, number of large deviations from the actual existence of the form, type, location, number and so on. Trace examination is one of the important means of criminal investigation technology. Observation and comparison of physical evidence surface traces can fully explore the maximum role of physical evidence to help solve the case. Common traces are fingerprints, footprints, tool traces, vehicle tire traces, gunshot traces, etc., traces on the surface of objects at the scene of the crime is objective and impartial, can reflect the fact of evidence.

In addition to scene trace extraction, crime scene reconstruction has also been one of the research

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hotspots in the focus of public security technology, which has been widely used in criminal case investigation and court proceedings, and is of great significance in obtaining key clues to solving the case and forming the chain of evidence. Crime scene reconstruction refers to the reconstruction of the crime content and crime process at the crime scene based on the evidence collected at the crime scene, such as the biological information of the crime location, the location of the traces at the scene, the current status of the physical evidence, and the relationship between each physical evidence, combined with the laboratory test conclusions of the physical evidence, and all the objective facts related to it, and logically integrated in the form of images or physical simulations, in order to identify the criminal's Investigative activity of personal characteristics and conditions of the crime. For those who have not been to the crime scene simple, intuitive and accurate to provide realistic case scene, such as ballistic trajectory, location of the body, blood distribution, the process of the crime, tools and other important information.

With the continuous upgrading and complication of crime means, the traditional criminal investigation technology is facing more and more challenges. In order to improve the efficiency and accuracy of crime scene investigation, it is necessary to comprehensively analyze and intelligently reconstruct the forensic traces at the crime scene with the help of advanced physical principles and intelligent technologies. The aim of this project is to develop a new type of criminal investigation technology integrating the extraction, analysis and intelligent reconstruction of criminal investigation traces through the in-depth study of the application of physical principles in criminal investigation technology, so as to provide strong technical support for the detection of cases.

2. Related Work

2.1. Trace feature extraction and analysis

Crime scene forensic traces are diverse. Fingerprint traces, in many cases played a key role in the investigation, the case investigators according to the fingerprints extracted from the crime tools can directly lock the identity of the suspect. The study of gunshot traces is also one of the key means of solving the case, the bullet passes through the chamber under the action of gunpowder pressure and the inner wall of the rifling extrusion and friction to produce traces of the rifling construction of different firearms, wear and tear there are differences in the degree of the bullet traces can be used to determine whether the bullet is fired for the same gun [1]. The shape, size, depth, location and other characteristics of the firearm firing pin head traces, as well as the impact marks on the thrown shells, etc., are also important features for identifying firearms [2]. Shoe print traces are one of the common traces left at the crime scene, and the rate of shoe print acquisition is usually higher than that of familiar patterns, which is of very high value and significance in the process of case detection. In addition, vehicle tire traces [3], tool traces [4] have high utilization value in the process of criminal investigation.

Traditional traces of access and comparison mainly rely on manpower, generally by the criminal investigation experts to analyze the traces and the results of the comparison, but the manual comparison of time-consuming, laborious, labor-intensive, manual comparison for the utilization of traces of clues is very low. The current deep learning image processing technology is developing rapidly and is widely used in various industries. Trace inspection automation trend is obvious, the inspection work is becoming more and more standardized, and trace inspection technology towards quantitative and qualitative analysis combined direction. Taking pictures of traces and extracting features with the help of deep learning image processing technology to analyze the characteristics of traces can improve the speed and efficiency of criminal investigation trace recognition.

At the level of trace comparison algorithm research, experts and scholars from many domestic universities have put forward many solution ideas for different types of traces. Shanghai Jiaotong University has done extensive research on shoe print comparison technology, proposed a variety of comparison ideas and technical solutions, using Zernike moments, edge description recognition, based on power spectral density and other methods, and achieved better experimental test results [5]. Jilin University uses image processing technology to analyze tire traces, using watershed segmentation algorithm, improved C-V model and SIFT-Gabor transform algorithm to extract the feature points of the tire trace pattern image and match them, with better noise immunity and excellent performance, but the algorithm complexity is high [6]. Huazhong University of Science and Technology developed a slug firing trace recognition system, using a new type of micro-constant force displacement sensor for non-destructive measurement of the slug surface, and using improved wavelet analysis to extract the slug trace feature signals, and achieved a high recognition rate [7].

The loose control of firearms and ammunition in foreign countries, the general public can hold firearms, resulting in many cases related to firearms and ammunition, and their research on firearms and ammunition traces has a history of more than one hundred years, and the research results are more advanced. The U.S. government established the Ceasefire data system in 1992 for storing the U.S. image database of gunshot traces, and further developed the Bulletproof system in 1993 jointly with Forensic Canada to realize the rapid collection of gunshot traces, querying, and Forensic has also developed the IBIS automatic gunshot trace recognition and retrieval system, and Russia has also successfully developed the IBIS automatic gunshot trace recognition and retrieval system. Forensic company also developed IBIS automatic traces of firearms identification and retrieval system, Russia has also successfully developed TANC traces of firearms computerized identification system [8]. The world's most advanced firearms and ammunition traces comparison system DRUGFIRE, with a warhead, shell recognition of the two systems, its function and efficiency is much higher than the TANC and IBIS system, but the principle of the three functions is basically the same [9].

2.2. 3D field reconstruction technology

In recent years, although the traditional criminal cases are decreasing year by year, the murder scene is still the focus of criminal technicians, at this stage, although 3D technology is not widely used in the field department, but the application of crime scene 3D technology to record and accurately restore the criminal cases has become an important research direction. Recently, Dr. Shen Zhengyan of Henan Police College has made a comprehensive discussion and research on the application of 3d Max in crime scene reconstruction, solving the problem of limitations of traditional methods and improving the utilization of information and visualization effect [10]. Nanjing Police College Professor Li Hao crime scene 3D reconstruction and virtual simulation combined with online to offline (O2O) hybrid practical training teaching mode to discuss, give full play to the network and the advantages of traditional practical training teaching methods, so that the practical training courses closer to the actual combat needs, students in practice to better develop the ability to investigate the scene and professional skills [11]. Wang Zhen, master reconstruction of the People's Public Security University of China to video information as the main line, the comprehensive use of time chain, video simulation to reconstruct a dynamic 3D crime scene [12]. Yunnan Police College Professor Liu Xuan according to the changes in the main body of the scene investigation, the use of high technology to understand the suspect crime new methods and means, the concept of scene investigation should realize the dynamic 3D space investigation, an important part of which is to restore the scene through 3D technology, consultation and analysis of the case [13].

The international community is also developing the application of 3D technology in criminal technology day by day, researchers such as George Galanakis of the Hellenic Foundation for Research and Technology (HFRT) described the importance of 3D digitization in crime prevention, crime investigation and education of law enforcement agencies, 3D digitization technology is further presenting its role in a variety of environments including 3D scanning of outdoors, indoors, and in large public areas, to reconstructing large areas of the scene [14]. Ursula Buck, Institute of Forensic Science, University of Bern, Switzerland, uses 3D methods to reconstruct a virtual accident or homicide crime scene, real colors and proportions of the deceased, the scene of the incident, and related items to make a virtual 3D reductions into the virtual incident scene, reconstructing the process of the crime to prove or disprove the suspect's statement [15]. An in-depth study of the use of immersive virtual reconstruction as an aid to jurors during high-precision 3D courtroom trials has been conducted by Carolin Reichherzer of the University of South Adelaide, Australia, in collaboration with researchers such as Dion Sheppard of the Institute of Environmental Science in Auckland, New Zealand, which confirms that VR can offer a promising solution for providing on-site access to the unavailable courtrooms to provide 3D crime scenes [16]. Vinesh Thiruchelvam, University of Asia Pacific, Malaysia, conducted a comparative study on the performance reliability and realism of constructing 3D scenes, using three software comparative studies of Pix4D, Agisoft Metashape and Sirv, which can be used to quickly construct reliable and realistic 3D scenes with Sirv [17]. Richard Fafak of the Department of Mechanical Engineering University in Iowa, USA, studied the numerical simulation of trajectories related to blood droplet diameter, reduced initial velocity and launch angle, and proposed a new investigative crime scene reconstruction tool based on the given distributions of the identified charts, to restore the distribution of blood in 3D [18]. American police are increasingly using 3D technology in crime scene investigations to analyze cases based on reconstructed scene data, and 3D reconstruction techniques are used to accurately depict the relationship of each piece of evidence so that field investigators can reconstruct the crime scene in case investigation.

From the development at home and abroad in recent years, it can be seen that the simple and flexible 3D technology is actively developing in public security education work and actual combat departments, which provides technical support for the fight against crime by accurately reconstructing the process of the crime, the investigation of the case, resource saving, physical evidence extraction and communication.

3. Relevant Technology

3.1. Image edge detection

Edge detection of an image identifies areas of an image where the pixel values change significantly, i.e., edges, by mathematical methods. This variation is usually described by the luminance gradient of the pixel.

Mathematically, an image can be viewed as a two-dimensional function I(x,y), where x and y are coordinates in the image, and I(x,y) is the gray value or brightness value of the image at that coordinate. The basic idea of edge detection is to compute the gradient at each point in the image, which describes the rate and direction of change in pixel values. The computation of gradient can be realized by partial derivatives:

$$G_x = \frac{\partial I}{\partial x}, G_y = \frac{\partial I}{\partial y} \tag{1}$$

Here, G_x and G_y are the gradients of the image in x and y directions respectively. They represent the rate of change of the image in these two directions. And the magnitude of the gradient (also known as gradient strength) is calculated by the square root of the sum of the squares of the gradient values in the x and y directions:

$$G = \sqrt{G_x^2 + G_y^2} \tag{2}$$

The gradient magnitude G indicates the intensity of the change in pixel values. A larger magnitude indicates a more significant change in brightness at that location, and therefore possibly an edge. The direction of the gradient can be calculated using the following formula:

$$\theta = \arctan\left(\frac{G_y}{G_x}\right) \tag{3}$$

Gradient direction θ Indicates the direction of the edges, i.e. the direction of the luminance change.

In practice, computing the gradient of an image is usually realized by convolution operation. Commonly used edge detection algorithms include Sobel, Prewitt, Roberts, and Canny, Sobel uses two 3x3 convolution kernels to compute the gradient in the x-direction and the y-direction, respectively:

$$K_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}, K_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \tag{4}$$

These convolution kernels are convolved with the image I(x, y) to obtain and , thus calculating the gradient magnitude and direction.

When an image is processed using edge detection, noise removal is first performed by smoothing the image (usually with a Gaussian filter) to reduce noise interference. Next the gradient is computed, using the convolution kernel described above to compute the gradient magnitude and direction of the image. Non-maximum suppression is then used, where only the gradient points with local maxima are retained and the gradient values at other locations are set to zero to ensure edge accuracy. Thresholding is then performed to remove weak edges and retain only strong edges by double thresholding method. This process prevents edge breakage and false edge detection. Finally, edge tracking is performed to further connect the edge pixels using connectivity analysis to form complete edges.

3.2. Neural radiance fields

Neural Radiance Fields (NeRF) is a computer vision technique for generating high-quality 3D reconstruction models. It utilizes deep learning techniques to extract object geometry and texture information from images from multiple viewpoints, and then uses this information to generate a continuous 3D radiance field that can render highly realistic 3D models at any angle and distance.

The NeRF technique builds a multilayer perceptron (MLP) model to represent the color and density of each point in the scene by combining input images from multiple viewpoints and camera parameters. During the training phase, NeRF uses image rendering techniques to render the generated 3D scene into a 2D image and compare it with the real image to optimize the model parameters. The key to the NeRF model is how to represent the color and density of each point in the scene. To do this, NeRF uses a technique called volume rendering. Volume rendering divides 3D space into many small voxels and interpolates the color and density in each voxel. By interpolating all the voxels, the color and density values of the entire scene can be obtained.

The structure of the NeRF implementation consists of two main components: an encoder and a decoder, as shown in Figure 1. The encoder usually consists of a convolutional neural network (CNN), which is responsible for extracting the spatial location and viewpoint features of each point in the scene from the input multiple viewpoint images and camera parameters. Each convolutional layer in the encoder maps the input data from a low-dimensional space to a high-dimensional space and extracts a more complex representation of the features. The decoder, which usually consists of a multilayer perceptron (MLP), is responsible for generating a continuous 3D radiation field from the features extracted by the encoder. Specifically, the decoder accepts as input the spatial location and viewpoint features of each point from the encoder and outputs the color and density values of that point. Each MLP layer in the decoder can map the input data to another high-dimensional space and extract a more complex representation of the features.

Figure 1 NeRF working block diagram. Using data from multiple perspectives for training, target locations in space have higher density and more accurate colors, prompting the neural network to predict a more continuous scene model.

In the training phase, NeRF uses a set of 2D images and corresponding camera parameters as inputs and uses rendering equations to convert the input data into a 3D scene. The rendering equations are used to calculate the intersection points of the rays emitted from the camera position and orientation with the objects in the scene, and to determine the color and density values for each point. NeRF then approximates the rendering equations using a neural network to minimize the differences between the generated scene and the real image.

4. Extraction and Analysis Technology of Criminal Investigation Traces

4.1. Crime scene footprint extraction

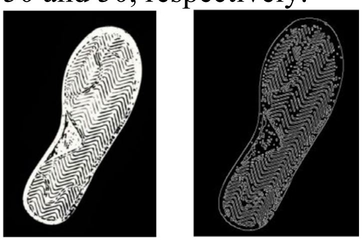
Footprint is a person standing, walking and other activities when their own weight and human muscle force through the foot on the ground and other material objects formed traces. Footprint inspection is through the analysis of footprints, prove and reproduce the process of criminal activity, to provide clues and direction for the investigation.

Photographic extraction of footprints, mainly the use of physical evidence photographic method, which is a realistic record of the footprints of the state, location, the surrounding environment, such as the relationship between objects and the original state of the effective method. Single plane footprint extraction using proportional photographic method, as the name suggests is with a standard scale with the footprint together with the method of shooting into the picture. On the site into a trip plane footprints, in addition to the proportion of the individual footprints separately, but also with a straight line continuous proportional photographic method to take pictures, in order to fix and record the corresponding step characteristics. The camera is moved in a straight line based on a single footprint photographed with the proportional photographic method, and then the scale of the scale is used to recover its step characteristics.

Electrostatic adsorption method for extracting footprints uses an electrostatic adsorber to apply a high-voltage electric field to the surface of the dust footprints, which polarizes the dust particles, thus making the electrostatic adsorption film or plate attractive to the dust particles, and when the dust particles are adsorbed to the electrostatic adsorption film or plate, the footprints are transferred from the ground to the electrostatic adsorption film or plate. It is suitable for extracting flat dust footprints, such as dust plus or minus layer footprints left on relatively flat and dry surfaces such as tiles, marble, wooden floors, floor leather, carpet textiles and so on.

4.2. Contour extraction and comparison

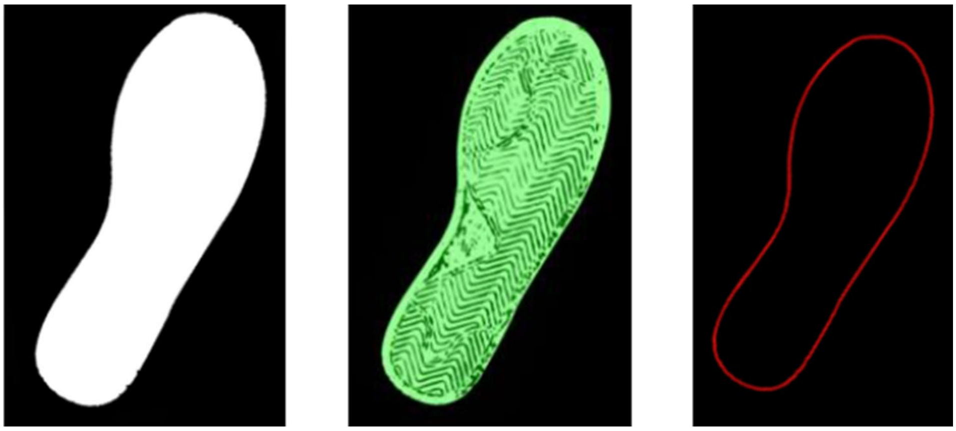
Contour-based comparison and recognition research is a popular area of computer vision research. Humans are more sensitive to gray-scale change information when observing images, which is specifically reflected in the fact that the sensitive recognition of human contours is higher than the sensitivity to color. In the field of criminal investigation trace texture recognition comparison, the contour is mainly used for the recognition of shoe prints, texture primitives, object shape, etc. Fig. 2(a) shows a thresholded footprint trace. The boundary of the contour can be obtained by performing edge detection on the labeled region. Fig. 2(b) is a binarized image, which can be regarded as having been seed-filled, directly to Fig. 2(a) canny edge detection, adjust the upper and lower thresholds of the canny parameter several times, and get the following results when the upper and lower thresholds are 150 and 50, respectively.



(a) (b)

Figure 2 (a) Trace image of shoe print. (b) Canny edge detection of shoe print.

The outline of the shoe print in Fig. 2(b) is visible, but fails to filter the texture inside the shoe print. To solve this problem, the shoe print in Fig. 2(a) is inflated to connect the tiny silos due to the texture of the sole into a piece, so that it becomes one with the contour of the shoe print. However, the swelling treatment will produce certain side effects, i.e., changing the morphology of the contour.



(a) (b) (c)

Figure 3 (a) Close operation result. (b) Contour retained after close operation. (c) Canny edge detection after close operation of shoe print.

Expansion and erosion are pairwise operations, and the expansion followed by erosion operation, i.e., closed operation processing, is performed on Fig. 2(a). When the closed operation is performed, the close elements in the image will be connected, but basically it will not change the shape of the original contour of the shoe print, and the image of the shoe print after the closed processing is shown in Fig. 3(a). The original image of the shoe print is labeled as green and superimposed with the closed processed shoe print to get Fig. 3(b), which shows that the shape of the contour is basically unchanged and the inner part of the shoe print is completely filled. Finally, canny edge detection is performed on Fig. 3(a) to obtain a complete and noise-free shoe print contour in Fig. 3(c).

After extracting the footprint contour, it needs to be compared and analysed. Contour unfolding comparison is to make the contour unfold into a one-dimensional curve according to certain rules, take the discrete points on the curve as the feature vectors of the contour, and get the degree of similarity of the two contours by calculating the distance between the feature vectors. Define the starting point on the contour, expand the contour along the point to generate the x-y coordinate curve, the horizontal axis coordinate is the identification number of the point on the contour, the vertical axis is the distance from the point on the contour to the center of mass of the contour, and then connect these discrete points to form a line sequentially.

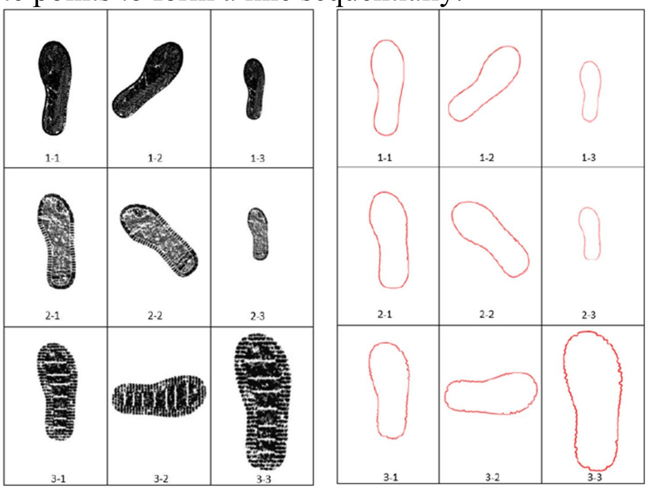


Figure 4 Shoe print contour match experiment.

The results of the shoe print profile comparison experiment are shown in Fig. 4. The nine shoe prints are divided into three groups, each group is from the same shoe, and the profile of the shoe prints is relatively close to each other, which is difficult to discriminate. Labels 1-1, 2-1 and 3-1 are the original images, labels 1-2, 2-2 and 3-2 are the images of the original shoe prints rotated at different angles, and labels 1-3, 2-3 and 3-3 are the images of the shoe prints scaled at different times. Contour extraction is performed on 9 shoe print images with similar shape of shoe print contours.

The above 9 contours are expanded and combined two by two to calculate the cosine similarity relationship between each other, as shown in Table 1.

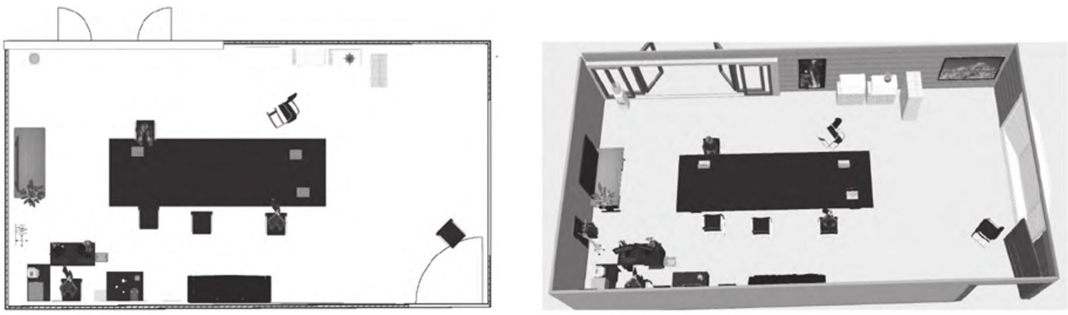
Table 1 Shoe print pearson similarity match results of deployed contour.

Num	1-1	1-2	1-3	2-1	2-2	2-3	3-1	3-2	3-3
1-1	1.0	-	-	-	-	-	-	-	-
1-2	0.9592	1.0	-	-	-	-	-	-	-
1-3	0.9842	0.9980	1.0	-	-	-	-	-	-
2-1	0.9373	0.9914	0.9766	1.0	-	-	-	-	-
2-2	0.9193	0.9844	0.9770	0.9961	1.0	-	-	-	-
2-3	0.9308	0.9909	0.9842	0.9965	0.9966	1.0	-	-	-
3-1	0.9137	0.9844	0.9865	0.9891	0.9960	0.9873	1.0	-	-
3-2	0.9521	0.9752	0.9735	0.9892	0.9824	0.9892	0.9787	1.0	-
3-3	0.9074	0.9859	0.9732	0.9836	0.9945	0.9819	0.9999	0.9836	1.0

5. Simulation Application of 3D Reconstruction Technology

5.1. Crime scene room reconstruction

Combined with the investigation of crime scene traces and physical evidence, biological samples and other investigations, the application of 3D technology to crime scene reconstruction, utilizing its advantages of non-contact, real-time and accuracy, can not only preserve the integrity of the crime scene, but also quickly and accurately record the 3D information of the crime scene, so that the process of the case can be clearly reproduced, and the staff in the courtroom will be able to revisit the scene of the crime again without physically being present at the scene, as shown in Figure 5. The crime scene is reconstructed using Blender software, which synthesizes a plan view of the simulated crime scene (a) and a 3D view under natural light (b). Adjusting the position of the light source, intensity, angle, specific object irradiation and other parameters, it is possible to specifically label the scene in the process of the crime with a huge number of accurate location, the original state, especially the special environment of the light, which helps to restore the most realistic state of the case.



(a) (b)

Figure 5 Simulated reconstruction of the crime scene. (a) planar graph. (b) Under natural light.

As can be seen in Fig. 5, 3D reconstruction technology can truly and objectively restore the real number of items at the crime scene, their positional relationship, and their spatial location distribution after the crime, which can help the scene investigators to analyze and collect the accurate tools of crime, their dimensions, evidences, and characteristics, etc., and to make three-dimensional records for the long-term re-survey and analysis work afterwards.

5.2. Ballistic reconstruction of the shooting

In the crime scene of the shooting case, basically, it will leave the bullet, shell, shooting residue and the formation of traces of gunshot after the firing of the firearm involved. Analysis of the scene of the gunshot traces to determine the type and model of the fired firearm is the focus of the shooting case, the gunshot traces are important physical evidence of the scene. The most important content of the reconstruction of the crime scene is based on the precise extraction of traces of physical evidence, according to footprints, fingerprints, traces of shooting residue, bullet points, traces of the use of tools and other comprehensive analysis of the reconstruction of the scene, Fig. 6 is a simulation of the scene left behind by the firing cartridges, shells, shooting residue, combined with the bullet holes in the clothes being shot, traces of shooting residue to determine the approximate trajectory of the ballistic path and the shooting distance, etc., and judged to have been fired 1 round of bullets. It was determined that one bullet had been fired, resulting in two wounds, two points of impact and two ricochets. Fig. 6 (a) is a general overview of the simulated scene, depicting that the criminal fired one bullet, which penetrated the victim's body (b), hit the floor, and bounced off the wall to form two impact points. According to the shooting traces and special angles, the shooting direction, height, distance and other parameters can be inferred (c), the force on the warhead or cloak and steel core, and their impact on human tissue, floor tiles, walls and other projectile objects, through the depth of penetration and radial penetration capacity, the distribution of the texture of the point of impact and the analysis of the stress-strain, and the traces of the cartridge case characteristics of the gun can be understood the type of the gun, the shooting of the initial kinetic energy, etc., which plays a vital role in the reconstruction of the shooting crime scene. scene reconstruction has a vital role. In addition, according to the bloodstain adhesion, the location and quantity of gun wrappings can also be used to assist in determining the ballistic trajectory, shooting distance, etc., or the DNA of the suspect extraction and prosecution of important evidence.

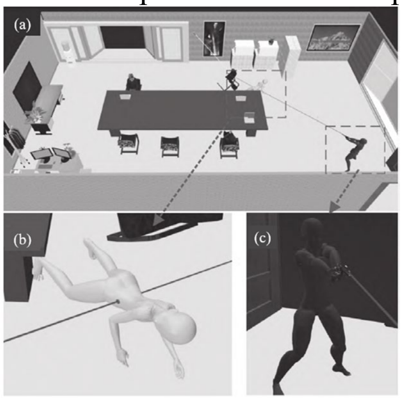


Figure 6 Simulated reconstruction of crime scene shooting. (a) Overall overview. (b) Shot state of the person being shot. (c) Shot state of the shooter firing a shot.

The three-dimensional map of the scene of the shooting case can well reflect the detailed characteristics of all the objects involved in the shooting process, and accurately reflect the quantity, distance, location and other physical evidence relationships. Objective restoration of the shooter, gun, gunshot traces, the victim's body, the shooting position between the distance, location, direction and other details of the relationship between the scene analysis to provide accurate data, the scene reconstruction for the court to provide strong physical evidence.

5.3. Fixation of traces and physical evidence and depiction of the criminal process

Scene investigation in the warheads, cartridge cases, firearms and firearms cases involving the focus of the scene of physical evidence, not only trace inspection and footprint extraction, latent fingerprints appear and other work. Also have to carry out the extraction of shooting residues, the sequence is very important, generally use non-destructive optical methods for footprints, fingerprints, as well as DNA, the discovery of trace physical evidence. After the discovery of fingerprints and other non-destructive extraction, can not meet the identification requirements of the need for further manifestation of the work should be in the shooting residue extraction, further use of lossy manifestation, fixation and extraction. Extraction work is more detailed, the surface of the object not only need to carry out the extraction of shooting residues, but also need to carry out the extraction of biological information such as DNA or other trace attachments, so the extraction of a huge number of evidence, the extraction order of the results will also have a huge impact. On the scene, it can be real-time according to the order of the investigators to find, discover, fix and extract traces and material evidence in the application of 3D technology to carry out detailed labeling, accurate records of the order of extraction and extraction of the type, quantity and other information for the public security of the actual work of the difficulties to find a solution.

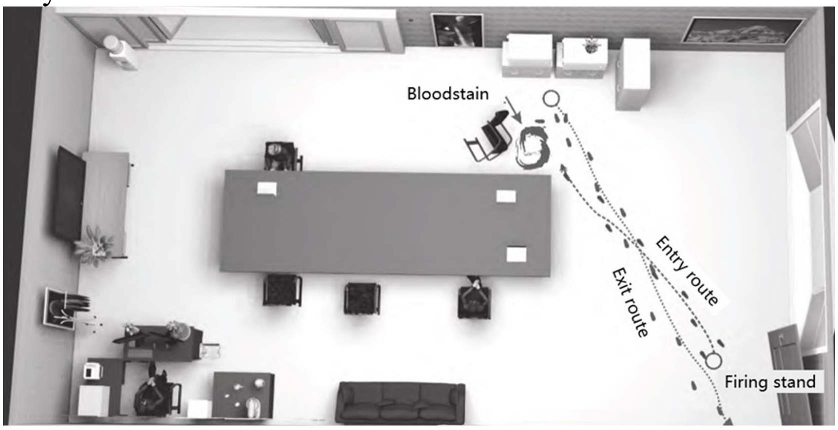


Figure 7 Analyzing the crime process by simulating footprints.

Fig. 7 is through the 3D technology simulation of the scene of the crime, can be engraved through the three-dimensional mode of the footprints left at the scene of the crime, can be based on the real footprints affixed to the barefoot, socks, shoes, the formation of a single or a trip of footprints, combined with the number of footprints left at the scene of the crime, the direction of the size of the footprints and the characteristics of the shoes for the analysis, the judgment of the gait characteristics of the specific parameters of the gait characteristics, the calculation of criminals, height, age, physical and other characteristics. The same can be based on the distribution of shooting residue and shell throwing direction, distance and other laws to confirm the judgment of the shooting point is correct. Even according to the distribution of criminal footprints, from the shooting point to the center of the blood trail in the path of departure can be clearly marked. Through the bloodstain distribution patterns, entry routes, exit routes and other important physical evidence to analyze the crime psychology and modus operandi, can visually reproduce the crime process.

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