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Research for the Application of 3D Technology in Crime Scene Investigation in Viet Nam

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Abstract:- Researching and manufacturing 3D scanning devices suitable for each scanning object has an increasing demand in industry and in life. The field of crime scene examination in the police profession in our country is also demanding innovation in line with the digital data platforms that the government is building. Grasping that practical need, the research team has researched and manufactured a 3D scanning device system including 1 mobile scanning device using infrared laser according to the Time of Flight principle and 1 static scanning device using structured light Gray Code. The device system is capable of 3D scanning and rendering large spatial areas with accuracy about 1 mm, thin tissues in 3D space at crime scenes, vehicle accidents, etc., and samples collected at the scene with an accuracy about 0.1 mm, contributing to improving the efficiency of experimental investigation.

Keywords:- *Structured Lighting, Time of Flight (TOF), Crime Scene, Virtual Reality (VR), Augmented Reality (AR).*

I. INTRODUCTION

3D technology has been researched and developed very strongly in recent years. Popular in many technology platforms as well as diverse applications in industry, life and security and defense. 3D scanning measuring devices help product quality management improve accuracy and productivity in industry; 3D recognition simulation is widely applied in the fields of entertainment, security and defense; 3D printing equipment improves the efficiency of prototyping and creates products with specific characteristics such as artificial bones, human biological parts, artificial meat...

In the fourth industrial revolution, virtual reality (VR) and augmented reality (AR) are applied in many different fields. The basic foundation of this technology is contactless 3D scanning devices based on principles such as laser scanning, structural light scanning, stereo scanning, etc. With the main advantages of high scanning speed, low hardware cost, accuracy suitable for scanning objects. One of our research areas is the application of 3D scanning technology to simulate crime scenes in order to improve the efficiency of experimental investigation.

The crime scene is the place where the crime occurred. Criminal cases which include cases, accidents, social evils, in which there is or no crime. That is the place where law enforcement agencies need to conduct an autopsy to detect and collect traces, evidence, as well as information that sheds light on the circumstances of the incident that happened [1]. In order for the survey and analysis of samples to be intuitive, capable of flexibly storing, it is necessary to study the application of field construction and 3D scanning technology. From the 3D image of the object, it helps professional staff to more accurately analyze the scene as well as the traces of the case. Reconstruction of organic specimens, tire tracks, shoe prints, wounds... the resulting data is more informative than other traditional methods, with access to episodic records or visual field information and not limited by the lifetime of traces….

Figure 1 is a simulated image that reproduces a traffic accident scene, from 3D spatial scanning data of the accident, determining the relative positions, brake tracks, dents on the body of the vehicle.... Virtual reality technology can be used to reconstruct the process of an accident. Simulation and exploitation of 3D data similar to the above can be applied in the experimental process of investigating criminal cases, professional training, combat training....

Figure 1: simulated image of the collision process in a traffic accident using 3D scanning technology and virtual reality [2]

The core issue to bring 3D technology into investigative practice is the research and application of 3D scanning devices and simulation data processing software. In the world, there are many companies that have developed equipment for surveying and 3D spatial reconstruction such as: Faro, Leica, etc. However, the high cost of equipment and software is difficult to use, so the deployment is equipped for Police units are very difficult. The research team realized the urgency of 3D rendering on the scene in the context that digital management methods and digital data traceability are gradually forming, thereby orienting the research and manufacturing of 3D scanning systems for CSI. Our research system consists of two devices: a scanner using a TOF sensor for large areas and specimens and a structural light scanner using a Gray Code for small specimens that need precision.

II. RESEARCH METHODS

2.1. 3D scanning method using ToF sensor

The operating principle of the 3D scanning device is to use 3D position sensors to identify points on the surface of the "object to be scanned". The obtained data is sent to the “data processing unit”. The data processing helps to build the grid coordinates of the object to be scanned. Using mathematical tools that can simulate, determine the size and characteristics of the object to be scanned. The 3D sensor used in the study is a TOF sensor that works on the principle of measuring the time it takes for light waves to travel from the source to the object and back to the sensor. d is the distance from the sensor, the simplest case can be expressed as follows:

$$d = \frac{t_r - t_e}{2} \times c \quad (1)$$

Where te and tr are the time to emit and receive light pulses, c is the speed of light in air. Determine the distance d of each scan point to obtain the spatial 3D point cloud you want to scan.

2.2. Structural light scanning method using Gray Code

The 3D scanning method using structured light is based on the principle of trigonometry in optics. The principle of 3D scanning device using structural light is shown in Figure 2. The projection device will project 2D sample images designed according to a certain coding method onto the surface of the measuring piece, the 3D profile of the work piece. details that distort the projected image and are recognized through the camera system. Analyze image data and incorporate projection coding methods to reconstruct the point cloud coordinates of the measured part. The scanning device using structured light is composed of three main parts: the image projection unit, the image acquisition unit and the measurement signal processing unit [3].

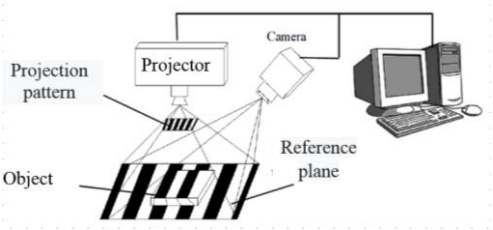


Figure 2: Schematic diagram of 3D scanning device with structured light

Gray coding is a form of structured light used in 3D profile scanning of parts with projections of only alternating black and white lines. The basic idea of this method is to project the projections in such a way that the projection space is divided into distinct parts, and each part can be identified by a binary code based on sequential projections. The method was first mentioned in the field of profile measurement by S. Inokuchi, K. Sato, F. Matsuda [4] in 1984.

During the measurement process, the projected samples are projected onto the measurement piece in turn and captured by the camera. When designing the Gray projection models, it is necessary to ensure the standards that Gartner [38] gave as follows:

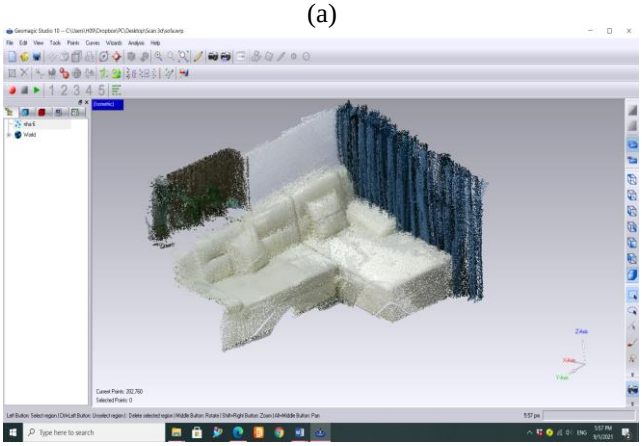
- The binary code of each projection is unique: Each code in the cipher suite is determined by a binary encoding algorithm that must be unique and there should be no duplication of codes.
- Self-adaptive ability: due to the influence of ambient light and the reflection of the workpiece surfaces, the gray scale intensity of light and dark fringes can change on different regions of the image. Photo. Therefore, a fixed threshold value may not satisfy the processing requirements on the entire image.
- The bit code for contiguous trails differs by only one bit. The decoding will build a phase image combined with the

analytical method to determine the coordinates of the measuring points.

III. RESULTS AND DISCUSSION

The field simulation 3D scanner is built on a sensor platform using the TOF principle. The software is developed on the Visual Studio 2015 platform with the QtCreator 5.11.1 library...In Figure 3, the device image is manufactured and the 3D simulation image of the room you want to scan and build. The device has the advantages of flexibility, accuracy, hardware cost to help equip professional units in the police industry to bring efficiency in their work. The device is capable of simulating large spaces such as rooms, stairs, car collisions... with an accuracy of about 1mm. The re-enacted case space makes it easier for officials to judge, and can move forward without needing to re-experience criminal acts that are very complicated today, and at the same time improve efficiency. of experimental investigation.

(a)



(b)

Figure 3: Device image and test scan data of TOF (a) Device image (b) 3D simulation of the generated space during test scanning

Figure 4 shows an image of a fixed scanning device using the principle of structural light with a structure consisting of a rotating table for scanning objects and a sensor cluster consisting of a two-camera system and a digital projector. The manufacturing equipment is capable of scanning samples with dimensions of 300x300 mm with an accuracy of 0.1 mm. Scanned and simulated specimen images can determine the dimensions. 3D point cloud data mining can be used for reverse engineering, prototyping, or reconstructing samples using 3D printing methods.

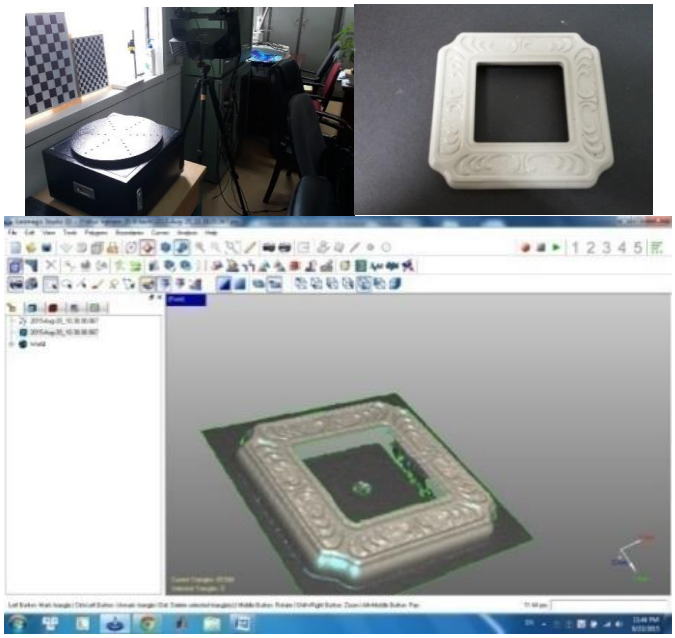


Figure 4: Image of fabricated structural light device and scanned specimen during experiment

The 3D point cloud data can be stored in a variety of 3D data formats suitable for many point cloud data mining software. The reconstruction scan using 3D scanning technology helps to reduce the time to examine and collect samples at the scene. Improve the efficiency of experimental investigation.

IV. CONCLUSION

The built-in 3D scanning system is capable of scanning crime scenes and samples collected from the scene, contributing to improving investigation efficiency. Exploiting point cloud data makes it possible to determine the relative positions of objects on the scene, analyze and judge some situations in experimental investigation. With a large spatial accuracy of about 1 mm and small specimens of 0.1 mm. The system can also be applied in many other fields to improve the versatility of products serving the police and civil service, which is an orientation in the development of science and technology of the industry.

REFERENCES

[1]. Ngô Sỹ Hiển, Nguyễn Xuân Yêm, Dương Văn Minh. “Kỹ thuật hình sự” tập 2, Nhà xuất bản Công an Nhân dân, Năm 2013.
[2]. https://www.vcrashusa.com/vc5
[3]. Daniel malacara (2007) “Optical Shop Testing”, A John Wiley & Sons, Inc., Publication.
[4]. S. Inokuchi, K. Sato, F. Matsuda (1984) “Range imaging system for3-D object recognition”, in: Proceedings of the International Conference on Pattern Recognition, pp. 806 –808.
[5]. H. G¨artner, P. Lehle, and H. J. Tiziani (1996) “New, highly efficient, binary codes for structured light methods”. In Proceedings of SPIE 2599, pages 4–13,