

# Application of Leading and Innovative 3D Technologies for Crime Investigation

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**Abstract** Until recently, 3D scanning, modeling and virtual reality technologies were associated exclusively with a spectacular picture on the PC screens. However, today each of us is faced with this kind of technology in our everyday lives.

In particular, such leading technologies can be used to restore the situation in which the crime was committed, to recreate the crime model, and also open up new opportunities and take to a whole new level the process of detecting, fixing and studying traces, and conducting various expert studies. The purpose of this paper is to study, based on the available information and practical results, not only the essence of 3D technologies and 3D scanners, in particular, but also the possibilities of their application for the purpose of disclosing and investigating crimes. The classification of existing models of 3D scanners allowed us to determine their advantages and disadvantages which can be somehow used in forensics and forensics.

**Keywords:** 3D technology, crime investigation, leading technologies, law, leadership

## 1 Introduction

The advent of 3D scanners was a breakthrough in the field of three-dimensional modeling. Prototypes of modern 3D scanners were used back in the 1960s. They did not have a wide range of capabilities, but at the same time they coped quite well with their main task. In the 1980s, scanner models improved thanks to lasers, and object capture was significantly improved (Watkin 2016). In addition, at about the same time, contact sensors were developed that made it possible to digitize the surface of objects with a solid and complex structure. The equipment was developed using military technology using navigators.

Naturally, not a single modern technology remains isolated in the field of science and technology that generated it. The interpenetration and integration of the achievements of different fields have predetermined the use of 3D-technologies not only for entertainment purposes, but for process optimization in relation to various fields of activity. 3D modeling is currently used in medicine to create artificial organs for transplantation; in aviation, appropriate software for realistic simulation of physical processes is used to adjust the route; in construction and design - for modeling devices and mechanisms. Simply put, hundreds of thousands of different companies in the world use three-dimensional computer simulation technologies for the design, design and production of objects of any complexity: from packaging carbonated drinks to the latest aircraft. Moreover, to create them, the same software is used that allows you to create three-dimensional digital mock-ups of future objects and processes. It seems promising to use 3D technology in the process of disclosing and investigating crimes.

Such characteristics make it possible to use 3D scanners to study objects and tracks found during the inspection of the scene of the incident or obtained during other investigative actions. This paper assesses some of the most promising areas of 3D technology for crime investigation.

## 2. Literature review

Currently, the 3D scanner is a stationary or small hand-held device for scanning objects with complex spatial geometry and reconstructing models in digital format (Nikoohemat et al. 2020). Simple scanners process images in a plane, and 3D scans physical volumetric objects, displaying information with a polygonal model or a cloud of points. Scanners analyze and digitally recreate a three-dimensional model of an object, its shape, relief and even color with a high degree of detail, working in different conditions (with insufficient visibility, in the dark, with vibration), with any materials, provide the desired output information format for software for working with it on a computer (Aleksandrov et al. 2010). At the same time, they use a special lamp or laser to illuminate parts, which increases the accuracy of measurements.

In Russia, a lot of research in various fields has been devoted to 3D-technology issues. However, at the same time, the issue of using three-dimensional modeling for solving and investigating crimes remains in the background. Among the studies in the field of 3D-technologies are some very interesting and inspiring such as the following ones: Vershinina (2014) or Wen et al. (2017). In addition, there are some interesting works by Sivanandan and Liscio (2016), Chase and LaPorte (2018), Buck et al. (2011), Bolliger et al. (2012), or Buck et al. (2013).

## 3. Materials and methods

In order to conduct this study, an analysis method was used, which made it possible, on the basis of available information and practical results, to study not only the essence of 3D technologies and 3D scanners, in particular, but also the possibility of their application for the purpose of disclosing and investigating crimes. The classification of existing models of 3D scanners allowed us to determine their advantages and disadvantages, which can be somehow used in forensics and forensics.

Until recently, for most people, 3D technology was associated exclusively with plasma panels or a spectacular picture on the screen. However, today each of us is faced with similar technologies in everyday life, including working on a laptop, turning the ignition key or even opening a can of drink. With each passing day, the tools in question are becoming more accessible, new prospects are opening up for the use of three-dimensional modeling technologies in various branches of science and technology. So, with the help of 3D-technologies, today it is already possible to print the necessary part that will meet the specified parameters, produce the organ necessary for the transplant, simulate the conditions under which this or that event could develop and proceed, and analyze this process. Including such technologies can be used to restore the situation in which the crime was committed, to recreate the crime model, as well as open up new opportunities and take to a whole new level the process of detecting, fixing and investigating traces.

The creation and implementation of 3D-technologies, like any other innovation, went through several stages in its development, which can conditionally be presented as follows:

- I stage: The history of 3D technologies originates more than a hundred years ago and is associated with the emergence of technology for creating three-dimensional images by shifting images that appeared long before the movie and even photography. The appearance of this method was made possible thanks to the professor from London, Charles Wheatstone, who in 1833 designed and assembled a mirror stereoscope, which made it possible to see a three-dimensional image consisting of two pictures drawn with a certain displacement. After only a few years in 1839, the French artist and inventor Louis Jacques Mandé Daguerre introduced the first camera to the world, which already in 1844 was transformed into stereoscopic thanks to the efforts of Ludvig Mozer, which made stereoscopic images very popular and in demand. Initially, they were static and, most often, became postcards, and posters.
- II stage: The development of the new method went so fast and caused such high interest that already in 1922, the first 3D-film in the history of mankind was presented to the general public. This creation was called "The Power of Love" and on September 27, 1922 it was presented in Los Angeles in the format of a three-dimensional image.
- III stage: In the second half of the 20<sup>th</sup> century, namely in 1984, the American Charles Hull developed the technology of "stereo lithography" (SLA) for printing 3D objects using digital models from photopolymerizable composite materials (FPK), which formed the basis for the ability to print 3D models, currently used in 3D printers. This technology was patented in 1986, exactly at the same time when 3D

Systems was founded and the first commercial device for three-dimensional printing was developed, which was simply called the "installation for stereolithography". A year later, Mikhailo Feigen proposed layer-by-layer formation of volumetric models from sheet material: films, polyester, composites, plastic, paper, etc., fastening the layers together using a heated roller. This technology is called "production of objects by lamination" (LOM). In fact, the sheets adhere to each other, and the laser cuts the contour.

The subsequent development of 3D-technology went quite rapidly. Over the past nearly two centuries, the 3D industry has experienced various periods and stages, each of which somehow ended with the fact that interest in 3D modeling has practically disappeared. And there are objective reasons for this: despite the fact that the method of creating 3D images itself is not complicated, in order for this to be in demand by the audience, a very serious and high-tech approach is required. Of course, it could not be realized earlier precisely because the scientific world did not have the necessary computer power, video playback capabilities, and other developments that allowed us to create a 3D image of the level that we have the opportunity to watch today. So 3D films created using the polarization method in the thirties of the last century required when playing special screens with a reflective effect. And most importantly, a very accurate synchronization of the projectors was necessary, and qualified personnel capable of solving the problems that were present at the 3D cinema of that time.

The basis of the 3D scanner is the ability to determine the distance to the object (individual sections of the surface of the object) at given points, convert the received data into a digital image (three-dimensional model), transfer it to a computer (Mikhailova and Doshina 2015). The scanner determines the coordinates of points in space on the surface of the processed object, analyzes them, forms a detailed digital model by deriving the received information in the coordinate. His work involves cameras, lasers, rangefinders, devices for lighting. The 3D scanner looks like a normal camera, which means that information is collected only from those surfaces on which the light beam was incident. Full-fledged modeling in some cases can be achieved only by conducting several scans. This is necessary for a detailed analysis of a fixed object when it has a complex, asymmetric, composite shape. All data obtained from the emitted ray is laid out in a common system where the planes are referenced and the simulation itself (Sivanandan and Liscio 2016).

Depending on the scanning technology used, the operating principle of the scanner itself is found. The backlight and built-in cameras measure the distance to the object being studied, and the images obtained during the process are compared, after which it is necessary to conduct a detailed analysis of the data obtained from the measurements and display the constructed digital, three-dimensional model on the screen. The use of such a technique and the corresponding software makes it possible not only to further print the constructed digital model of the object, but also to study it in detail both in digital and in material form. All this not only makes it possible to recreate objects that, for objective reasons, cannot be attached to the materials of the criminal case in kind, but also carry out various types of research with the obtained 3D models without fear of damaging them or irretrievably losing them.

Depending on the scanning technology used, all devices are divided into two groups, each of which can equally be applicable in the process of recording traces of crime and other objects, taking into account the nature of the traces being recorded:

1. Scanners using the contact scanning method, implying direct contact with the scanning object;
2. Scanners using the non-contact scanning method, which allows you to create a scan of models located in hard-to-reach places (for example: caches, bullet holes, internal defects of parts, etc.).

The contact scanning method is possible due to the presence of a mechanical probe in the scanner connected to the contacts in the scanner. Such a probe is equipped with a sensor capable of measuring the height, width, depth of the scanned object. The resulting coordinates are collected in a grid, which can be adjusted from the corresponding software. The mechanism provides for the angular movement of the probe, necessary for various kinds of hollows and holes. The process of such scanning can be accelerated on its own by changing the grid step: reduce complex areas, increasing accuracy and reducing time.

Such devices operate on the principle of sensing an object through physical contact when it is on a precision test surface. Such scanners are highly accurate, but they have a significant drawback, which in certain cases makes it completely impossible to use them to fix traces at the crime scene: it can change or damage the object as a whole or its surface (Soltanzadeh et al. 2014). However, it is worth noting that the use of such devices is possible on solid objects, since unstable materials (such as sand, soil, etc.) may not retain their original appearance, which, of course, affect the result obtained - the resulting model. In this kind of 3D-scanners, 3 types of mechanism are used:

1. A carriage or measuring "arm", which is in a fixed perpendicular position, and the study occurs at the moment of movement of the carriage, when the "arm" moves along the object. This imprinting method can be used to scan flat objects and their convex parts.

2. A high-frequency angular sensor is able to scan the internal space of an object with recesses and inlets, as well as perform complex mathematical calculations.

Using these two mechanisms helps to collect information from large objects with transverse partitions and several internal compartments.

3. The coordinate measuring machine allows you to read the subject very accurately, but it can damage or deform it.

Scanning in a non-contact manner is based on the method of studying scanned objects using ultrasound and X-rays. If we study the scanning process in detail, we will see that it occurs due to the property of reflection of the light flux from the surface. At the same time, by light flux we mean equally both ordinary light and a certain kind of radiation. And after such a procedure, the object is subjected to digital research.

In the event that the scanned objects are in illuminated places, reflection of light in the visible range is used. This action allows us to draw a certain analogy between a non-contact 3D scanner and a version of a video camera. However, such illumination is usually not enough for a detailed analysis of the object, the reason for which is the fact that the light can spread unevenly. All this leads to the need to use additional illuminators, which in turn increases the cost of the scanning process and the loss of factors such as compactness and mobility.

The most common technologies used in the work of contactless scanners are the active and passive principle of radiation.

When using the active principle of radiation, direct scanning of objects occurs through the direction of waves from a laser beam or structured light. The scanner sends such rays to the object, while the camera records data about its location in space. The movement of the laser is accompanied by fixation in the field of view of the camera in different places. Such three-dimensional scanners are called triangulation, since the beam, camera and endpoint form a triangle.

Three-dimensional scanners that work due to the passive principle of radiation analyze reflected radiation through light. A laser beam is used as a light source, which, in particular, has the properties of a range finder. It calculates the distance and time the beam moves back and forth. In other words, a certain kind of light "burst" occurs, the reflection time of which is recorded using a special sensor. As you know, the speed of light is a constant value, and knowing the time during which the beam travels the distance to the object and back, you can calculate the distance from the scanner to the object. In 1 second, such 3D scanners can measure up to 100,000 points.

The most common are two scanning technologies - laser and optical. Laser based, respectively, on the work of laser rangefinders, with which the model is read with maximum accuracy. However, the use of such a scanner is not possible if a person is subject to scanning, since the object must be in a completely static position during the scanning process. When using optical technology, a second-class laser is used (hazardous to the eyes in specular and diffuse reflection). The advantage of such a scan is its high speed, and also that the reading of an object is possible even when the object is moving (James 2012). It is not suitable for scanning mirrored, shiny and transparent surfaces, but it is the best option for scanning a person.

Modern developments in the field of 3D-visualization make it possible to combine these technologies, expand the scope of their use, make it more convenient to use and more user-friendly for use. So, released in 2015 by a Russian company, the world's first wireless hand-held scanner designed to digitize medium and large objects (people, cars, yachts, etc.) has already been discontinued. It was replaced by more advanced scanner models, which allow to expand the scope of 3D technology - portable handheld scanners with interchangeable lenses (mini, designed to work with the smallest objects. The models are obtained with the highest resolution and highest accuracy (within 0.15 mm and 40 microns); midi is the best choice for scanning medium-sized objects (including automobile engines and the human body including); maxi. These lenses allow you to get models of vehicles - large boats, cars n, airplanes and people (in full growth) allowing digitizing objects of various sizes with a high degree of accuracy, from a coin to a yacht. In addition, it is now possible to scan objects with a black / shiny / fluffy surface, with sharp edges and very thin walls, hair. Over the past five years, the price range of similar scanner models has decreased three times, and their capabilities continue to expand.

We hope that in the near future, 3D scanning of traces at the scene of the incident will completely supersede traditional methods of recording and removing traces.

In addition, a full-fledged scanning of the scene of the incident and the subsequent work of the investigator and experts with the 3D model, which allows again and again to return to the scene of the incident, where time, lighting, weather conditions and the smallest traces are not, are a promising area for the application of 3D laser scanning technologies in forensics. changes. (Fedotov 2007, pp. 34-38). Today, such devices are widely used in forensics to obtain three-dimensional models of crime scenes.

Some time ago, the United States Department of Homeland Security established and provided special grants to several dozen private companies, which, in turn, pledged to create and present 3D contactless fingerprinting technology. The startups Flashscan 3D and TBS Holdings (Sapse and Kobilinsky 2011) achieved particular success

in carrying out these studies. So both companies use the scanning method with structured light, that is, a grid of light lines, by reflection of which a three-dimensional model of the scanned object can be compiled. This kind of three-dimensional scanning has significantly accelerated the process of building a three-dimensional model (scanners from both manufacturers spend less than one second on a finger, and in the future, developers promise to increase the speed to 0.1 s), reduces the number of unsuccessful attempts to scan (due to the fact that there is no contact with scanner, and accordingly there is no risk of contaminating the surface of the glass or greasing the print).

However, this is not the limit of the possibilities of using 3D scanners in forensic research. Among other things, the capabilities of the 3D scanner made it possible to bring to a completely new higher quality level of ballistic examination. The high sensitivity of the scanning technologies used allows you to accurately capture and study the grooves and grooves remaining on the pool after the shot, which are a kind of fingerprints by which experts can identify the weapons used with a high degree of certainty.

Until recently, conventional photographs of a bullet taken from various angles were used to carry out such studies. However, it is very difficult to talk about the effectiveness and reliability of this method, if only because even a minimal displacement of the fixing device (camera) could significantly complicate the study and even affect the results of the analysis. For example, a forensic expert could take two different grooves from different sides of the bullet for one. However, with the advent of specialized software products, experts and specialists have the opportunity to direct white light through a microscope to a bullet that is subject to investigation in a criminal case, and depending on how intensely this light is reflected, judge the depth of the tracks located on the object..

#### 4. Conclusions

Summing up our findings and results, we can conclude that leading 3D technologies penetrate not only the natural sciences, but also the fields of the humanitarian and applied sciences. Moreover, it can be shown that they can be very helpful in criminalistics. The chosen direction of our study, of course, affects the provisions of the forensic science, as it is directly in contact with the main task - the investigation and disclosure of crimes.

Of course, a number of problematic aspects associated with the 3D technologies should be noted here. First, the equipment that should be used to obtain voluminous models in forensics is worth impressive financial resources. Second, the use of such technologies inevitably requires increasing the level of competencies of specialists and experts.

However, even in the presence of such shortcomings, the advantages provided by the use of the 3D leading technologies considered allow obtaining more information from the scene and making the crime investigation process more qualitative and effective.

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