OPTICAL 3D SCANNER TECHNOLOGY

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ÖZET

Bir bilgisayardaki nesnelerin 3D modellemesi hem zorlu hem de zaman alan bir görevdir. İmalatta 3D üretim teknolojilerinin geliştirilmesiyle 3D taramaya ihtiyaç duyuldu ve nesneler veya kişiler 3D modelleme yerine optik 3D tarayıcılarla kısa sürede ve ayrıntılı olarak çalışma bilgisayar ortamına aktarıldı. 3D parça veya modeli 3D tarama cihazlarıyla dijital hale getirin ve farklı formatlarda dijital formata aktarın. Dijital ortam, iletilen materyali etkileyebilir. Dijitalleştirilmiş model üzerinde düzeltmeler yapabilir ve gerektiğinde modele yeni formlar ekleyebiliriz. Yüksek hassas 3D tarama teknolojisi sayesinde, taranmış nesnelerin tüm ayrıntılarını bir bilgisayar ortamına sorunsuz şekilde aktarabiliyoruz, çünkü 3D tarama ile çok kısa sürede yapabiliyoruz. 3D taramanın yaygın olarak kullanılan birçok alanı vardır. Görüntü işleme kapasitesi artmakta olan bilgisayarların artan üretimi ile birlikte gelişmekte olan 3D tarama teknolojileri, tıbbi ve endüstriyel gibi birçok alanda giderek daha fazla kullanılmaktadır. Tıbbi spesiyaller 3D Tarayıcıların yardımı ile yapılırken, parçaların kalite kontrolü için 3D Tarayıcılardan toplu üretim yapan otomotiv şirketlerinden yardım almak mümkündür. Optik bir 3D tarama sırasında, nesneye hafif bir top gönderilir ve nesnenin genel taslağı tanımlanır. Nokta bulutlarında, taranacak nesne dolup taşar ve nesne bilgisayar ortamına aktarılır. Artan endüstri ihtiyaçlarına en iyi çözümleri bulmak için 3D tarama tekniklerine verdiğimiz önem sayesinde, mühendislik uygulamalarından üretim süreçlerine kadar her türlü ürün geliştirme faaliyeti mükemmel yapılabilir.

Anahtar Kelimeler: Optik 3D Tarayıcı, Mühendislik uygulamaları, Çözümler

ABSTRACT

3D modeling of objects on a computer is both a hard work and a time consuming task. With the development of 3D production technologies, 3D scanning is needed and objects or persons could be transferred to the computer environment in a short time and in detail with optical 3D scanners instead of 3D modeling. It is required to digitize a 3D part or model with 3D scanning devices and to transfer it to digital format in different formats. The digital medium can interfere with the transmitted material. Corrections can be made on the digitized model and new forms can be added to the model when necessary. Thanks to highly precise 3D scanning technology, all the details of scanned objects can be transferred seamlessly to a computer environment, it can be made in a very short time with 3D scanning. There are many areas where 3D scanning is commonly used. Image processing capacity is increasingly used in many areas such as emerging 3D scanning technologies, medical and industrial, with the increasing production of computers. While medical specialties are made with the help of 3D Scanners, it is possible to get help from automotive companies that make mass production, from 3D Scanners for quality control of the parts. During an optical 3D scan, a light ball is sent to the object and the general outline of the object is identified. In the point clouds, the object to be scanned is filled in and out, and the object is transferred to the computer environment. Thanks to the importance, 3D scanning techniques are placed to find the best solutions for increasing industry needs, every kind of product development activity from engineering applications to manufacturing processes can be done perfectly.

Keywords: Optical 3D Scanner, Engineering applications, Solutions

1.INTRODUCTION

In laser scanning techniques, one laser beam is used as a light source. Such laser light sources are not always suitable for digitizing some objects. In the projection method, ordinary halogen white light, which is absolutely safe as a light source, is used. 3D scanning is the process of digitizing an existing part or model with 3D scanning devices and transferring it to the computer environment [1].

Laser scanners record three-dimensional coordinates of millions of points in a very short time span. Direct measurements of spot clusters can be obtained by this system, on the surface scanned by the laser. 3-D models of objects are obtained by recording, combining, thinning, and forming a polygonal triangular mesh, filling voids and surface crossing [1]. 3D scanners, such as cameras, also have cone-shaped fields of view and only information can collected by using them for blurred and non-blurred surfaces. In order to obtain information on all aspects of the obesity, more than one scan is often required from many directions.

These scans have to be brought to a common reference system, which is called registration, and then merged to form a complete model. All this process, ranging from a single range to all the models, takes the 3D scan name. The three-dimensional scanners have two types; contact and non-contact. Point clouds created with a 3D scanner are usually not used directly. Polygonal 3D models are used by many applications, instead of point clouds. A process of converting a point cloud into a polygonal 3D model is called reconstruction. Finding and connecting neighboring points are involved by reconstruction to form a continuous surface [2]. The point cloud obtained by 3D scanners is a three-dimensional structure consisting of many points located in close proximity to each other and transmitted to the digital medium. According to the nature of the work being done and the work done, the point cloud, which consists of thousands and even tens of thousands of three-dimensional coordinates, should best represent the surface to be picked up and ideally modeled. A laser scanner system (TLS) consists of the following components; scanning unit (scanner), control unit, power supply, tripod and tripod [2].

2. 3D LASER SCANNING

With the advent of computers, it was possible to build up a highly complex model, but the problem came with creating that model. So in the eighties, the tool making industry developed a contact probe. At least this enabled a precise model to be created, but it was so slow. The thinking was, if only someone could create a system, which captured the same amount of detail but at higher speed, it will make application more effective. Therefore, experts started developing optical technology. Using light was much faster than a physical probe. This also allowed scanning of soft objects, which would be threatened by prodding. At that time, three types of optical technology were available:

- The point, which is similar to a physical probe in that, it uses a single point of reference, repeated many times. It was the slowest approach as it involved lots of physical movement by the sensor.
- The area, which is technically difficult, it is demonstrated by the lack of robust area systems on sale.
- The stripe, the third system - was soon found to be faster than point probing as it used a band of many points to pass over the object at once, which was accurate too. Therefore, it matched the twin demands for speed and precision.

So stripe was clearly the way forwards, but it soon became apparent that the challenge was one of software. To capture an object in three dimensions, the sensor would make several scans from different positions. The challenge was to join those scans together, remove the duplicated data and sift out the surplus that inevitably gathers when you collect several million points of data at once. One of the first applications was capturing humans for the animation industry, *3D Scanners launched,* which allowed fast, highly accurate scanning of very detailed objects. Meanwhile Cyberware were developing their own high detail scanners, some of which were able to capture object color too, but despite this progress, true three-dimensional scanning - with these degrees of speed and accuracy - remained elusive [3].

Digibotics did introduce a 4-axis machine, which could provide a fully 3D model from a single scan, but this was based on laser point - not laser stripe - and was thus slow. Neither did it have the six degrees of freedom necessary to cover the entire surface of an object, neither could it digitize color surface. While these optical scanners were expensive, Immersion and Faro Technologies introduced low-cost manually operated digitizers [3].

3D Scanners took the key technologies of a manually operated arm and a stripe 3D scanner - and combined them in Model Maker. This incredibly fast and flexible system is the world's first Reality Capture System. It produces complex models and it textures those models with color. Colored 3D models can now be produced in minutes.

Non-Contact Technique

Non-contact 3D scanners, as the name implies, while using them, it is not required to make physical contact with an object surface. Instead, noncontact 3D scanners rely on some active or passive techniques to scan an object. The end result is a highly accurate cloud of points that can be used for reverse engineering, virtual assembly, engineering analysis, feature and surface inspection or rapid prototyping. [3].

Non-Contact passive technique

Passive non-contact 3D technique does not radiate the subject with energy. Instead, passive 3D scanners rely on reflected ambient radiation. Most scanners of this type detect visible light because it is readily available.

Non-Contact passive scanners

Passive scanners do not emit any kind of radiation themselves, but instead rely on detecting reflected ambient radiation. Most scanners of this type detect visible light because it is a readily available ambient radiation. Other types of radiation, such as infrared could also be used. Passive methods can be very cheap, because in most cases they do not need particular hardware but simple digital cameras. Common passive non-contact 3D scanners include stereoscopic video scanners, photometric scanners, Silhouette scanners and image-based modeling scanners. Examples of non-contact passive scanners will be presented in the following sub-sections. **[3].**

Stereoscopic Systems

Two video cameras are usually employed by them, slightly apart, looking at the same scene. By analyzing the slight differences between the images seen by each camera, the distance is possibly determined at each point in the images. This method is based on the same principles driving human stereoscopic vision.

Photometric Systems

A single camera is generally used by them, but multiple images are taken under varying lighting conditions. These techniques attempt to invert the image formation model in order to recover the surface orientation at each pixel.

Silhouette Techniques

Outlines created from a sequence of photographs are used by them, around a three-dimensional object against a well contrasted background. These silhouettes are extruded and intersected to form the visual hull approximation of the object. With these approaches, some concavities of an object (like the interior of a bowl) cannot be detected.

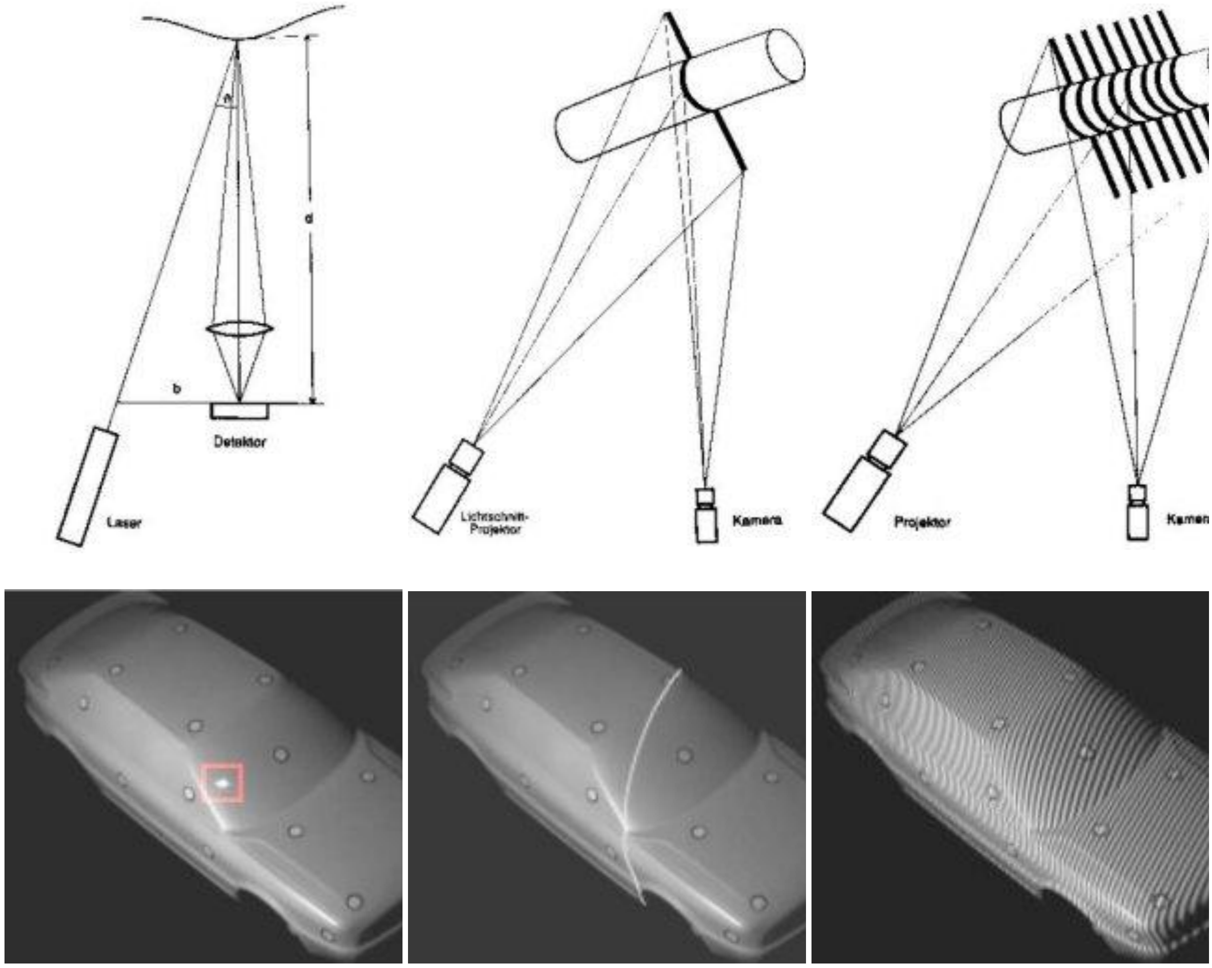

Figure 1.a. Optical triangulation. **Figure 1.b.** Light section technique. **Figure 1.c**. Fringe projection technique.

Non-Contact 3D Scanners

As their name suggest, non-contact 3D scanners do not need any physical contact to probe the subject. Generally, these scanners are fixed on a stand. Active or passive methods are used by them to create a precise cloud of points. The cloud of points is then used in engineering analysis, rapid prototyping, virtual assembly and other industries.

Passive non-contact 3D scanners

Different types of passive non-contact 3D scanners are silhouette scanners, stereoscopic video scanners and photometric scanners. These devices are the most economical of all the scanners. Ambient radiation those situated around the object is utilized by them for determining its shape. Scans are carried by them by using an already present light source rather than emitting radiation themselves [3].

What is 3D Scanning?

3D Scanning is the process of transferring products without computer aided data to the computer environment. Modern manufacturing technology is made using production and computer aided manufacturing methods. For this reason, while the products are designed in the computer environment at the design stage, analysis, virtual reality, simulation, mold design and so on. Applications such as computer-aided programs are used with them. It is required to create 3D CAD data of the product. Digitization systems are mainly used in the manufacturing sector to create CAD data for parts without 3D data or for quality control purposes [4].

How Does 3D Scanning Work?
3D scanning systems are the process of projecting a light source onto a piece of material and digitizing the resulting millions of points of photographic processing of the camera with the reflected light. The resulting numerical data is called the point cloud. This point cloud can be given as polygon data according to the software of the data technology. The polygon data is the shell data from which points are visualized. The outer surfaces of the parts can be scanned by light and camera-based scanning systems. With XRAY CT technology, however, the internal details of the parts can also be obtained. Generally used data formats are; STL, OBJ, PLY, WRL and so on. formats [4].

3D Scanning Applications
Screening systems are used in many sectors especially reverse engineering and quality control.
Below you can see some of these sectors;
1. Automotive Urea-GE activities
2. Analysis of competitive products in durable consumer goods
3. Modernization projects for Defense Industry
4. Personal implant, orthosis and prosthesis projects in the medical sector
5. Archiving data for cultural heritage
6. Reverse engineering for molds
7. Designing personal clothing for the textile industry
8. Use of scanned data as stock in the machining stages of cast parts

Advantages of 3D Scanning
The light sources are used and the cameras vary according to the technology. Screening technologies offer different advantages depending on their application, sensitivity and size. Considerations in 3D Scanning The topic of digitization systems is developing day by day.

3. MATERIAL AND METHOD

3.1. Materıal

Both photogrammetry and topogrammetry methods used in 3D optical scanning, 2D photographs of 3D objects are taken and 3D images are rotated in computer environment. Digital cameras are used for these operations. Instead of a film in these cameras, there is a CCD (Charge Coupled Device) sensor behind the lenses that converts the light intensity into electronic signals and can transfer it to the computer [5].

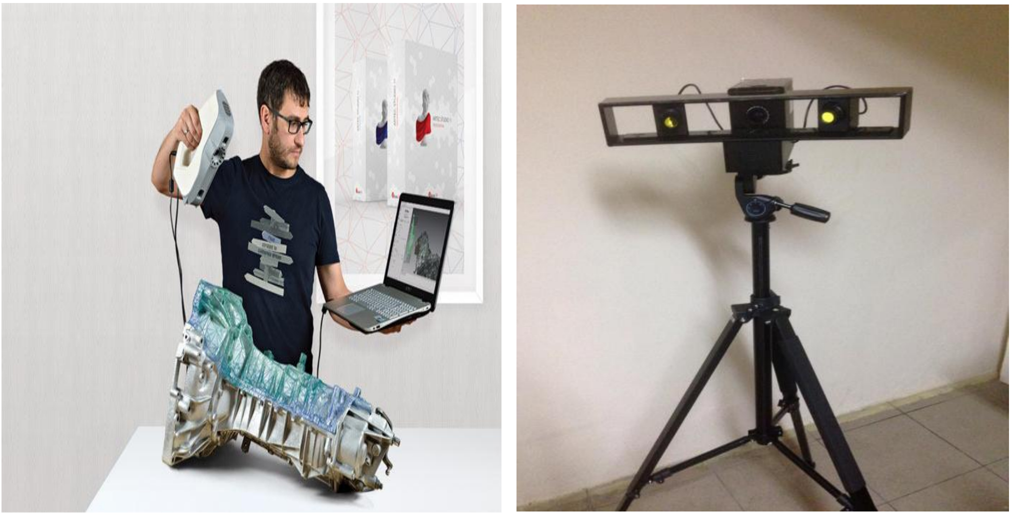

Figure 2.a and b. 3d optical scanning device.

Table 1. Structure Sensor 3D Scanning [6].

Resolution	Up to % 1 of the measured
Frame rate	30 - 60 FPS
3D scanning rate	40 – 350 cm
Area view	Horizontal: 58° , Vertical: 45°
Speed	30 – 300 mm/s
Battery Life	3 – 4 hours active scan,
Weight	95 gr
Dimensions	119.2 x 27.9 x 29 mm.

3.2. Method

In 3D scanning, the object is scanned in 2 dimensions with one or more cameras. Then it is transferred to the 3D coordinate system. With the help of computer it is possible to measure object's references or surfaces and forms in the form of point cloud. Optical metrology differs from active and passive methods.

Active methods:

• Optical Triangulation (1D) • Light section techniques (2D) • Fringe projection techniques (3D)

Optical Triangulation: A laser pointer and optical detector are arranged in a triangular structure, so that the distance of the point where the laser beam is dropped is determined by the detector, which is called the triangular focal point.

Light section techniques: The light section technique is an improved version of the optical triangle. In this technique, a line drawn on the object and the objects are obtained in the plane of the three-dimensional profile with the aid of an optical detector.

Fringe projection (fringe projection) techniques: The fringe projection technique is an improved version of the light extraction technique. In this method, three-dimensional surface information is obtained by multiple light sections, in other words, the patterns of the black and white strips are reduced to the surface of object and transferred to the computer environment with the help of one or more high resolution cameras.

Passive methods: Stereometry (3D) and Photogrammetry (3D)

Stereometry: No light fringe is dropped on the object surface to be measured. Instead, the object 3D surface is obtained by calculating from superimposed images from two cameras [6].

4. EXPERIMENT RESULTS

The turntable setting is performed. The table is positioned on a lighted 3d table with the person standing still. The rotary table mechanism is operated. The second person with the turntable operation is positioned appropriately and the projection device is positioned to scan at the predefined angles. Browsing work is repeated for sections missing (non-reflecting regions).

Figure 3.a. Scanning side view. **Figure 3.b**. Scanning Front view. **Figure 3.c**. Scan back view

Figure 4.a. Screening process and result, side view

Figure 4.b. Screening process and result, rear view

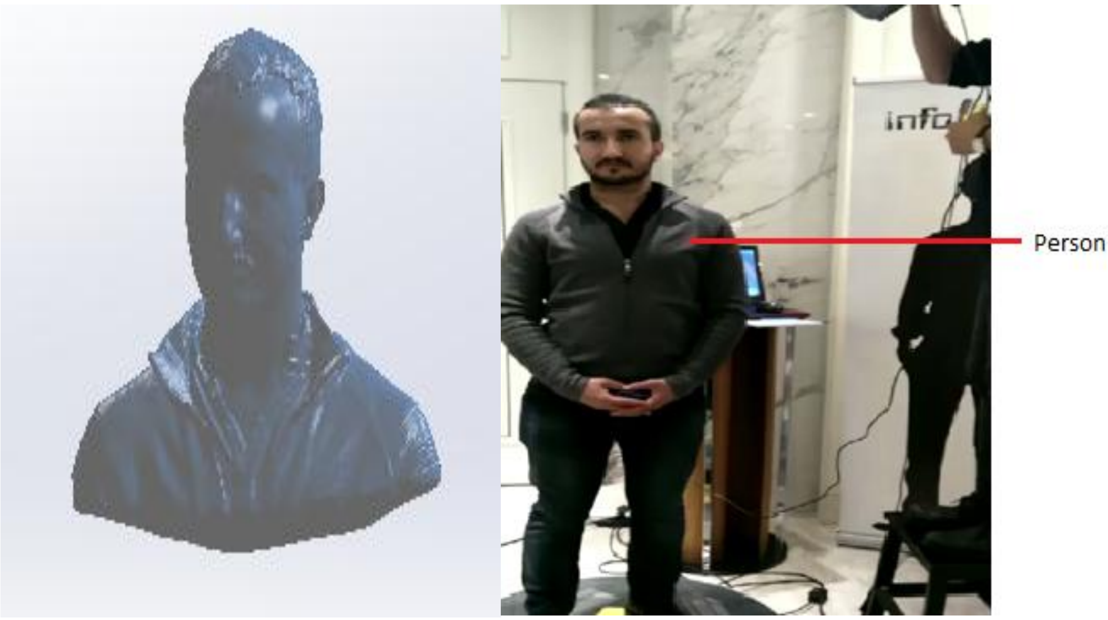

Figure 4.c. Screening process and result, front view

4. CONCLUSION

In this study, the tensile specimen which had the 3D digitization technique, is used to scan 300,000 dots of data per second with light projection. The application is operated by using multiple laser sources. Colored tissue data using laser scanning camera is provided. Double-camera data collection is used to accurately create a colored texture map associated with 3D geometry. Thanks to the importance, 3D scanning techniques are placed to find the best solutions to the growing industry needs, every kind of product development activity from engineering applications to manufacturing processes can be done perfectly.

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