# LASER SCANNING TECHNIQUES AND MECHANICAL ENGINEERING APPLICATIONS

# LAZER TARAMA TEKNİKLERİ VE MAKİNE MÜHENDİSLİĞİ UYGULAMALARI

**Ferit ARTKIN[1]**

**[1]Öğr.Gör.Dr., Kocaeli Üniversitesi, Hereke Asım Kocabıyık MYO Makine ve Metal Teknolojileri Bölümü Kocaeli/Türkiye, Makine Mühendisliği,**

**ORCID ID: 0000-0002-8543-6334**

## Özet

Lazer tarama; endüstriyel, tersine mühendislik ve kalite kontrol dahil olmak üzere çeşitli makine mühendisliği uygulamalarında kullanılmaktadır. Mekanik boyutsal inceleme çeşitli kullanımlardan sadece birisidir. Diğer standart metroloji teknolojileri ve metodolojileriyle karşılaştırıldığında, lazer tarama teknolojisi daha yüksek çözünürlük ve önemli ölçüde daha hızlı 3D sayısallaştırma sağlamaktadır. Lazer tarama, mühendislik araştırmaları açısından önem taşıyan yapılar hakkında bilgi toplamanın en önemli araçlarından biri haline gelmiştir. Diğer yöntemlere göre temel faydası, sadece seçilen geometrik parametrelerden ziyade yapının bütün bir modelini oluşturabilme yeteneğidir. Taramanın çıktısı, bir 3D model oluşturmanın temelini oluşturan ve ardından eksenler, kenarlar, kesitler, yüzey alanları vb. gibi karakteristik unsurların takip ettiği bir nokta bulutudur. Tüm yapının modellenmesi gerekmediğinde veya çok zor olduğunda, yapının istenen yönlerinin tek başına tahmin edilmesiyle basitleştirilebilir veya seçilen bilgiler doğrudan buluttan alınabilir. Nihai amaç veya tür ne olursa olsun, ayrık, yoğun bir nokta bulutu yerine yapının sürekli bir modeli, kaydedilmesi gereken veri miktarında önemli bir azalmaya olanak tanır ve periyodik ölçümlerin karşılaştırılmasına olanak tanır. Yapay zeka (AI), dijital ve mobil teknoloji ilerledikçe daha yaygın hale gelmektedir. Yeni donanım ve bulut tabanlı çözümler sayesinde makine öğreniminin etkisini bu sektörlerde daha da arttırdı. Toplanan 3D lazer nokta bulutu verileri haritalama, ölçüm, analiz, modelleme, izleme, sanal gerçeklik ve diğer faaliyetler için kullanılabilir. Elde edilen 3D nokta bulutu verileri ve 3D modelleme sonuçları standart formata dönüştürülerek diğer mühendislik uygulamaları tarafından tanınabilecek ve işlenebilecek dosya formatlarına aktarılabilir. Makine öğreniminin, yeni donanım ve bulut tabanlı çözümlerin piyasaya sürülmesinden bu yana bu alanlar üzerinde daha büyük bir etkisi olmuştur.

**Anahtar kelimeler:** Lazer Tarama Teknikleri, Ölçüm Teknikleri, Metroloji, Makine Mühendisliği

## Abstract

Laser scanning is utilized in a variety of mechanical engineering applications, including industrial, reverse engineering, and quality control. Mechanical dimensional examination is just one of the several uses. In comparison to other standard metrology technologies and methodologies, laser scanning technology enables for higher resolution and significantly faster 3D digitization. Laser scanning has become one of the most essential means of gathering information on structures of importance to engineering surveys. Its key benefit over other methods is the ability to generate a whole model of the structure rather than simply its selected geometrical parameters. The output of scanning is a point cloud, which serves as the foundation

for creating a 3D model, followed by its characteristic elements such as axes, edges, cross sections, surface areas, and so on. When modeling of the complete structure is not required, or is too difficult, it can be simplified to approximation of the desired aspects of the structure alone, or retrieve selected information straight from the cloud. Regardless of the end purpose or kind, a continuous model of the structure, rather than a discrete, dense point cloud, allows for a significant reduction in the amount of data that must be saved and allows for the comparison of periodic measurements. Artificial intelligence (AI) is becoming more common as digital and mobile technology advances. The impact of machine learning has increased in these industries thanks to new hardware and cloud-based solutions. The gathered 3D laser point cloud data may be utilized for mapping, measurement, analysis, modeling, monitoring, virtual reality, and other activities. The acquired 3D point cloud data and 3D modeling results may be transformed into standard format and exported into file formats that can be recognized and processed by other engineering applications. Machine learning has had a greater impact on these areas since the launch of new hardware and cloud-based solutions.

**Keywords:** Laser Scanning Techniques, Measurement Techniques, Metrology, Mechanical Engineering

## 1. INTRODUCTION

In contrast to image-based techniques, laser scanning is an automatic, direct measurement of 3D points. It refers to the embedded automatic deflection of laser beams that are actively emitted, and the backscattered signal is collected by a sensor to produce a detailed 3D description of a surface using point clouds. These unstructured, massive point clouds are analogous to data and require, as opposed to single-point observations, several post-processing techniques. One laser beam is employed as a light source in laser scanning procedures. Such laser light sources are not always appropriate for digitizing some items. The projection method use conventional halogen white light as a light source, which is completely safe. 3D scanning is the process of digitizing an existing part or model and transferring it to a computer environment using 3D scanning technologies. In a very short period of time, laser scanners record the three-dimensional coordinates of millions of locations. This technology can take direct measurements of spot clusters on the laser-scanned surface. Recording, combining, thinning, and constructing a polygonal triangle mesh, filling voids, and surface crossing are used to create 3-D models of things.



## 2. METHOD

Laser 3D scanners, like cameras, have cone-shaped fields of view and can only capture information from blurred and non-blurred objects. More than one scan from many angles is frequently required to acquire information on all elements of objects. These scans must be brought to a common reference system, known as registration, and then integrated to make a complete model. The 3D scan term refers to the entire process, from a single range through all models. There are two types of three-dimensional scanners: touch and non-contact. Point clouds made with a 3D scanner are rarely used directly. Many apps now use polygonal 3D models instead of point clouds. Reconstruction is the process of transforming a point cloud into a polygonal 3D representation. To produce a continuous surface, reconstruction involves finding and connecting neighboring points. The point cloud produced by 3D scanners is a three-dimensional structure made up of many points that are close to each other and are sent to a digital medium (R. Fabio, 2003).

The point cloud, which consists of hundreds, if not tens of thousands, of three-dimensional coordinates, should best represent the surface to be picked up and ideally modeled, depending

on the type of the task being done and the work done. A laser scanner system (TLS) is made up of the following parts: a scanning unit (scanner), a control unit, a power supply, and a tripod. (Berbercuma G., 2006).




**Figure 1.** Laser 3D Scanners can be used to get RO and 3D Models (creaform3d, 2014).

## 3. FINDINGS

Laser range sensing is a powerful digitizing technique for acquiring 3D coordinate data on the surface of an item. Commercial laser range sensors/scanners may currently be installed on computer controlled milling machines, robots, or coordinate measurement machines (CMMs) (Artkin F., 2022) for reverse engineering (Hsi-Yung Feng et al., 2003) (S.C. Aung et al., 1995) and re-manufacturing (F. Xi et al., 1999) (S. Tamura et al., 1994). When compared to the touch-trigger probe digitization method, laser digitizing offers the benefits of high speed, high resolution, and non-contact sensing. These benefits have also prompted plastic surgeons to consider using a laser scanner as a novel surface measurement tool for computer-aided facial restoration in clinical trials (M.J. Milroy et al., 1996). Despite the laser scanner's growing popularity, a few enhancements to its functions are still needed, with digitizing accuracy being the most difficult to improve. Common laser scanners are at least an order of magnitude less precise than the touch-trigger probe. Based on laser scanned data, the inspection findings of a precision ground steel ball bearing reveal a 25 m variation from the nominal radius, 25.4 mm (G. Dalton, 1998) (J.G. Chow, 1997). This restricts the laser scanner's applicability in precise dimensional examination of produced components.



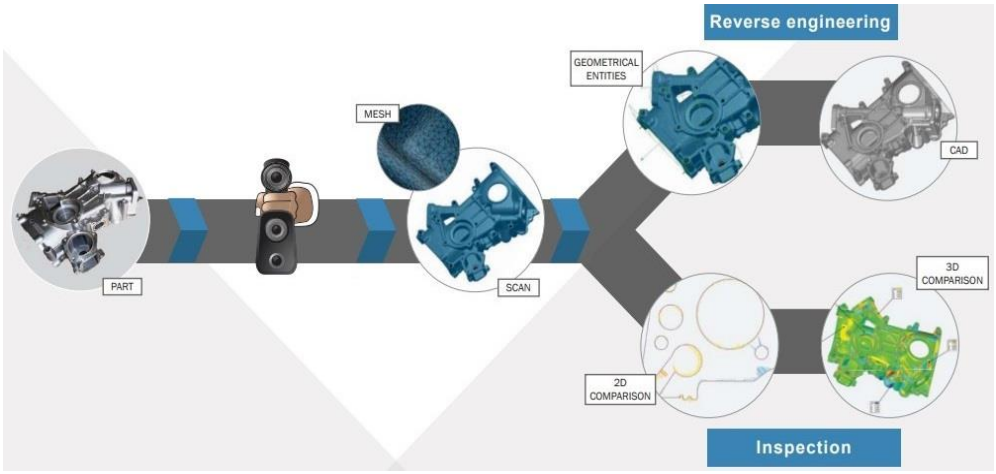



**Figure 2.** Extracting dimensions to reconstruct a CAD reference file for reverse engineering or rapid prototyping (creaform3d, 2014).

3D scanning has evolved as a vital tool in all stages of the product lifecycle management (PLM) process. This is especially true of the latest generation of genuinely portable, self-positioning

scanners (Özer, G., 2020). The ability of 3D scanning to bridge the gap between physical objects in the real world and digital design environments has become extremely valuable in a wide range of industries that use PLM, including aerospace, automotive, consumer products, manufacturing, and heavy industries. These sectors gain from shorter time to market, higher quality, lower warehousing costs, and a better understanding of product performance (Sürmen, H.K., 2019). Laser 3D scanning is utilized in the PLM design stage for computer-aided design (CAD), fast prototyping, and testing, simulation, and analysis (CFD, FEA). In the manufacturing stage of PLM, laser 3D scanning is utilized for applications such as tooling design, assembly and production, and quality control (Tezel, T. et al., 2018).

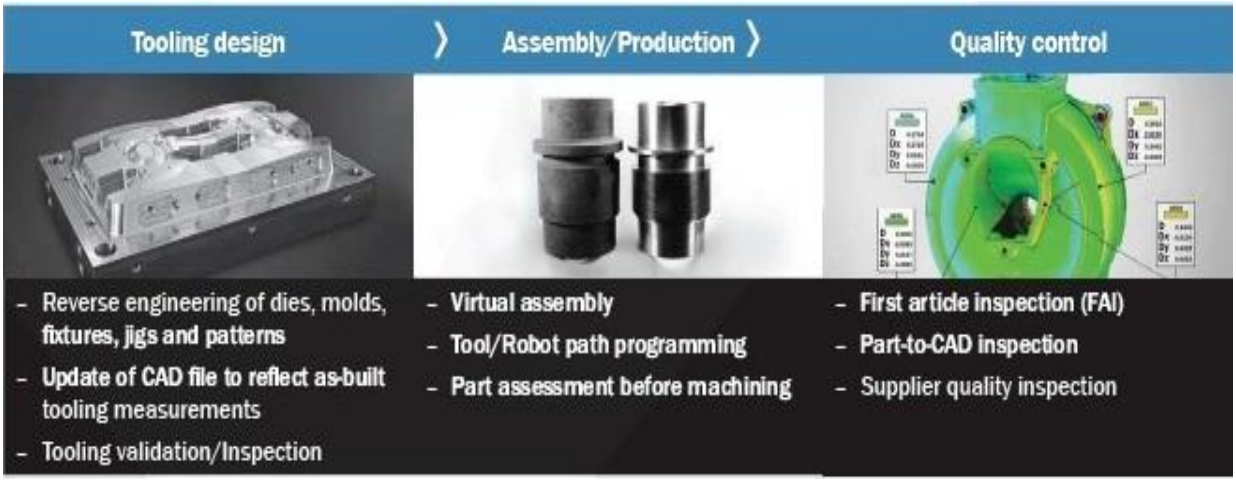



**Figure 3.** Laser 3D Scanning in Product Lifecycle Management (PLM), (creaform3d, 2014).



Stamping, casting, and plastic injection are all prone to phenomena such as shrinkage and spring-back, which is the difference in form between the real contours of dies and the shape of the stamping generated in them. As a result, matching the physical die or mold to the CAD shape is complicated. This is where portable 3D scanning comes in: Data from 3D scans gives insights into aberrations that may occur during mold and die manufacture. The ability to properly model die and mold geometry and the related components it creates helps decrease design iterations, saving time and resulting in parts that more closely resemble the CAD reference.

## 4. RESULT, CONCLUSION AND SUGGESTIONS

3D laser scanning technology detects an object's form and gathers data defining the position of the object's outer surface. This novel technology has found applications across a wide range of industries, including discrete and process manufacturing, utilities, construction, archaeology, law enforcement, government, and entertainment. Over the last two decades, laser scanning technology has grown and developed to become a prominent surveying method for the capture of spatial information. A wide range of instruments with varying capacities is now commercially accessible. Laser scanners' high-quality data are currently employed in numerous surveying specialized domains, including topographic, environmental, and industrial.

These data contain dense point clouds that have been raw, processed, and altered; digital terrain and surface models; 3D city models; railroad and power line models; and 3D documentation of cultural and historical locations. 3D laser scanners use three primary sorts of techniques: Time-of-Flight, Phase Shifting, and The process of triangulating. 3D scanners are classified into three types: Airborne scanners, Teristerial scanners, Handheld scanners. Advances in technology in the areas of data quality, software processing, and ease-of-use are fast extending the

possibilities for 3D laser scanning. The more effective product offerings improve the commercial benefits of 3D laser scanning while producing proportionately higher income.

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