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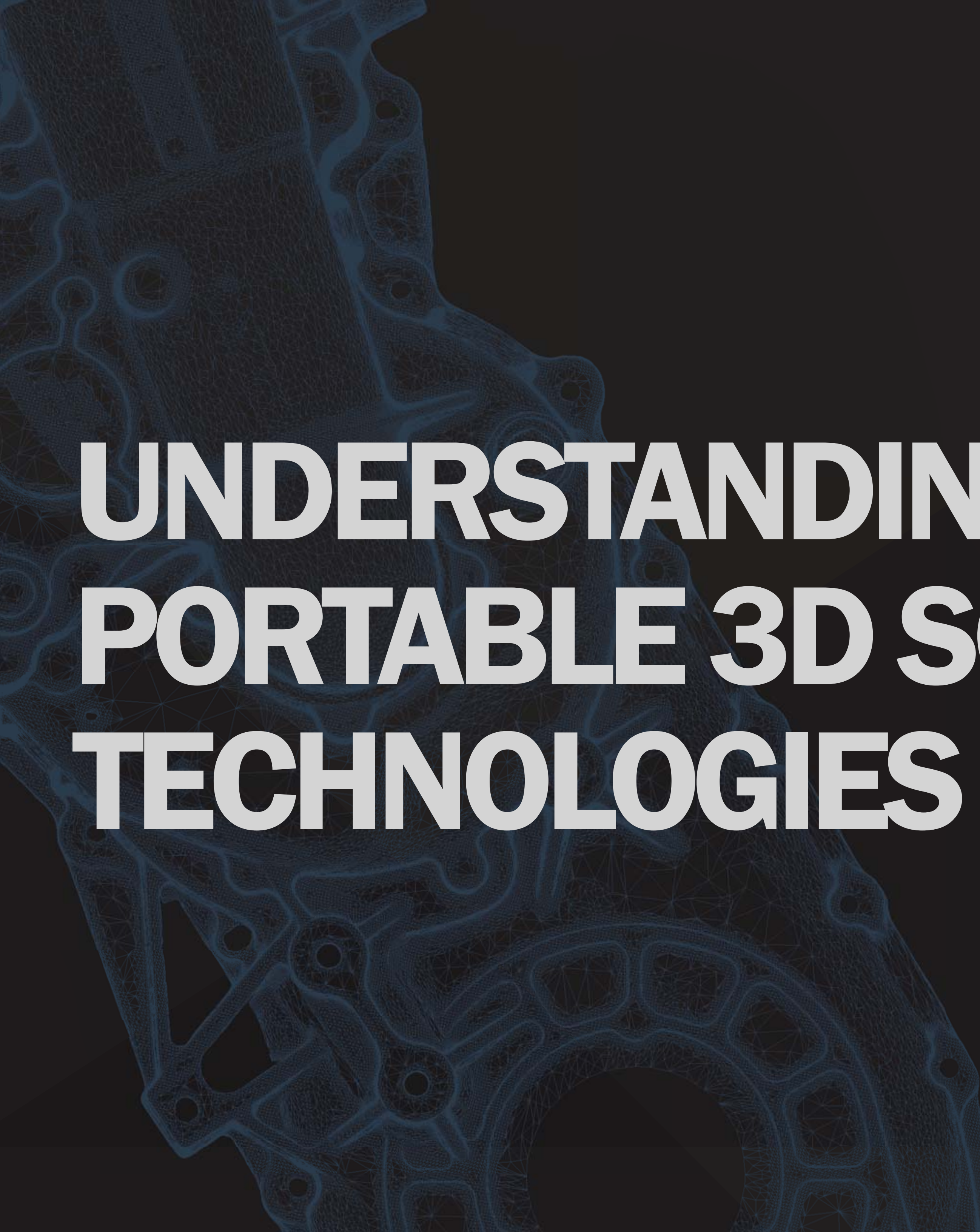
Ebook #2

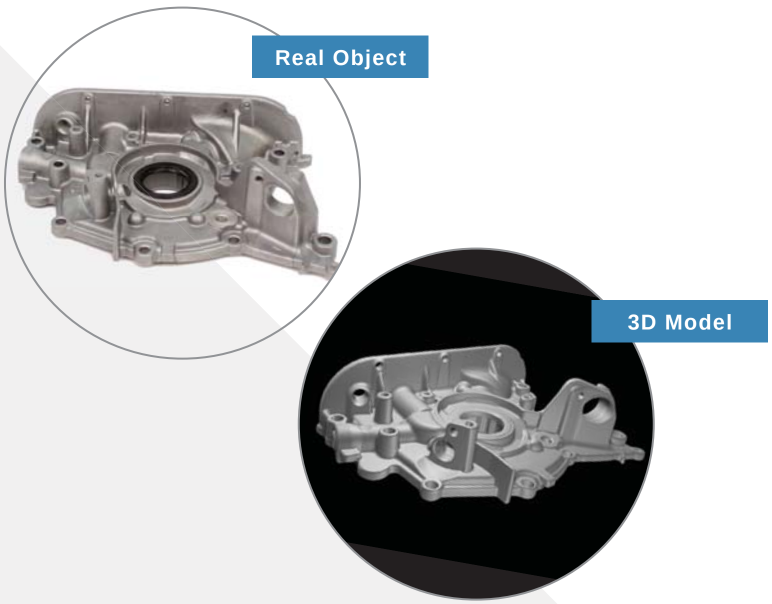


UNDERSTANDING PORTABLE 3D SCANNING TECHNOLOGIES

Fulfilling the promise of 3D scanning

Consider two of the driving technologies of the 21st century -- computing and telecommunications -- and it becomes clear: the merging of portability, quality and reliability drives market movement from marginal to mainstream. So it was with computers and cell phones and so it is with professional 3D scanning.

Over the last decade, huge leaps in accuracy, speed and quality have made portable 3D scanning an integral tool in just about every critical industry that drives the global economy: design, engineering, manufacturing, medical and archiving/preservation.



In this ebook, we'll explore the ever-evolving world of portable 3D scanning:

- The advances
- What defines portability
- The positioning methods

At the end, you should have a good idea about what solution is best for your particular needs.

Big performance in small packages

The knock on portable 3D scanning systems used to be that they couldn't match the performance of their hulking big brothers. That might have been true even five years ago, but it isn't any longer.

Consider these specifications for the newest generation of hand-held scanners:

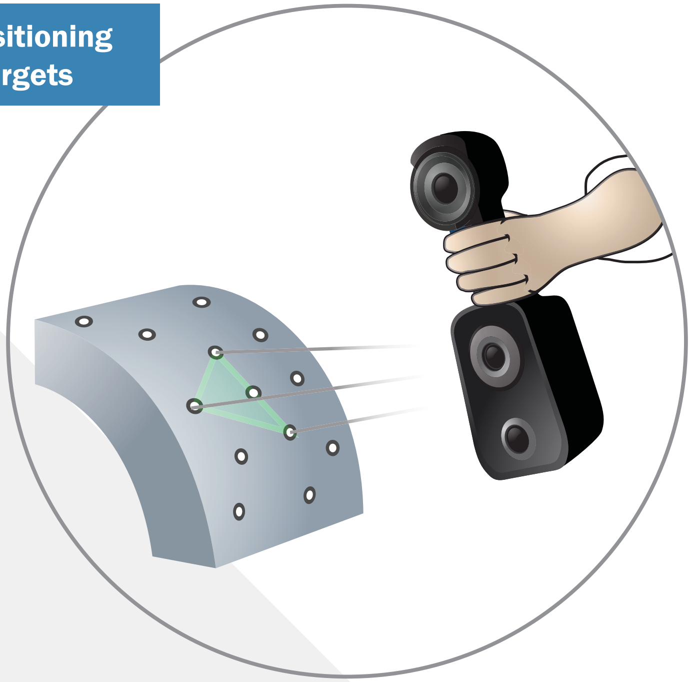
- Accuracy up to 0.030 mm
- Resolution up to 0.050 mm
- Scanning speed of up to 550,000 measures per second
- Weight of less than two pounds
- True portability in the field or the shop
- Stability in environments where vibration is the norm.

THIS COMBINATION OF SPEED, ACCURACY, PORTABILITY AND EASE-OF-USE HAS BEEN DELIVERED THROUGH A SERIES OF TECHNOLOGICAL BREAKTHROUGHS, THE BIGGEST OF WHICH IS SELF-POSITIONING.

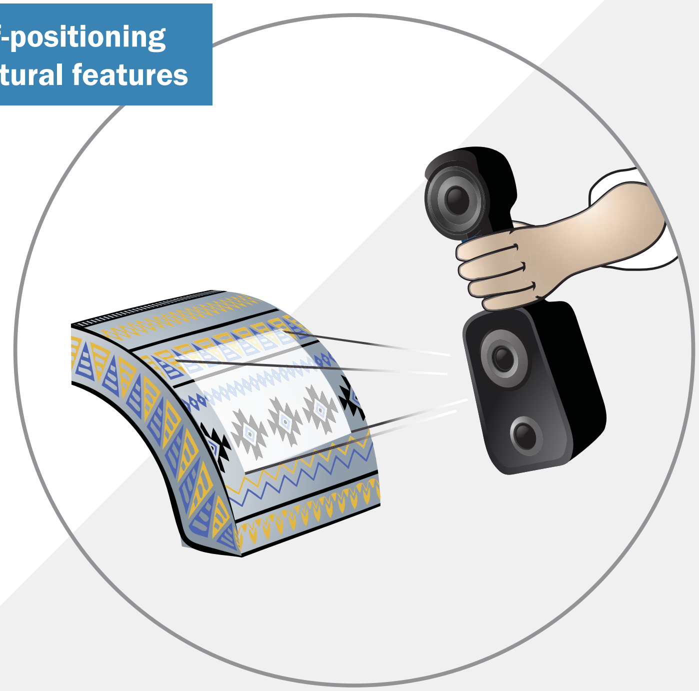
Self-positioning: making it all possible

Self-positioning is the breakthrough innovation of relying on the object being scanned as the reference for positioning. This is as opposed to using an external positioning device such as an arm, CMM or tracker.

Self-positioning by targets



Self-positioning by natural features



SELF-POSITIONING HAS OPENED UP A NEW WORLD OF APPLICATIONS FOR PORTABLE 3D SCANNING AND DELIVERED THE IMPORTANT BENEFITS OF TRUE PORTABILITY AND DYNAMIC REFERENCING.

True portability on the road or in-house

True portability comes from not having to use an external positioning device, resulting in a compact, lightweight and standalone 3D scanner. This kind of device can be transported comfortably to remote locations and can operate in tight spaces and unstable environments.

True portability also means having the flexibility to accomplish multiple types of tasks within a dedicated room, on a shop floor or on-site.


Shop floor


On-site

A RECENT SURVEY SHOWS THE IMPORTANCE OF PORTABILITY TO 3D SCANNING USERS:

45%

CITE PORTABILITY AS ONE OF THE THREE MAIN FACTORS THAT MOST INFLUENCE THEIR DECISION WHEN BUYING A 3D SCANNER

43%

IDENTIFY PORTABILITY AS THE MAIN FACTOR IN CHOOSING A HANDHELD 3D SCANNER OVER OTHER CONFIGURATIONS SUCH AS ARM-MOUNTED OR TRIPOD-BASED SYSTEMS

RESPONDENTS IDENTIFY PORTABILITY AS THE KEY FACTOR IN THE FOLLOWING ENVIRONMENTS:

- Shop floor
- Outside field work
- Customer or supplier locations
- Unstable or uncontrolled areas.

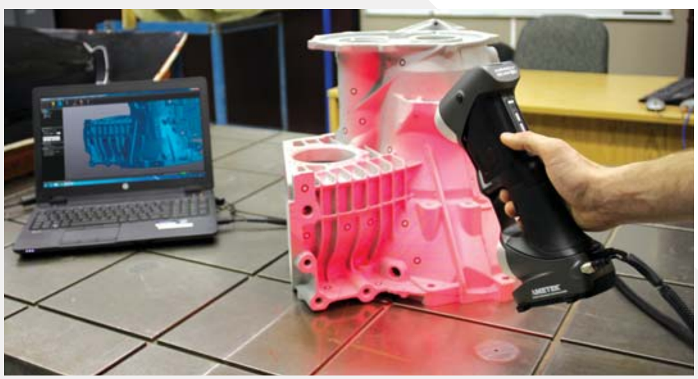
True portability on the road or in-house

BEYOND THE ABILITY TO TAKE A 3D SCANNER ANYWHERE, PORTABILITY HAS THE ADVANTAGE OF FLEXIBILITY: THE SAME SURVEY REVEALED THAT

50%

OF PARTICIPANTS USE THEIR SCANNERS IN A DEDICATED ROOM, LAB OR STUDIO.

But, they still said that portability was a primary factor in their buying decision.



Flexibility is directly related to optimizing a 3D scanning investment, as it enables users to accomplish a wide range of scanning tasks with a single, transportable system. The greater variety of objects you can scan and the greater number of places in which you can scan, the greater the return on investment.

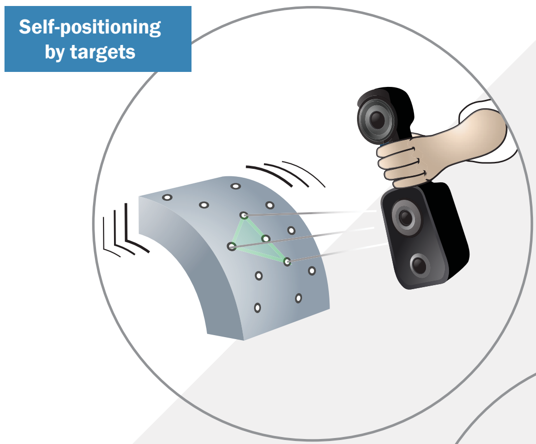
Dynamic referencing: better stability and reduced errors

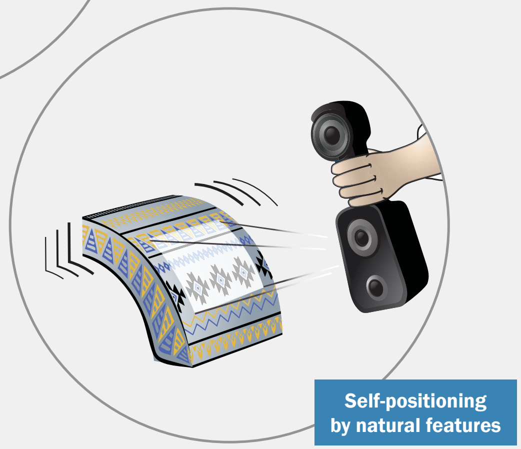
The other critical byproduct of self-positioning is dynamic referencing. Dynamic referencing allows the reference system to be based on the object itself rather than an outside fixed reference.

This small but important aspect brings many important advantages that can make the scanning process faster, simpler and more accurate.

Principal advantages of dynamic referencing include:

- Eliminates need for rigid equipment set-ups; objects can be freely manipulated during scanning
- More accurate measurement in environments where vibrations are occurring, such as in the field or on the shop floor
- Reduces mistakes from less-experienced users





Positioning methods for portable 3D scanners

Although portable 3D scanners are often similar in size and shape, the different positioning methods they use can have an important impact on performance and usability.

In the sections that follow, we'll explore the two main positioning methods for portable 3D scanners:

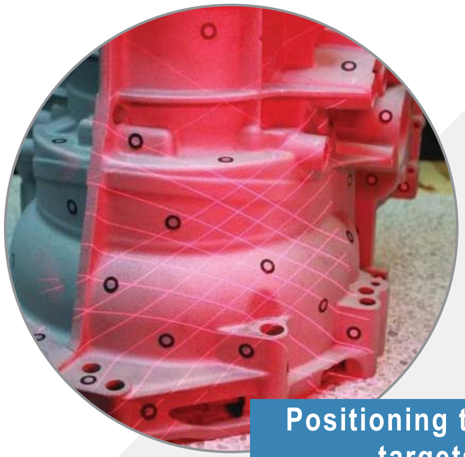
- Positioning through targets
- Positioning through natural features (geometry and/or color)
- Third method that is a blending of the two (hybrid positioning)

At the end, you should have a good idea about what type of positioning system best aligns with your 3D scanning needs.

Positioning through targets

Positioning through natural features

Positioning through targets



Positioning through targets

In this method, positioning targets are applied before scanning, either on the object or around its immediate surroundings in the case of a precious artifact that cannot be touched or altered, for example.

The targets enable users to register all the different camera frames for the 3D data sets acquired by the scanner. Targets usually have a simple geometric shape, often a circle, and are specifically designed for easy detection by the 3D scanner's optical components.

Before scanning, there is a process called pre-modeling to obtain a dedicated algorithm and a preliminary descriptor for the object being scanned. These two items make target detection easier and more accurate.

After the scanner detects targets individually, the next step determines their relative position nd normal. A target data set with a minimum of three targets is used to position the scanning frame.

As the scanner is moved around the part, new targets are detected and registered on the global positioning model.

Why positioning through targets?

Positioning through targets is the only method that enables portable 3D scanners to deliver metrology-grade quality, which in the past was restricted to measurement arm scanners and stationary structured-light 3D scanners.

Positioning through natural features

(geometry and/or color texture)

This method uses the object's inherent characteristics -- its shape and texture attributes -- to provide scanner positioning. When positioning through natural features, surface reconstruction happens in real time while the object is being scanned. As data is acquired, the scanner will detect some shapes and textures on the scanned area and register them for future use.

Positioning through natural features

When analyzing each new frame, detected features will be compared with previously registered ones to match up the images and help determine the scan object's position.A scanner must have strong self-positioning capabilities and built-in intelligence to position itself using natural features. Refining the registration or correcting a frame requires anticipating the next frame in real time.

The natural features of the scan object must be prominent enough to be detected accurately by the scanner. The density of the data for a single frame must also be high enough for it to extract data.

While this method is flexible and may seem to speed the time required for a project, there are important aspects that must be taken into account. arm scanners and stationary structured-light 3D scanners.

Why positioning through natural features?

Unlike positioning targets, natural features vary from one object to another. The resulting precision and accuracy can be greatly affected by the type of objects being scanned. Most objects include at least some surfaces with few defining details.

Hybrid positioning

It is possible to combine target and natural positioning into a hybrid positioning mode. Users can compensate for the lack of natural features in a given object or specific areas by adding positioning targets.

Although hybrid positioning would appear to be the best of both worlds, it will not generate metrology-grade results: Users can never be completely certain that they are covering every area that needs to be covered in order to ensure the type of absolute accuracy of scanning with positioning targets.

Positioning through targets

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Positioning through natural features

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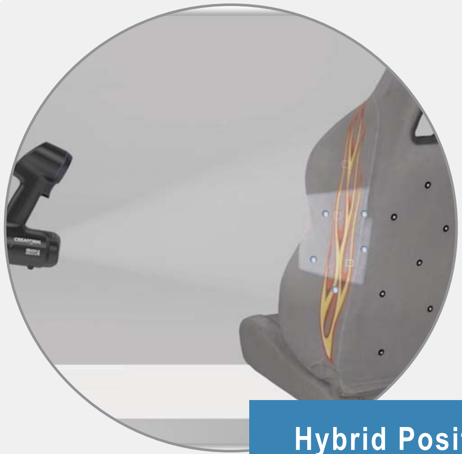

Hybrid Positioning

Matching 3D scanning needs to positioning methods

THE ULTIMATE QUESTION THIS GUIDE IS DESIGNED TO ANSWER IS THIS:
WHAT'S THE RIGHT PORTABLE 3D SCANNER FOR MY NEEDS?

If you've gotten this far, you probably have a good idea, but here's a summary of the relative matches of positioning methods to 3D scanning requirements.

OPTION 1
SIMPLICITY

If your main goal is speed and simplicity, a 3D scanner using the natural features positioning method is probably right for you. The trade-offs are lower accuracy and possible lack of natural features on the scan object, which can mean increased time spent modeling and making corrections.

OPTION 2
FLEXIBILITY

If your application requires flexibility, but not high accuracy or metrology-grade resolution, the hybrid positioning method is the best solution. These 3D scanners are perfectly suited for scanning applications such as industrial product development, where absolute precision is not required.

OPTION 3
ACCURACY

Some applications require a level of precision or resolution (details) that scanners using the hybrid positioning method cannot match. For these applications, using a high-range portable scanner with positioning targets is recommended.

Portable 3D scanning: It's only just begun

Most of the key developments in 3D scanning have come about in less than a decade. Portable 3D scanning is still a very young discipline with tremendous untapped potential.

Here are just a few of the developments we can expect in the near future:

- More sophistication and intelligence integrated into 3D scanners
- Greater speeds and resolutions at increasingly affordable prices
- Increased ease of use and automation that give everyone access to the power of 3D scanning
- Greater flexibility for a wide range of scanning tasks and environments

As 3D scanning continues to be adopted by more organizations with new applications and vendors keep delivering more computing power in smaller form factors, every day brings a new potential breakthrough for portable 3D scanners. Stay tuned on the evolution of this rapidly developing technology.

Glossary of 3D scanning terms

- **3D scanner** -- A device that captures data on the shape and colors of a real-world environment for processing in the digital world, such as construction of 3D models.
- **Accuracy** -- The accuracy of a mesh file is measured by the deviation between the actual part and the measured result. It depends on the specifications of the scanner used and on the quality of the set-up. In 3D scanning, accuracy differs from resolution (see below).
- **Alignment** -- In 3D scanning, this refers to the act of bringing all the scans into a common reference system, where data is merged into a complete model. Also called registration.
- **CAD** -- Computer-aided design; the act of creating a digital model for design, engineering and manufacturing. The models are based on various geometric entities such as triangles, lines and curved surfaces. Typical formats for CAD models are .stp and .igs.
- CAE -- Computer-aided engineering; the act of digitally simulating performance of objects and assemblies. CAE encompasses simulations such as finite-element analysis (FEA) and computational fluid dynamics (CFD).
- **CFD** -- Computational fluid dynamics; a digital process by which engineers can simulate how fluids such as air, water and gas behave within different design, engineering and natural environments.
- CMM **arm** -- A coordinate measurement machine that uses a point or ball probe on an articulating arm, allowing users to collect individual 3D data points from a physical object.
- **CMM arm encoder** -- An opto-electronic device that detects the incremental lines on a scale to determine positioning. An encoder is also known as a reader head.1
- **CNC milling** -- Computer numerical control; computer-controlled milling machines that can create products along multiple axes for improved precision.

- CAI -- Computer-aided inspection; the use of 3D scanning to compare an as-manufactured part to its CAD equivalent or ideal specifications for quality control, wear-and-tear assessment and other forms of analysis.
- Customized manufacturing -- Using 3D scanning and complementary software to enable wide varieties of design choices at a reasonable cost. Sometimes called mass customization. Can also be used to describe the ability to customize medical and sports products -- such as prostheses, athletic shoes and dental implants -- for individual physiologies.
- Digital archiving -- The ability to save models of physical objects in a digital environment, saving time and money.
- Digital reconstruction -- The act of scanning a physical object in order to rebuild or renovate it close to its original state or at a different scale.
- Dynamic referencing -- The ability of a scanner to ensure that the measuring device is continuously locked to the part by an optical link, providing greater accuracy in factory and field environments.
- FEA -- Finite-element analysis; a digital process by which engineers can simulate how the structure of an object or assembly performs under different environmental stresses.
- Normal -- In 3D space, a surface normal is the vector cross product of two (non-parallel) edges of a polygon.2
- NURBS -- Non-uniform rational b-spline; a mathematical model used in computer graphics and CAD to generate curves and surfaces.
- Optical CMM scanner -- A 3D scanner tracked by optical CMMs. Optical CMM cameras track passive or active reflectors affixed to the 3D scanner itself and to the part being scanned to dynamically reference them in 3D space.
- Photogrammetry -- A methodology for extracting high-accuracy measurements from photos of an object or environment.
- Product lifecycle management (PLM) -- The practice of monitoring and managing a product from inception to end of useful life.
- Point cloud -- A set of data points within a coordinate system. In a three-dimensional coordinate system, these points are usually defined by XYZ coordinates, and are intended to represent the external surface of an object. Typical formats for point clouds are .txt, .igs and .ascii.

- **Rapid prototyping** -- The process of quickly fabricating a model of a physical part or assembly using 3D STL or CAD data. 3D scanning is often the front end of the process and 3D printing the back end.

- **Reverse engineering** -- The process of discovering the technological aspects of a device, object or system through analysis of its structure, function and operation. In 3D scanning, the reverse-engineering process involves measuring an object and then reconstructing it as a 3D model.

- **Resolution** -- Defines the level of details visible in the scan data and measured in millimeters (mm). It can be compared to a screen resolution, which is defined by the number of pixels. A higher resolution increases the number of triangles in a mesh file.

- **Repeatability** -- The variation in measurements taken by a single person or instrument on the same item under the same conditions.

- **Self-positioning 3D laser scanners** -- Laser scanning systems that use retro-reflective targets as a reference. These scanners do not require external positioning systems because the position of the scanner in relation to the object being scanned is determined by triangulation between the scanner's two cameras and the patterns of the positioning targets. Data acquisition is in real time.

- **Self-positioning 3D white-light scanners** -- The scanner obtains its position relative to the physical object by looking at the distortion of the white-light pattern on the scanned part. These scanners obtain their position on a continuous basis in real time as they move over the part.

- **STL** -- Stands for stereolithography or standard tessellation language; a file format native to stereolithography CAD software created by 3D Systems Inc. and supported by many other software packages. STL files are used widely for rapid prototyping and computer-aided manufacturing.

- **Triangulation** -- The process of determining the location of a point by measuring angles to it from known points at either end of a fixed baseline. The point can then be fixed as the third point of a triangle with one known side and two known angles.

- **Triangle mesh** -- The output of self-positioning 3D scanners, this is a mesh from an optimized surface that takes into account measuring conditions and consistency. This is also referred to as a polygon model. Typical formats are .stl, .obj and .sat. An STL file can be used directly for applications such as rapid prototyping and computer-aided inspection or converted into NURBS surfaces for CAD.

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