

A hand is holding a 3D scanner probe, which has a red handle and a white sensor head. The probe is positioned over a large, white, spherical object that has a grid of small holes on its surface. The background is dark and out of focus, showing some industrial equipment. The entire image is overlaid with a dark, semi-transparent diagonal band that runs from the bottom left to the top right.

5 REASONS

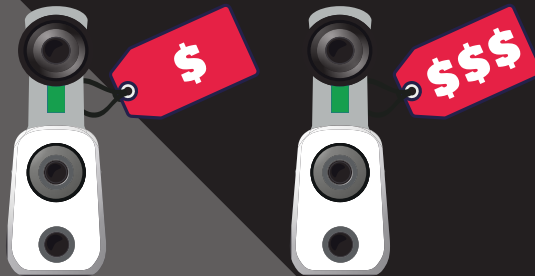
BEHIND THE PRICE OF INDUSTRIAL
PORTABLE 3D SCANNERS

In recent years, a new category of scanners has been entering the market. These hybrid models—between the scanners made for consumers and the metrology-grade scanners made for professionals—bring a new dimension to 3D scanning. Offered at an affordable price, they charm a large professional clientele, including designers and engineers. The latter are even tempted to use them in reverse engineering or design applications because of the specifications that manufacturers promulgate.

In order to demystify which applications are more suitable for one type of sensor rather than another, a comparison between these two categories of scanners—low-cost and high-end—is necessary. Why is there a significant price difference between the two scanner grades? Why, despite this difference in price, do the specifications seem to be comparable? Does it not seem too good to be true?

This white paper highlights the secrets of making portable 3D scanners—the most popular metrology-grade 3D scanners nowadays. It also aims to do the following:

- Explain why it is a challenge to design a scanner that simultaneously features significant accuracy, resolution, speed, versatility, and ease of use.
- Reveal the perceptions and interpretations, true or false, that people have of these parameters depending on the level of their requirements.
- Disclose the benefits that users will get from the five value parameters.



THE FIVE VALUE PARAMETERS

Making a scanner is relatively easy. After all, it is only an assembly of components, such as lenses and cameras, mounted in a housing. Nevertheless, designing a quality 3D scanner does not stop there; it requires software to enable data acquisition and a calibration procedure to ensure measurement accuracy. For this, technical expertise and know-how are mandatory. In addition, the technological challenges of thermal and mechanical compensations must be considered, since the sensor is used in an unstable environment. Let's see how a manufacturer can design a portable 3D scanner and ensure users quality performance across the parameters of accuracy, resolution, speed, versatility, and ease of use.



ACCURACY

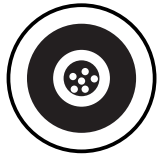
RESOLUTION

SPEED

VERSATILITY

EASE OF USE





ACCURACY

By definition, accuracy is the closeness of a measurement to a known reference. Traditionally, an accurate measurement required an environment where there was no vibration or motion between the measuring instrument and the measured part. However, the development of portable 3D scanners made it possible to take measurements without a rigid measurement setup. This new measurement context certainly brings a lot of flexibility, but it also generates a technological challenge.

TECHNOLOGICAL CHALLENGE

To reach accuracy without the need for setup rigidity implies that the entire chain of components is accurate, including the calibrated lenses and cameras for which the models of distortion are known and taken into account during modeling, and the housing, which takes into account thermal and mechanical compensations.

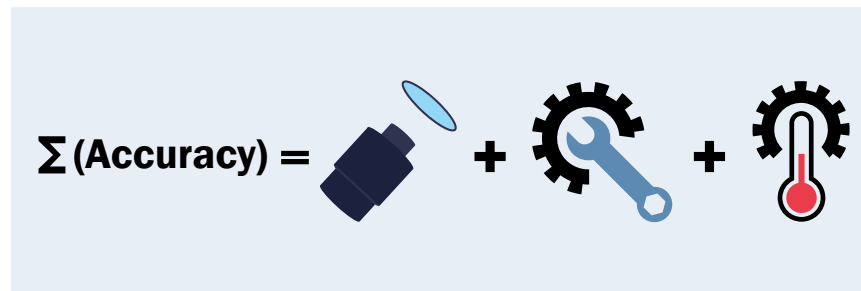


Figure A: The Optical Path

All components are calibrated to ensure the accuracy of the sensor.

Portable 3D scanners are supplied with their pre-calibrated reference artefact and a calibration procedure. This way, if internal components undergo micro-displacements during transport or use, the sensor can easily compensate them. Thus, no matter how the device is used and no matter who uses it, it will have the same accuracy, and the measurement results will be the same. Low-cost scanners, however, usually do not have this level of analysis and calibration quality, which will have an impact on the measurement accuracy.

PERCEPTION

People attach greater importance to camera resolution since it is a reference known in photography. More megapixels seem to mean better quality. This is not necessarily the case. The optical path and data interpretation capabilities have more impact on the measurement accuracy. A single parameter cannot be isolated to deduce the quality of a sensor. As illustrated in Figure A, all components must be considered in the calculation of accuracy. Plus, due to the quality of the sub-pixelar interpretation, the eye has the ability to recognize finer details than the resolution of the camera.

BENEFITS

Opting for a scanner that offers good accuracy ensures reliable measurements and usable data. Indeed, when making a 3D scan, the user searches for a virtual replica as reliable and as close to the real object as possible. The objective is often to achieve a perfect design fit, without the need for iterations. Therefore, having accurate measurements on the first draft saves time and money.



RESOLUTION

By definition, resolution is the smallest variation in a quantity being measured that causes a perceptible change. Resolution will, amongst other things, depend on the quality of the positioning. If the data are incorrectly positioned, aligned, or integrated, it is equivalent to taking a picture in an unstable environment. A blur will be created, and, in the end, the picture will not be a reflexion of the camera's true potential. The resolution of a scanner, therefore, is not exclusively a function of the camera's resolution. The optical chain (see Figure A) and the data processing have an impact on the resolution and realism of a 3D scan.



TECHNOLOGICAL CHALLENGE

The challenge is to maintain good positioning in a non-rigid measurement setup where wrongfully positioned data will create a blurry effect on the scanned data. To achieve this, randomly placed positioning targets on the part, supplied with high-end 3D scanners, provide a unique and recognizable reference. This is the most accurate method to ensure the sensor's accuracy, which has an impact on the resolution.



PERCEPTION

People tend to rely on specifications submitted by manufacturers. Since there is no industry standard for how parameters are characterized, it is necessary to get into the habit of questioning this information. For example: a data sheet gives a resolution of 500 μm . What resolution is it referring to? Is it the size of the reconstruction triangles or the size of the finest detail that can be observed? It is the lateral resolution or the z-resolution? Reconstructing a surface with too high resolution will generate oversampling: a heavy file that will provide no additional information.



BENEFITS

Smooth surfaces require little resolution, while inking points and teeth, often needed in reverse engineering, require a lot of resolution. A device that gives the ability to capture the finest details will greatly facilitate the work of engineers. The objective with a 3D scanner is to complete a task on the first try without innumerable tests and iterations.



SPEED

The scanning speed is directly related to the frame rate—the acquisition rate and the capture rate of images—and the transfer rate to the computer. The speed of data processing depends on the performance of the computer used, but it depends even more on the quality of the algorithms developed. Some processing algorithms are faster than others, and, therefore, they are more efficient at processing data under limiting conditions.

In most 3D scanners, the speed of scanning and data processing is specified in points/sec or measurements/sec. Some sensors directly process 3D surface points in real time (directly in .stl), while low-cost 3D sensors will generally measure a cloud of points and then convert them into .stl. Moreover, high-end 3D scanners are still built with cables because, despite major advancements in wireless technology, cables still remain more reliable and efficient in transferring high data rates.



TECHNOLOGICAL CHALLENGE

The quest to increase speed while ensuring quality measurements still remains a challenge for scanner manufacturers. If the scanner offers high-quality tracking, the user can quickly scan a part. However, if the sensor tends to lose tracking due to poor positioning, the user will need to start over and erase bad data. If the theoretical capacity to collect information is not applicable in practice due to the color of the part or the type of coating, the scan must be stopped. Specification sheets and promotional videos rarely mention this, and users should take this challenge into account.



PERCEPTION

As explained above, speed is closely linked to software algorithms developed to process data. Due to advancements in scanning technology, several open source libraries have recently appeared in the market. It is, therefore, not surprising that users are tempted to use open source software. However, users must know that compatibility and integration issues are more difficult to deal with in open source software than if the complete system is supplied by the know-how of a single manufacturer. Open source software comes with its share of limitations, which cannot be counteracted with updates.



BENEFITS

Manufacturers of high-end scanners continue to improve their software even after the unit is sold. Thus, performance continues to improve even after the sale. Therefore, the user will always possess an up-to-date device.



VERSATILITY

The versatility of a sensor is its ability to interpret any type of data, regardless of the material, shape, color, or size of the part. Designing a versatile 3D scanner, however, entails many challenges because the size of the angle view will be opposed to the resolution (like in photography, where a landscape has less resolution than a portrait).



TECHNOLOGICAL CHALLENGE

There are technological challenges for all of these parameters. For example, a dark object is difficult to scan because it returns little light. The challenge is being able to work with increased sensitivity to see the little light that comes back and accurately interpret it. In contrast, a chrome-plated, reflective object will be hard to scan due to too much reflective light. An external shooting will be also difficult to scan because of too much ambient light. The projection is not observable.



PERCEPTION

It is, however, false to believe that a single sensor can scan both small and large parts. Generally, 3D scanners will be specialized for a specific range (or they will be mediocre everywhere).



BENEFITS

The choice of a versatile 3D scanner gives the user the ability to scan different types of materials, shapes, colors, and sizes. By defining his specific needs, the user can wisely select the most suitable scanner for the part to be analyzed.



EASE OF USE

Ease of use affects the level of experience and training required to operate a 3D scanner. It influences the quality of people's work and the quality of the results they get. Simplicity of use is what makes scanning fun!



TECHNOLOGICAL CHALLENGE

If the device is accurate but a nightmare to work with, no one will use it, and it will remain in its box. The challenge for manufacturers is to offer many functionalities while keeping the device intuitive and each feature easily usable. In order to keep it simple, affordable models offer just a few features. Thus, they are limiting for users, especially if their objective is complex to achieve.



PERCEPTION

It is wrong to believe that the magic of scanning occurs only by pressing a button. In addition to having to map data on the scan, there are operations to do, actions to take, and data to fill and clean.

Scanning is rarely the final objective. An object is scanned for a specific purpose—either to redo a new version of an object that is no longer available or to design another part that will interface with this object. The ultimate goal is not to scan. The goal is to use the scan for other purposes. Work begins when the scan is complete.



BENEFITS

Choosing a 3D scanner with a high degree of ease of use means that no matter how experienced or trained the users are, they can perform a scan and get the same results as a skilled operator.

As illustrated in Figure B, high-end 3D scanners are expensive because they offer key features—measurement accuracy, resolution, speed of acquisition, versatility of shapes, sizes, colors, and material, and ease of use—as simultaneously available on a single sensor. Those 3D scanners exist because experts spent many hours developing their products and innovating their know-how.

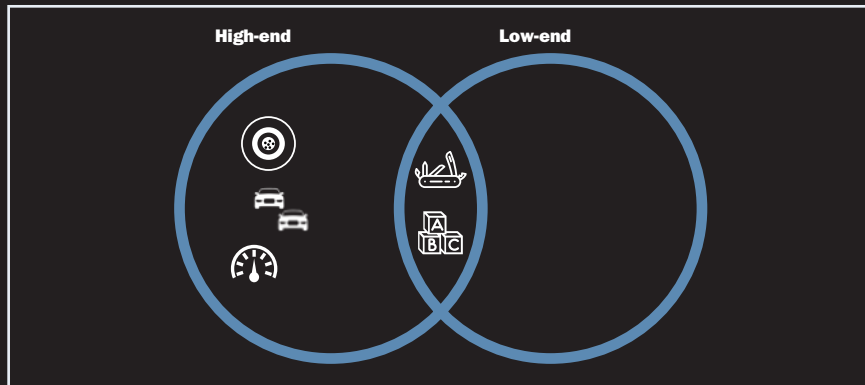


Figure B: The Scanner Type Spectrum
The most present parameters in each scanner grade

Nevertheless, affordable 3D scanners remain suitable for some non-industrial and pro-consumer applications, where the accuracy requirement is not critical and the available money to invest is low. However, engineers and designers who need professional and industrial features and believe that they can obtain the same results and benefits with low-cost scanners risk being disappointed. As shown in Figure C, portable 3D scanners are designed to fulfill professional tasks in professional applications, including quality control, quality assurance, product development, reverse engineering, and design.

When specifications seem too good to be true and valid, it's probably because they are neither true nor valid. Go beyond the promised specifications and keep your needs in mind when choosing your next 3D scanner.



Figure C: The Pyramid of Applications
The most rigorous applications in terms of accuracy

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