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START YOUR 3D SCAN TO CAD JOURNEY

A beginner's guide to the world of 3D Scanning

3D scanning, like 3D printing was for a long time out of reach for all but the largest organisations, thanks to recent developments decent scanning equipment is now much more widely accessible. 3D scanning is an overly broad field, with a vast array of different technologies available to cover a wide gamut of different requirements, as a result it can be easy to get lost. This article aims to guide engineers, hobbyists and model makers interested in using this versatile technology for their projects and provide an indication to the possible costs for each possible situation

Notes on 3D Scanners

There are many types of 3D scanner available, and prices can vary from a few hundred pounds to six figures for some of the more specialist systems. When looking at a 3D scanner for engineering and design work there are two types that are worth considering, depending on the types of object to be scanned.

·Handheld scanners, where the object remains stationary and the scanner is moved around the object to capture the data,

·Fixed scanners where the scanner is mounted in a fixed position (usually on a tripod mount) paired with a turntable. Fixed scanners are usually the less expensive of the two options and are well suited to smaller objects (any object that can reasonably held with one hand is typically a good candidate for a fixed scanner) whereas handheld scanners are invaluable when wanting to scan much larger items (for example car body panels). .

There is certainly an element of 'you get what you pay for' - and as a rule of thumb I would avoid the cheap entry level scanners for engineering work as these typically do not offer a high enough level of accuracy or point density. There are scanners available for a few hundred pounds with colour but only suitable for artistic work, the accuracy and point density are too low to be used for engineering

Once the type of scanner is identified then key specifications to look for are:

3D point accuracy (the maximum deviation of a captured point vs the real object).

This is typically a single value for fixed scanners, whilst handheld scanners offer a range of values based on scanning distance. For engineering work you need a scanner with a plus / minus 0.1mm (100 microns) point accuracy or better to ensure reliable enough data to work from.

3D point density (the number of points captured in an area).

Higher point density results in a smoother mesh and allows fine details to be captured. The point density needed does depend somewhat on the size of the object being scanned – a low density of 0.5mm between points would work fine for larger components with minimal surface detail for example a car body panel but this would not be suitable for small objects with fine details such as threads or a knurl pattern.

As with point accuracy, handheld scanners often specify a range of point densities depending on the distance the scanner is from the object being scanned, where positioning the scanner closer to the object will result in a higher density of points.

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The Einscan range of 3D scanners are at the lower end of the price range that and can be used for engineering work. Fixed scanners with a starting price of £1110.00 can be good value for money whilst handheld Einscan versions costing between £4500 to £6000 depending on the specification required are also great value when compared to other scanners with a similar accuracy.

Capture technology used

There are number of different options available, the more advanced (and usually more costly) options work with a much wider range of surface finishes and can therefore scan objects with less or no surface preparation. Most of the more cost-effective scanners use an optical solution based on visible light. These scanners are susceptible to interference from ambient light so are best used indoors in a shielded area, and typically can only scan objects with favourable surface finishes such as light in colour with a matt finish. On the positive side optical scanners can generate data that is competitive with more exotic solutions that are many times the price, and there are ways to work around the surface finish limitations using things such as matting spray (a chalk like powder you spray on to the surface of an object to make it easier to detect on the scanner, which can be wiped away afterwards) or even something as simple as covering the object in masking tape (which may prove easier to remove than powder, depending on the specifics of the object in question).

At the other end of the spectrum you have the high powered laser based scanners, these scanners can capture most objects with no surface treatment at all, it is possible to scan polished stainless steel directly using these specialised scanners which would be impossible with an optical scanner, the downside of this device is the price where £60,000 is a reasonably priced scanner.

Notes on Data Types

3D scanners generate data in the form of a ‘point cloud’, which is a list of 3D co-ordinates of the captured points. Scanners are typically bundled with software to capture and provide basic data processing capabilities and will convert the point cloud data into a triangulated mesh format (either an STL file, as used for 3D printers, or an OBJ file if the scan data includes colour information). This mesh data can be used for 3D printing (although usually data directly from a scanner will need some work before this is feasible), and can be imported directly into applications that work with meshes such as animation focused packages like 3D Studio or for use in inspection software like Geomagic Control X (which allows a scan to be compared in detail against a reference model which is either another scan or 3D model from a CAD system).

Inspection is the most common use for 3D scanning technology and so the big focus of most bundled scan software is on mesh formats – which unfortunately is of little practical use for engineering. This is where 3Dscan to cad (often referred to as reverse engineering) software comes in – this is the missing link that allows captured scan data to be converted into something that will work in major 3D cad applications such as Alibre Design or SolidWorks.

Side notes on mesh processing (of interest to model makers and hobbyists)

The software bundled with most scanners usually includes at least some mesh editing capabilities, namely the ability to align multiple segments of scan data together and delete unwanted data (e.g. removing the scan bed or background from the data).

Other common tools include hole filling (which can either be flat, tangential, or full curvature coherent with the surrounding mesh. Mesh ‘decimation’, sometimes referred to as simplification, depending on the software used for reducing the size of the scan data set because often scanners pick up more data than is required.

The tools bundled with scanners are mostly rudimentary so software such as the Geomagic range offer a comprehensive set of mesh editing and repair functions to enhance the data from the scanner. These tools add to the basic set by providing features like smoothing, defeature (this removes unwanted details from the mesh) deviation-based decimation (which removes point based on a user specified tolerance from the mesh - biasing the remaining points to areas of high curvature which helps preserve detail), full mesh repair and rebuild tools and even the ability to thicken a single shell mesh which is a time saver as it allows only one side of a uniform shell to be scanned. These tools are essential if wanting to work with the mesh data directly e.g. for a 3D print or if the intention is to create a surface model from the scan data.

3D Scan to cad software – making scan data engineering friendly:

There are a range of different 3D scan to cad software packages around that offer different levels of conversion, each of which is a trade-off between speed and fidelity of the final model. When converting scan data into a cad format there are three main options:

Auto-surface wrapping the model.

This is usually the quickest option, as the software will take the mesh data and cover it with an organic nurbs surface which can then be exported as either IGES (best suited if the resulting surface is open) or STEP (only suitable if the final model is a closed shell). This is ideal if the data is only needed as reference in the target CAD system.

The main down side to auto-surfaced models is that the data is treated as organic by the CAD system meaning the surfaces cannot be referenced in assemblies for constraints or used as sketch planes in a part work space. The other draw back to this approach is that the mesh data is converted exactly as is, which is not always desirable if there are unwanted surface detail, damage on the original part or incomplete areas where the scanner could not get any data. Software packages that offer this level of capability include Geomagic Wrap or Quicksurface Free Form.

Manually reconstructing the model partially or fully to be output as a solid STEP file.

This requires more modelling work and a larger tool set but results in a higher quality model. The mesh is used as reference for cross sectional data and the model is then created in a similar way to how it would be modelled in CAD. It is possible to use hybrid modelling, a mix of manual and auto surface tools in combination to save time, whereby critical areas can be manually reconstructed with the auto surface tools filling in the gaps. The advantage of this approach is that the resulting model features recognisable CAD geometry such as flat planes and cylindrical faces, which can be used for assembly constraints or worked with in the part editing tools. This approach also allows for more flexibility in terms of the mesh used – so long as the critical information is there, holes and other imperfections in the mesh data can be worked around without the need to spend a great deal of time repairing the mesh first. Examples of software packages offering this type of capability are Geomagic Design X and Quicksurface.

A full, parametric model including the design history.

This is the top tier of scan to cad capability and offered by Geomagic Design X – the model is manually constructed in the same way as above however once complete the model can then be transferred to a target CAD system including all the sketches and 3D functions used to create the model. This capability is limited to a selection of specific CAD systems such as SolidWorks, Inventor, Creo etc), there is no standard format for design history data, so Design X gets around this limitation by driving the target software package and reconstructing each sketch and feature in sequence. It is an impressive capability and results in a fully editable model on the target system, although somewhat niche as in most cases a solid model without history is sufficient. For those who truly require reverse engineering then this is the main way to proceed.

Example project, a classic car seat rake adjuster hand wheel

To illustrate some of the above, here is a rundown of the steps in recreating a seat rake adjuster hand wheel commissioned by Auto Sparks, specialist suppliers of wiring looms and electrical components for classic cars (www.autosparks.co.uk). The model was produced in using Geomagic Design X to create a cad friendly 3D STEP file.

Fig 1

This scan was created using a 3D Systems Capture scanner – a fixed blue light scanner. The scan data was taken directly into Design X. The scanner has picked up a lot of fine detail including the text and some damage on the inside of the centre cap mount which needed to be worked around.

Fig 2

Note: a typical issue with 3D scanning something with a cavity like this is that its can be very difficult to get data from the inside the cavity, resultingo in holes (the brown areas)in the finished scans) are a common issue. Luckily there is enough data here to create a full section for the part so this wasn’t an issue as the goal was to create a solid model (this wouldn’t be suitable for an auto surface model however).

Fig 3

The first step in reconstructing a mesh is to region it – the colour coding denotes areas the software has identified as continuous and are classified into types such as planar (the light green area on the top), cylindrical (the purple region in the centre) or free form for other areas (e.g. the text). The planar and cylindrical regions can then be used to align the mesh to the XYZ co-ordinate system – in this case the model has been oriented with the central axis aligned to Z and the green flat surface positioned onto the XY plane.

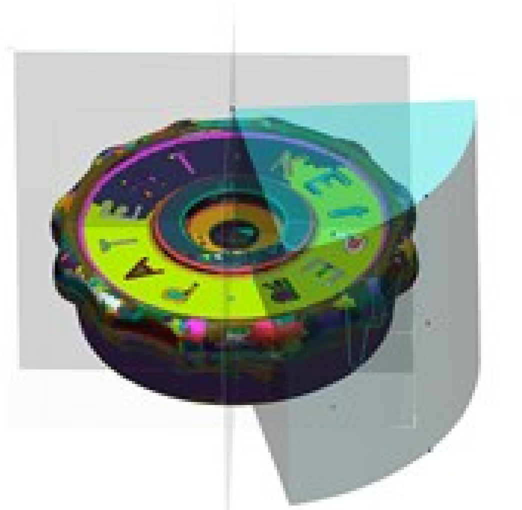

Fig 4

With the model aligned to the co-ordinate system we can then use the tools to reconstruct the part. The sectioning tools allow sections to be generated from the mesh either as a thin slice, or taken as an average over an area as shown in fig 4 (sectioning over an area helps to mitigate against incomplete areas of the data).

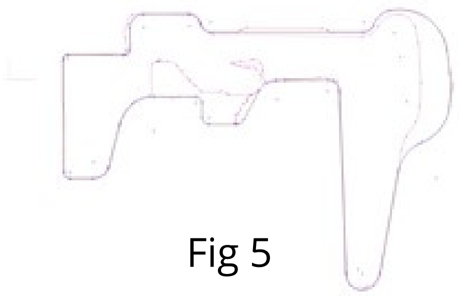

Fig 5

The section tool creates a series of pink reference lines which can be used to create the a cross section sketch (the dark lines) as shown in Fig 5. Segments of line can be automatically fitted to the reference data, and the sketch tools include all the standard CAD sketching features such as constraints, trim functions and so on.

Fig 6

Fig 6 – A revolve created from the section sketch.

Fig 7

When manually reconstructing a part, it’s important to be able to assess the accuracy of the reconstruction vs the scan data. Scan to cad tools provide the ability to create an accuracy heat map (called the ‘accuracy analyzer’ in Design X) that colour codes the model based on a tolerance as shown in Fig 7. In this case the scale has been set to +/- 0.25mm from the source data (green areas) with yellow / red areas indicating more material than expected and blue areas denoting less. The analysis highlights the need to add in a feature to describe the scallop cut outs around the edge and the blue area highlight the lack of text on the top surface. This also indicates that the sample scanned was slightly warped, which was not desirable to replicate in the final component (the yellow area to the top). This is where manually reconstructing a part can provide benefits to allow the model to be reconstructed to ‘design intent’ instead of creating a perfect replica of the source object.

Fig 8

Fig 8 – the finished 3D STEP file imported into CAD after all features have been reconstructed.