Best Practices for 3D Scanning

Getting the most out of 3D scanning using 3D Systems Sense™ application

Scanning with 3D Systems' Sense

Introduction

Sense is 3D Systems' scanning application based upon their award-winning Sense handheld scanner and software. That product has been hailed for how it has been able to make 3D scanning more accessible and capable for everyday use.

How Scanning Works

When scanning an object with Sense, the 3D camera is continually collecting "depth frames". These depth frames are not like a standard 2D image because instead of a color value at every x and y coordinate, they have a depth value that says how far away something is from the camera. This depth is determined by projecting an infrared laser profile onto the object and interpolating the image to figure out how far away each pixel is.

The depth frames are aligned and merged and the resulting data looks like a group of thousands of triangles in three-dimensional space that describes what the 3D camera saw. Color images from the 2D camera are then used to create what's called a texture map. That texture map is aligned and projected onto the object to make it look like what you scanned.

Scanning from All Angles

Whether you use the Sense handheld scanner or a device with integrated Intel RealSense scanner, one of the things to keep in mind is that you will only get scan data on areas the camera can see. Whenever you are scanning something, you do need to make sure to the camera gets a chance to see all the sides of the whole object. Just like you, a 3D camera can't know what the other side of something looks like, unless it gets a chance to see it.

Object Recognition

If you are scanning an object or a person, Sense will attempt to identify the subject you want to scan, and isolate it from the background. This feature, called Object Recognition, helps the application in setting the *scan volume*[1] and the *voxel*[2] size. It also helps with *automatic plane clipping*[3] to clean up the creation of a 3D model from the scan data.

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[1] Scan Volume: The volumetric area within which the application collects depth data to create a model, defined by an invisible box with a given height, width and depth

[2] Voxel: A volume element that can be thought of as a "volume pixel" or a representation of what a depth camera sees at any x, y, z point in space

[3] Automatic Plane Clipping; Automatic plane clipping refers to the process of identifying a plane in 3-dimensional space and using it to clip out data (e.g. table top or floor)

Sense engages the object recognition feature by looking for either objects on top of flat planes (like a table top or a floor), or facial features. When the camera detects either an object or a face during the scan preview phase, it places a green box (object) or orange box (face) around the object to show you what it thinks you want to scan. Should that prove correct and you get the scan captured, Sense will automatically delete away any data that is not part of the object or person.

In many ways the green/orange box is your best indicator that you are on track to getting a good object scan. When you're trying to scan an object, it is highly advisable to place it on a table with nothing else around it, and be sure that the green box is visible when you press Scan. Likewise, when trying to scan a person, make sure other people are not visible in the view and always start by looking directly at the face.

Tracking during Scanning

When you are using your camera to scan an object or person, the camera is continually building and updating a 3D mathematical model of the camera path. The process of keeping track of where the camera is relative to the object or person being scanned is called "tracking". If you ever see a message about "lost tracking", it means the application has lost track of where it is relative to the object or person. Usually returning to a place where you were getting a good capture earlier is enough for the application to reacquire its place.

Sense currently tracks solely on the geometry of the object and pays no attention to the colors or patterns that we see. This makes some objects exceptionally difficult to scan like a vase, soda can or basketball. Scanning vertically symmetrical objects is therefore not recommended unless you can add some measure of geometric diversity to the scan. That diversity can be added simply by placing a couple of other objects around the vase that can be seen from various angles as you move around it.

Another useful tool is Track Assist. This is a PDF containing a special colored pattern that can be found in the Help menu of the application. This PDF, when printed on a color printer and enabled in Advanced Settings, can be very useful for scanning difficult-to-scan objects, as described previous paragraph. Simply place the pattern on a flat surface and put your object on the pattern. As you scan, the camera uses the colored pattern to aide the tracking process. Track Assist is available as a single-page pattern (for objects up to ~6") and a two-page pattern (for objects up to ~15").

What Materials Cannot Be Scanned

This class of 3D cameras use a single band of IR (infrared) light to generate the depth data. This allows the cameras to flood the room with patterns and lights to help determine the depth of everything in the room without anything being visible to the human eye. The challenge is that IR is very different than visible light, especially when limited to single wavelength.

For the range of the IR, the camera can pick out depth information, unless the item absorbs, reflects or transmits the IR light. So that means the camera cannot scan glass, mirrors, highly reflecting items or very dark/black items. While it may look like your app has failed in the scan, the reality is the camera failed to deliver valid depth data.

Feature Size

The size of items that the camera can see is driven by a mix of the IR light issues, the number of depth pixels available to the image, and the distance away from the camera. A good rule of thumb is to make sure that no feature is smaller than the diameter of a No. 2 pencil. The size concern is also affected by material, so keep in mind that if you have something that is both thin and shiny black…that is simply not going to be seen by the camera.

The Target Ring

In the center of the screen, you will see a circle. This circle should be centered on your scanning subject as much as possible. It's where the camera is looking to try to recognize the object or person being scanned. If you stray too far away, you move too much of the object out of the camera's view.

Getting Good Color

The color texture map is created from images captured as you move around the object being scanned. The textures are created from these images, so in order to get a great selection of images, users should pause occasionally to allow the system to snap a good image. If you move quickly around the object or rotate it very fast, you will introduce motion blur into the image capture process. To mitigate motion blur, the application will prompt users to pause every so often, which allows for a good set of stable images to use in texture mapping.

If You Lose Tracking…

Go back to an area of the object you have already scanned and hold still for a few seconds until the system reacquires tracking. The global tracking engine should resume tracking very quickly. If you find you are losing tracking repeatedly in a certain section, try moving out or in as you go around that section to get more depth data captured. If it still loses track, try introducing a little extra geometric complexity (or try Track Assist) and try again.

Am I Too Close or Too Far?

The app will only show full color pixels where it has valid depth data. Anything out of range will be a very faint grayish color. As you move around (or rotate) the object being scanned, you will see that the app fills in the color of the objects and fills in

holes. When you can see a full color object on screen during the scanning, you know you have enough data. As you scan, if it's not filling in color for a region, again trying moving in closer or out a little further until it starts to fill in the missing space.

Creating a Finished Model

Once you are done collecting data, press the Finish button on the right side of the screen. That will go through the accumulated data and create a 3D representation in just a minute or two with a full texture map. You'll notice that the flat surface (e.g. table top) you captured the model on isn't there. Sense detects the plane and trims a few millimeters above it to give you a separate model.

The model editing tools behave very similarly to photo editing tools. *Crop* cuts away everything that isn't in the box. *Erase* just erases the part you highlight. The *Color* tool allows you to tweak the brightness and contrast of the color images. *Solidify* fills in any holes in the scan and creates what is called a "watertight" model, perfect for printing on a 3D printer.

After you make your edits, be sure to press the Apply button to complete that particular editing step. If you are unhappy with your edits, use the Undo button to try again.

What Can I Do Now?

After you have a model you are satisfied with, print it locally if you own a 3D Systems Cube 3D printer. You can also export it to use in any other program via industry standard file formats (.obj, .wrl or .stl). Lastly, you can share your cool 3D models with your friends and family by posting it to Sketchfab or Facebook.

Scanning Tips and Tricks

1. Pick the right scanning option before starting a scan:

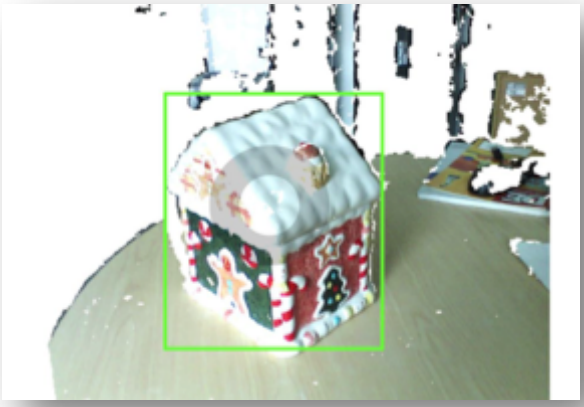
- To scan objects, pick the **Object** option
    - NOTE: In Advanced Settings, users can change the default Scan Volume which will determine the volume to use if Object Recognition is unable to identify an object on a flat surface
- To scan a person's head and shoulders, pick the **Head** option
- To scan an entire person's body, pick **Full Body** option

2. Determine the appropriate scanning distance

- For the Sense handheld scanner, the object or person should be between 6" and 60" away from the scanner.
- For device with Intel RealSense F200 (user-facing) camera, the object or person should be between 8" and 36" away from the device.
- For device with Intel RealSense R200 (world-facing) camera, the object or person should be between 18" and 72" away from the device.

3. Let scanner detect the object

For object scanning, make sure the green box appears around the object you are scanning and is stable (not moving or flashing too much) before clicking Start Scan.

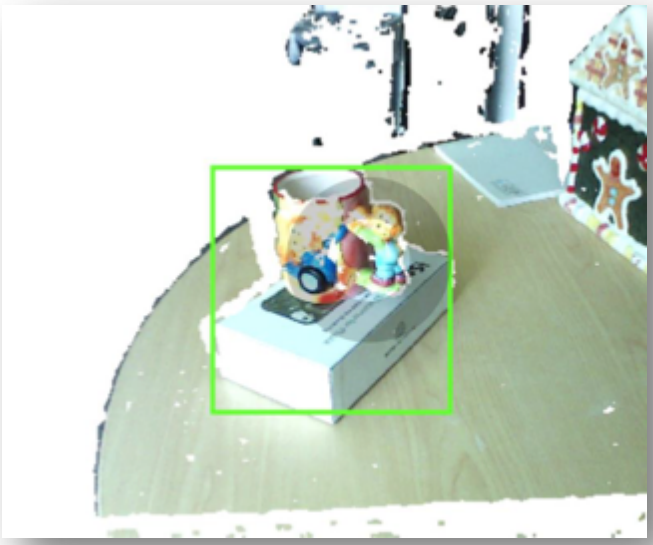


4. Move the camera slowly during scanning

Start scan, and move the camera slowly around the object. When you see some areas that have holes, try to point the camera at those areas to capture the missing data. If you're still seeing the holes, move the camera backward a bit until you see the data.

5. Small/symmetrical object scanning

If you're scanning something really small (like a computer mouse), or something that is symmetrical (like a soda can, or vase), it's better to put a box underneath or another object aside it to help tracking. No worries…that "tracking helper" object can be easily deleted using the crop tool when arrive at edit screen.



6. Lost tracking

If you do run into "lost tracking", slowly move the scanner back to a point on the object or person that you have already scanned and you should be able to regain the tracking. If this keeps occurring, try to put "tracking helper" objects next to it and restart scan.