Tru3D ™ vs. 2D Machine Vision for Error Proofing

Summary:

Tru3D™ is designed from the ground up to be a "better than 6-sigma" assembly verification system. This is accomplished by adhering to five core principles:

1. Minimize the Effects of Process Noise
2. Use 3D Information for 3D Assemblies
3. Keep it as Simple as Possible
4. Use Redundant Information at All Opportunities
5. Log Information for Future Data Mining

Minimize the Effects of Process Noise:

All manufacturing processes produce assemblies that vary. Sometimes this variation prevents the correct operation of the assembly (e.g. missing, or improperly seated snap ring) and sometimes it does not (e.g., dark vs. light color surface). Variation that does not affect the correct operation of the assembly is called "process noise." The goal of all inspection systems is to detect detrimental variation while ignoring process noise.

A 2D vision system does not inspect an assembly; it inspects an image of an assembly. In order for a 2D vision system to perform an inspection on an image, feature pixels must contrast significantly with background pixels. The placement, distribution, intensity, color, collimation, and polarization of the lighting are the most critical factors in determining the system's ability to create contrast in an image. It can be a straightforward task to design an adequate lighting scheme for a particular inspection of a particular assembly. However, it is exponentially more difficult to design a lighting system for a variety of inspections on a variety of assemblies that minimizes production noise such as:

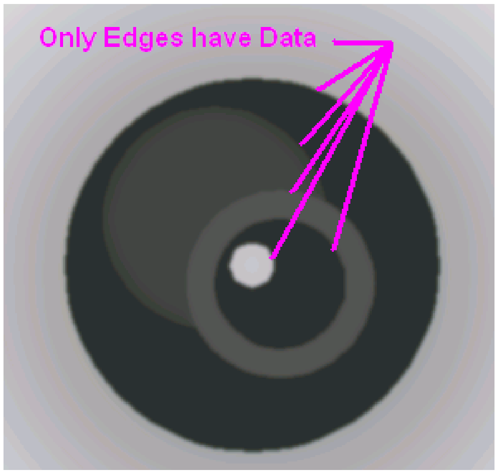
- Surface Finish (textured, smooth, etc.)
- Placement Variation (X, Y, Z offset, tilt, etc.)
- Surface Color (dark, light, mottled, etc.).

Tru3D inspects a three-dimensional (3D) surface map of an assembly. The surface map is constructed by creating and locating high contrast light patterns on the assembly's surface. This technique does not rely on precise light positioning, intensity, or color. Because the system is locating high contrast patterns, as opposed to contrast between part features in the image, it is vastly more tolerant of production noise. As long as the structured patterns are visible on the assembly's surface, an accurate 3D map is created regardless of surface finish, placement, or color.

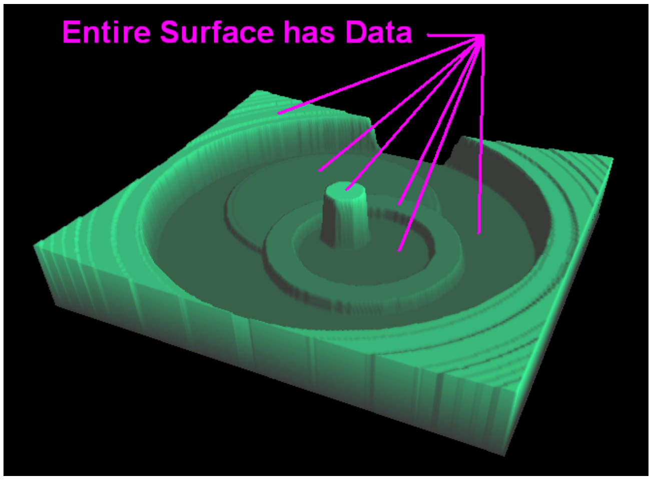
Assembly Verification & Error Proofing | High-Speed 3D Vision Inspection | High-Speed 2D Inspection | Full 3D Surface Metrology
3980 Ranchero Drive | Ann Arbor, Michigan 48108 | Ph: 734-761-8989 | www.coherix.com

Use 3D Information for 3D Parts:

Assemblies are inherently 3D objects, and many inspections on these objects are best accomplished using 3D data. When a 2D vision system inspects a 2D image of a 3D assembly, it can only infer height information. As an example, a 2D system cannot tell if it is looking at an actual assembly or a photograph of an assembly. While this is not an issue for inspections such as printed label inspection, it makes 2D inspections (e.g. is a part bent toward or away from the camera) unreliable or impossible. 2D systems are also limited in that they can only extract data from parts of the image where there is contrast between pixels. If a 2D system was deployed to detect the presence/absence of a dark washer on dark assembly, the best it could do would be to look for the edge of the washer. This would likely be a low reliability inspection because the contrast of any edge would be poor, and only a handful of pixels in the image could be used to infer the presence of the washer.



Tru3D creates a 3D map of the part surface. The system uses this map to perform reliable in-plane and out-of-plane inspections. Since the precise (X, Y, Z) coordinate of each point in the surface map is known, decisions are made using tens of thousands of data points. In the example of detecting a dark washer on a dark background, each surface pixel of the washer would be used to detect its presence as opposed to just a few points along its edge. This is the difference between a marginal inspection and one that is exceptionally robust.



Assembly Verification & Error Proofing | High-Speed 3D Vision Inspection | High-Speed 2D Inspection | Full 3D Surface Metrology
3980 Ranchero Drive | Ann Arbor, Michigan 48108 | Ph: 734-761-8989 | www.coherix.com

Keep it as Simple as Possible:

Even the most capable inspection system in the world is not useful if it is too complicated to setup, operate, or maintain. All inspection systems need a certain amount of configuration information to operate. While some of this information must be externally specified (e.g., desired inspections, and pass/fail tolerances), an inspection system should internalize as many of the "non-intuitive" parameters as possible.

2D vision systems rely on a precise spatial relationship between a part, lighting and a camera to create an image that can be inspected. These systems can be difficult to setup and maintain because even small variations in the location of any of these components with respect to each other can result in an unreliable inspection.

Typical 2D vision systems also require that an operator specify information such as light levels, camera exposure and various image processing parameters (thresholds, filter sizes, regions of interest, etc.). This imposes a level of technical sophistication on an operator that may not be realistic. If these parameters are not set up properly, the system will not perform optimally.

The Tru3D sensor head is a monolithic unit so there are no components to misalign during setup. As long as the sensor head is positioned at its nominal standoff, and is pointing at the part, it will inspect parts reliably.

Tru3D also implements a straightforward touch screen interface that provides a complete, but minimal, set of options. The system uses as much a priori knowledge about the part(s) and inspection(s) as possible to minimize the number of parameters an operator must specify. The operator also interacts with a 3D model in real-world measurement units which is more intuitive than working with a 2D image in pixels.

Redundancy is Good:

Decisions made on a single piece of data are particularly susceptible to error. When multiple or redundant pieces of data are collected, it is possible to mitigate the overall error by "voting" and/or averaging data. To maximize reliability, an inspection system should use as much information as it can collect and process without impacting the throughput of the process.

A typical 2D vision system will acquire one image and inspect it with predefined image processing parameters to make a decision about the goodness of a part. This is the fastest and most straightforward way to perform an inspection, but it also minimizes the amount of information collected and processed. Oftentimes, it is not possible to make a 6-sigma level decision using this minimal amount of data.

The Tru3D system collects and processes as much information as required to perform an inspection(s) reliably. During a single inspection, it may vary the number and brightness of the samples, and the processing parameters. Typically, a surface map is constructed using dozens of full resolution samples acquired over a period of several seconds. This level of redundant data collection and processing ensures that the inspection(s) are performed as reliably as possible.

Log Information for Future Data Mining:

Inspection systems are designed to inspect for expected defects. Oftentimes, however, a part can have a defect that was not anticipated at the time the system was deployed. When this happens, it may be desirable to add a new inspection to the system.

Adding a new inspection to a 2D inspection system may require changing and/or adding lighting or inspection algorithms. This is likely to change the way the existing inspections behave. In any case, the quantification of the overall reliability of the system has to begin all over again.

The Tru3D system can log the 3D model of any or all of the parts it inspects. If a new defect is discovered, the logged information can be accessed to answer questions such as:

- Is it possible to inspect for this defect in the 3D model?
- How many parts in the past have exhibited this defect?
- If the system inspects for this defect how will it affect the overall overkill and underkill rates?

By mining this historical data, the performance of any new inspection can be precisely quantified before the inspection is released to production and since there is no change in how the 3D model is created, the evaluation of the system will not have to start all over again.

The Tru3D system can also display this historical data in the form of a “process video” where any or all of the surface maps previously inspected are shown sequentially. Viewing the data this way can make subtle process trends easier to identify and understand.