Video Measurement

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Video measurement is an accepted way of monitoring critical dimensions of manufactured parts. It lets manufacturers ensure that processes are under control and that parts are within specification. Video measurement systems analyze an image of the part, so the process is non-contact. The image is usually magnified many times, so the system is like a microscope with the eyepiece replaced by a camera. This alone does not make a video measurement system. Many systems magnify the image of a part and present it on a video monitor, but do not measure. For example, an inspector might make decisions by visual analysis of a magnified image. So how is a video measurement system different?

Video systems measure, relying on high resolution images for the necessary accuracy. Vision systems typically analyze lower resolution images to compare a part to a master, count parts in the image, or do simple measurements. Video systems are usually standalone — you take the part to the system. Vision can be standalone, or it can be done on-line, viewing parts as they pass by on a belt, for example. The key difference is that vision systems usually "look" at parts that may be in motion, while video systems measure parts that are on the machine for the specific purpose of being measured.

Image is everything

Video measurement relies on image processing. This requires the image to be converted to electrical signals. This is done by "reading" the signal levels from each of the pixels in a digital sensor (camera). The image is magnified until the feature of interest covers many pixels so individual details can be determined unambiguously. Good video measurement systems use sub-pixeling algorithms to further enhance edge detection.

Since it is the image that is measured, the optics must be of good quality to faithfully present the image to the camera. Aberrations in the optics might be interpreted as a measurement error in the part. A zoom lens allows video measuring systems to maximize detector coverage for features of a wide range of sizes. Fixed magnification systems usually have the highest optical quality, but they require the tradeoff of choosing the best magnification to satisfy the range of expected feature sizes.

Positioning

To measure, it is necessary to know the position of the image and the part throughout the measurement volume of the system. This encompasses position sensing on macro and micro scales. Taking Z motion alone (motion along the optical axis, perpendicular to the image plane), it is necessary to move the camera/optical assembly so the feature of interest is within the focus depth of the optics at the particular magnification being used (depth of focus usually decreases as the magnification increases). This requires the entire camera/optical assembly to move while retaining its critical alignment. This is usually done with motorized linear slides and scales to keep track of position. Once the lens meets this condition, autofocus takes over to maximize the sharpness of the image. The final position of the focused image relative to the original datum is noted by the software.

Illumination

Now that we can move the camera, change magnification and achieve proper focus, we need to acquire data points. Since we are looking for edges, illumination is important. The best data comes from the highest contrast image. Since edges can be straight, curved, have a radius, be on the perimeter of the part or along a feature on the surface of the part, different methods of illumination are necessary. Back lighting (profile illumination) is best for through-holes and the perimeter of the part. The intensity must be adjustable to avoid saturating any pixels with too much light or having too little light resulting in a poor signal-to-noise ratio. The optimal illumination also varies with magnification.

Some features can be illuminated from directly overhead with the same intensity constraints. Special oblique angle lighting is helpful for highlighting subtle surface features. For example, a ringlight made up of concentric rings of LED lights fronted by a Fresnel lens allows illumination at selectable angles of incidence as the different rings are illuminated. Segmenting those rings allows the light to be directional. This is especially helpful for features that lie in a particular orientation. For example, vertical features (as viewed on the monitor; lying in the Y axis of the machine) are best illuminated with lighting from the left or right (±X). More segmentation means more control of the angle of illumination which lets you maximize edge contrast of features in virtually any orientation.

Motion

Now we can get the highest contrast images on the camera directly above the part. Remembering the earlier point about magnification it is easy to understand that it is rare that the entire part is within the field of view at one time. This means the part needs to be moved under the lens until every feature to be measured is in the field. Since this is a measuring machine, all motion in the X-Y plane must be quantified. X-Y stage travels of video machines extend to as much as one meter or more. Parameters of importance include straightness of travel, stage speed and resolution. Open loop motion uses counts of a known size and assumes a position is reached based on the accumulation of a given number of counts. Closed loop motion adds a feedback device such as a linear scale to actually measure the stage position. Total system accuracy depends on the type of motion system and the quality of the stage, motors, bearings, drive electronics and scales.

Structure

The accuracy of the measurement depends on the structural integrity of the system. The three axes must be orthogonal (true 90 degrees apart). This requires a precision design and exacting assembly procedures. No part of the machine must move independently of any other or that offset will affect measurements. This requires a stable, damped mechanical structure. Video measuring systems are made of materials such as steel and granite for the structural stability.

System

Video measurement consists of the choreographed motion of XYZ stages, magnification setting, changes in illumination type, intensity and angle and the acquisition and processing of data points, that ultimately lead to a digitized model of the part which contains all the dimensional and angular relationships of the part under test. There is a lot going on, but user interaction with the machine need not be complex. Well-designed metrology software optimizes the results of measurement routines so users can concentrate on what they get out of video measurement instead of what they put into it.

The next step

Even as video measurement has advanced, complementary technologies have been added to systems to expand their functionality. These multi-sensor measurement systems might use touch probes, allowing access to features that are difficult to image or are beyond the range of the optics. They might use laser sensors for autofocus and surface scanning. Metrology software has evolved to accommodate multi-sensor measurement. Products such as Optical Gaging Products' MeasureMind3D Metrology Software control multiple sensors and incorporate the data from the sensors seamlessly. Video, probing and laser data can be part of any measurement routine without the need for different fixtures.

Multi-sensor measurement systems do a great job of expanding the capabilities of an already powerful platform. The cost justification for a multi-sensor machine should consider reduced fixture requirements, freed-up time on dedicated machines and a lower total cost of ownership.

Video measurement systems are capable of accurate measurements of complex parts. With additional sensors they can do even more.

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Reprinted from *Quality in Manufacturing*, November/December 2001