Active vs Passive Scanning for Multi-Point Measurement

The distinction between touch-trigger (single point) measurement and scanning is well known. Touch trigger has been described as a “woodpecker” approach—measure a point, move to another location, measure again, and repeat until the job is done. The surface or feature condition between the points that are actually measured may be estimated by interpolation, but significant deviations can be missed. Also, because each measurement is a discrete operation and the measuring head must be repositioned to measure the point, the process can be very slow. Scanning, on the other hand, is accomplished with a fluid and continuous movement that can quickly and accurately measure hundreds or thousands of points along a path as the stylus moves across a surface. But while all scanning technologies offer advantages over single-point measurement, all scanning probe heads are not the same.

There are two available contact scanning technologies: passive and active. Both record surface data based on the movement of a stylus connected to a scanning head. The difference is what goes on inside the scanning head. Passive scanning probe heads use springs to hold the stylus in its neutral position and strain gauges to measure deflection as it is moved by contours of the surface being measured. (See figure 1) Active scanning probe heads use software-controlled electromagnets and force controllers in place of springs and strain gauges.

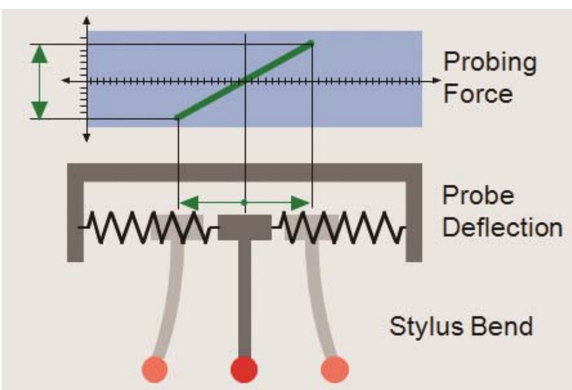


Figure 1

Passive Multi-Point Scanning

The problem with springs is that the farther they are compressed or stretched from a resting state, the harder they resist, and that change in resistance can occur over a very small deflection. In a scanning operation, this occurs when a high spot—one that is closer to the scanning head as it moves across the surface—deflects the spring significantly more or less than surrounding areas. Increased resistance by the spring, even a relatively small amount, can actually reduce the accuracy of the strain gauge reading. Higher resistance by the spring also increases the pressure of the stylus tip against the surface being measured, which can distort the surface of a thin or soft material and throw off the measurement. In addition, stylus bending (which occurs with any form of contact measurement), is much more pronounced and is not linear in a passive scanning system since the spring force is not a constant. This will reduce the reliability of the measuring results.

The only way to minimize these problems in a spring-based passive system is to keep spring compression within a narrow range from neutral, a "sweet spot." This distance can be relatively small and is generally not a problem if the surface being scanned is mostly flat and has a low surface roughness. But if the surface is more contoured the scanning head itself must be frequently repositioned to keep stylus travel within its narrow range of maximum accuracy. (See figure 2) As the diagram shows, the scanning head must be regularly repositioned to stay within the acceptable distance from the surface as it scans up the "slope" of the surface. But even *within* each step, measuring force changes as the stylus is compressed and released within its limited range. Each repositioning of the scanning head takes time, significantly slowing the measuring process.

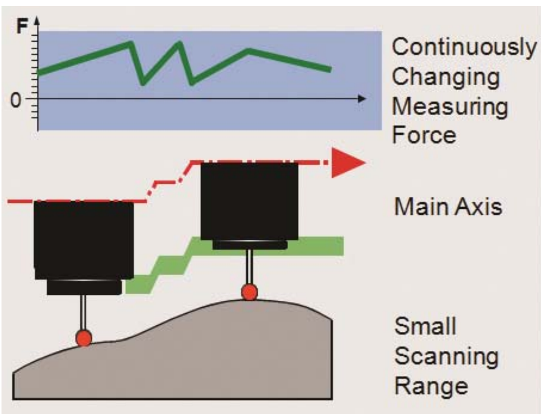
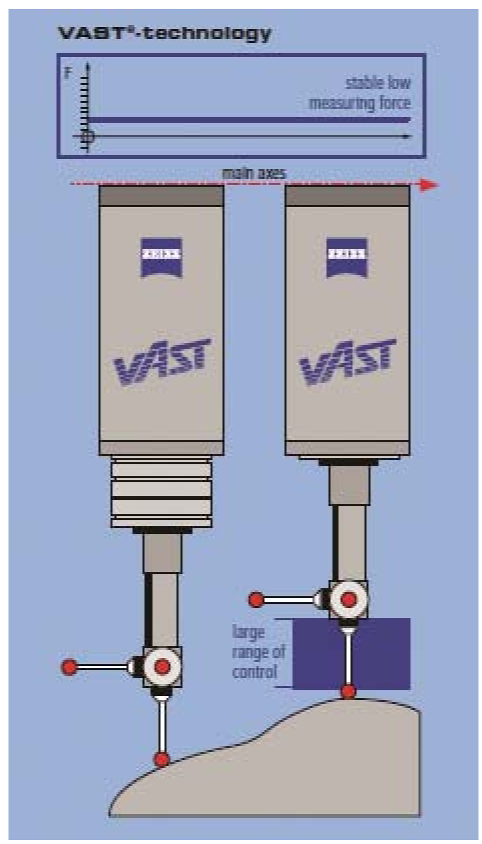


Figure 2

Active Multi-Point Scanning

In an active system, on the other hand, force controllers maintain a steady force on the stylus regardless of its position. Unlike springs, which cannot be adjusted, an active system monitors deflection in real time and adjusts the measuring force to keep it both low and constant regardless of position. This allows a much larger range of movement for the stylus without having to reposition the scanning head and without changing the force exerted on the measured surface. (see figure 3, right) Within the active system's wider range of motion, the measuring force remains constant. This increases accuracy and speeds up the whole process by eliminating the need to frequently reposition the scanning head.



Active scanning's less frequent repositioning becomes more valuable as the contour of parts being measured increases. But it is particularly beneficial in applications like reverse engineering, in which there is no pre-existing CAD model to work from and the contours of the part are not preprogrammed. In either case a spring-based passive system would have to frequently interrupt scanning to reposition the head or scan much more slowly so the CMM could keep spring compression within acceptable range. Otherwise it would have to use readings taken when springs are compressed beyond their ideal range and accept that they might be less precise than desired. This is not the case when using an active system with force controllers to keep scanning pressure even over a far wider range of travel.

In a production environment scanning speed can directly affect yield. Factors like tool wear or thermal deformation can cause parts to deviate from specification even during a single shift. If many or all parts are being scanned, measurement throughput is critical. Faster scanning will require fewer machines to handle measurement. Faster scanning also means quicker identification of problems on the line, reducing the amount of scrap or required rework. In either case, anything that slows scanning or reduces accuracy costs money. Active scanning keeps things moving.

Dynamic Influences

The more complex a measured surface becomes, the greater the advantage of an active scanning system. In addition for the need to frequently adjust the scanning head of a passive system, complex surfaces may require a longer stylus—in some cases up to half a meter in length—to reach into holes or along vertical surfaces. Where contours create lateral pressure on the stylus or where the stylus must approach the surface horizontally, a thicker, heavier stylus may be needed to minimize bending, resulting in inaccurate readings. Because the springs in passive scanning probe heads aren't adjustable, they are less able to compensate for the length and weight of these styli. An active system, on the other hand, can easily adjust to maintain even pressure regardless of the length and/or weight of the stylus and regardless of the angle of the surface being measured or the orientation of the stylus taking the measurement.

Consequences of Scatter

No measuring device is perfect, but passive systems are significantly more subject to scatter (or probe system noise) than active systems due to:

- Inconsistencies in probing force as springs are compressed
- Potential deflection of lightweight probes or measured surfaces caused by excessive measuring force
- Inability of springs to compensate for heavier stylus weight
- Data distortion due to "mix-and-match" componentry

Scatter in data from passive systems is typically addressed using filtering algorithms that smooth out “bumps” in the measured data. This can *partially* overcome inaccuracies in measuring larger features but can blur or totally eliminate finer features, essentially “averaging them out of existence.” Active scanning probe heads, by reducing scatter, provide more accurate reading of both large and small features. (See figure 4)

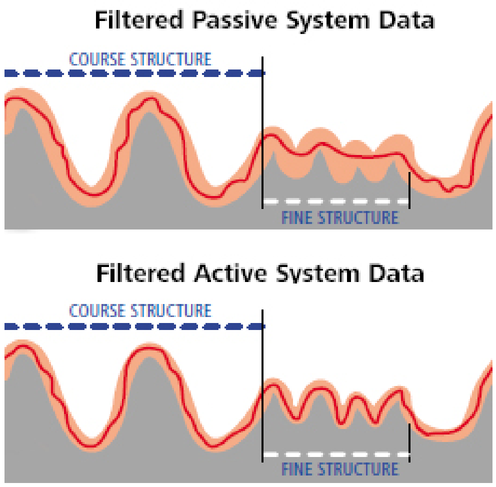


Figure 4

Balancing Speed and Precision

Measuring tasks vary in the degree of accuracy required and in how quickly they must be completed. The software control of active scanning allows easy rebalancing of operations to emphasize speed or accuracy. Essentially, this is a pie being divided between two competing values. But regardless of how it is divided, active scanning provides a larger pie than passive, allowing higher speed with comparable accuracy or greater accuracy with comparable speed.

Return on Investment

Active scanning technology has become more affordable and more mainstream as capabilities improve, and it is diversified among a broader range of applications. Where speed is essential, active systems are significantly more productive and can actually reduce the number of measuring systems required for the application. Except in the simplest, flattest applications, active systems are more accurate than passive systems at *any* given speed. The advantage of active scanning systems grows as the measurement task or the object being measured becomes more complex.

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