Comparing volumetric accuracy between two hand-held 3D laser scanners

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Introduction

In the reverse engineering process, it is vital for the measurements of a replicated model to be as similar as possible to the original object. Technology, such as the Coordinate Measuring Machine (CMM), can produce measurements accurate to the thousandths of an inch, however it is expensive. They are also limited in the objects they can measure due to size constraints. Hand-held laser scanners allow users to take accurate three-dimensional measurements while being more affordable and accessible (Kersten et al., 2016).

The Artec Spider is a hand-held 3D scanner designed to scan small items with complex geometry. It was developed to aid in computer-automated design (CAD) processes. The Artec Leo is a wireless hand-held 3D scanner that can capture high-resolution models of objects in color. It has an automatic onboarding processing feature that allows the scanner to simultaneously process and scan. (Seifert & Griffin, 2020).

The purpose of this study is to determine scanning capabilities of the Artec Spider and Artec Leo by comparing accuracy of volumetric measurements of objects with the CMM, the current industry standard.

Materials and Methods

Two objects were scanned, a 123 block and a ring gauge. The 123 block had sides that measure exactly one, two, and three inches. The outer diameter of the ring gauge was 2.35 in. Both objects were sprayed with talcum powder to remove texture and oriented in a way where all the distinct features could be scanned. Each object was scanned by the Artec Spider (Figure 1) and the Artec Leo (Figure 2). The processing software Artec Studio was used to convert the scans from a cloud point data set to a mesh file so a CAD file could be created. This included removing the base, erasing unnecessary data, aligning each individual scan, completing global registration, outlier removal, and sharp fusion.

Measurements of each distinct feature on each object were taken 15 times using the measuring tool in Artec Studio. For the 123 block, width, length, and thickness were recorded and for the ring gauge, the inner and outer diameter, and thickness were measured. These features were used to calculate each object's volume.

The CMM (Figure 3) was used to scan multiple locations to acquire measurement data of distinct features by using a probe tip. The software for the CMM calculated the measurements for each feature from the scan. The measurements taken were used to calculate the volume of the object and its percent error between the scan data and the CMM.

Figure 1 (above): Artec Spider, the total height is 7.5 in.

Materials and Methods (continued)

Figure 2 (right): Artec Leo, the total height is 9.0 in.

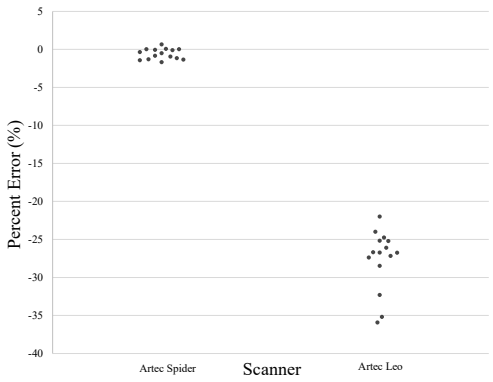
Figure 3 (right): CMM, the scanning probe is 3.5 in.

Results

Four one-sample *t*-tests were used to determine if there was a significant difference in mean percent error of volumes between measurements acquired by the scanners and those of the CMM for two certifiable objects, a 123 block and a ring gauge.

The *t*-tests calculated for the ring gauge (Graph 1) yielded significant differences in both data collected from the Spider when compared to the CMM ($M = -0.576$, $SD = 0.698$, $t(15) = -3.20$, $p = .006$) and the Leo when compared to the CMM ($M = -27.6$, $SD = 3.95$, $t(15) = -27.0$, $p < .001$). The *t*-tests calculated for the 123 block (graph 2) indicated no significant difference between the measurements from the Spider as compared to the CMM ($M = 0.071$, $SD = 0.46$, $t(15) = 0.60$, $p = .560$, but did indicate a significant difference between measurements from the Leo as compared to the CMM ($M = 4.84$, $SD = 2.11$, $t(15) = 8.89$, $p < .001$).

Comparison of error distributions for volume between scanners and CMM for a ring gauge

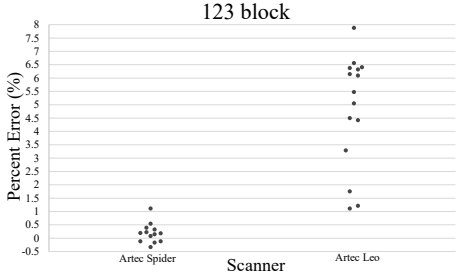


Graph 1 (left): The graph shows the values of percent error between the volume of a ring gauge obtained from the Spider and Leo scans to CMM measurements.

Results (continued)

Comparison of error distributions for volume between scanners and CMM for a 123 block

Graph 2 (right): The graph shows the values of percent error between the volume of a 123 block obtained from the Spider and Leo scans to CMM measurements.



Conclusion

The purpose of this study was to determine if the volumetric accuracy of the Artec Spider and Artec Leo would be comparable to that of the CMM when measuring two objects of different shapes and sizes.

There were significant differences in the measurements of both scanners compared to the CMM for the ring gauge. However, the Spider yielded insignificant differences in volumetric measurements for the 123 block, while the Leo yielded significant differences. Based on the results of this study, the Spider achieved a higher level of accuracy when making volumetric measurements for the 123 block, but based on low sample size, it cannot be concluded that it is more accurate overall. A potential explanation for greater accuracy in scanning the 123 block as opposed to the ring gauge may be due to the difference in volumetric shape. The CMM should still be used if accurate dimensions are needed. While there is some support for use of the Artec Spider for volumetric measurements in this study, further analysis should be done by scanning more objects of varying sizes and shapes to determine accuracy. More scans on each object could also lead to a more accurate assessment of scanners' capabilities.

References

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