

Improved Speed and Accuracy for Archaeological Site Scanning

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Abstract

During viewpoint framing for long-range laser scanning, nearly all current scan control software assumes a uniform bounding box selection (parametric UxV) within an XYZ world. Here we suggest a new system of scanner control that does not make this assumption, but instead uses active parsing of incoming points to enable automated, “subdivided” scan viewpoint framing.

1 Unique Challenges in Large-Scale Scanning

Because access to archaeological sites is often limited, it can be difficult to scan large sites at relatively high resolution. In the case of our laser scanning at the Ramesseum in Egypt (below), our goal was to establish detailed architectural plan, section, and elevation views of a site many hundreds of meters in dimension.



Figure 1. The Ramesseum, Thebes, Egypt.

Current survey techniques can yield approx. 1:1000 digital maps [Duran, Toz]. However, to resolve the complex plan at the Ramesseum, we estimate a resolution of 10mm would be ideal. Even through our team was able to acquire points rapidly (~1000 points/sec), it was still not practical to scan the entire site at this resolution, since this would require approximately 250 days.

2 Increasing Detail via Progressive Refinement

We propose a refining technique to 1) detect edges during the scanning process, and 2) mark these border areas for rescanning at a higher resolution specified by the user. This is particularly appropriate for archaeological sites such as the Ramesseum, where the large-scale structure of the site is composed of rectilinear elements (as shown above). Ours is a ‘poly-resolution’ approach that aims to concentrate detail where it is critical for establishing relevant architectural details (i.e., corners) while allowing less critical surfaces (walls) to be scanned more rapidly.

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In the scene below, an initial synthetic scan pass is shown in red. Note that the actual spacing between scanned points on the target surface (*PIV*, or Point Interval Value) increases with the angle (θ_{scan}) and distance (δ_{scan}) of the laser head relative to the scanned surface. Since the movement of a scan head is typically monotonic, as shown in Fig. 2, the target *PIV* for the higher resolution scan must take into account θ_{scan} . That is, to maintain the target *PIV*, the rotation increment of the scanner must decrement as θ_{scan} increments. Since scan point confidence falls with increased θ_{scan} , a natural limit to θ_{scan} can be set and the program instructed to flag low-confidence points for user review.

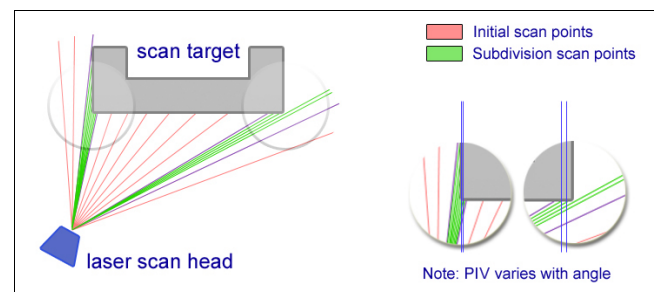


Figure 2. Schematic plan view of a sample scene.

During the initial (red) scan, our proposed method evaluates the change in δ_{scan} from point to point. When the $\Delta\delta_{scan} > Depth\ Threshold$ (a user specified value), a corner has been detected and a detailed scan is launched (shown above in green) to determine a more accurate position for this edge, which in turn allows for greater precision in view registration via ICP. The *Depth Threshold* can be set by the user so that minor changes in distance (for instance, the uneven bricks in the wall shown at left) do not trigger an automated scan refinement pass.

The following is pseudo code for a single scan line:

- While $UV_{current} > UV_{end_of_line}$
 - If $\Delta\delta_{scan} > Depth\ Threshold$
 - Reset laser to UV_{prev}
 - Frame $UV_{prev} \rightarrow UV_{current}$
 - Scan framed region using $PIV_{highres}$
 - If $\theta_{scan} > UserLimit$, flag these points as low confidence for the user
 - end (If)
 - Else increment $UV_{current}$ to next scan point
 - end (If)
 - end (While)
- End Of Algorithm.

References

DURAN, Z., TOZ, G. 2002. Documentation and analysis of cultural heritage by means of photogrammetric methods and GIS, Istanbul Technical University, Division of Photogrammetry