Use of a highly deformable snake arm robot for large volume, high resolution measurement

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The Challenge

When taking measurements, using optical metrology systems, many factors must be considered in the selection of optimal sensor placement. Therefore, this choice usually requires compromises. One area of consideration is how far away from the subject sensors should be placed. When placed closer, it is generally possible to achieve higher local accuracy and improve sampling. However, this reduces the observable volume which causes problems when measuring larger objects.

One common solution is to capture multiple measurements from optimal positions, then merge the results. However, this easily introduces errors and the need to take many measurements individually can be a slow process.

A New Approach

This system builds on existing approaches that use a six Degree of Freedom (6DoF) tracking system, in conjunction with a mobile sensor package. An improvement is sought by way of combining this with a highly deformable robotic platform. This allows multiple mobile sensors to capture data concurrently from poses optimised for accuracy and resolution of measurement. The tracking system then locates and combines these measurements in the global coordinate system without the need for an additional registration process.

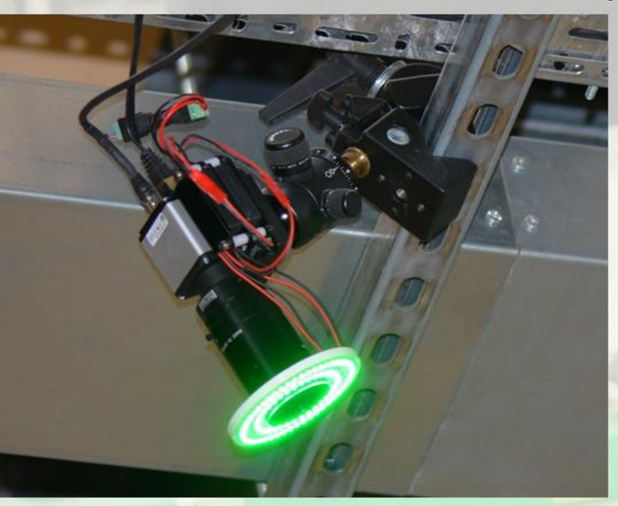

Fig.2 - Ceiling Mounted Tracking Cameras

The Robot Platform and Sensors

The robot platform used is an OC Robotics snake arm, which is 2.1m long with 12 segments, each with two degrees of freedom. A KUKA KR 500 is used to position the snake arm, allowing for flexible coverage over a volume of $10m^3$.

Mounted to this are a number of photogrammetric sensor packages, consisting of stereo-camera pairs with individual ring lights, (Fig. 1). These were constructed from low-cost, light-weight parts.

This system allows for full field data capture with a single pair of images captured from each pose.

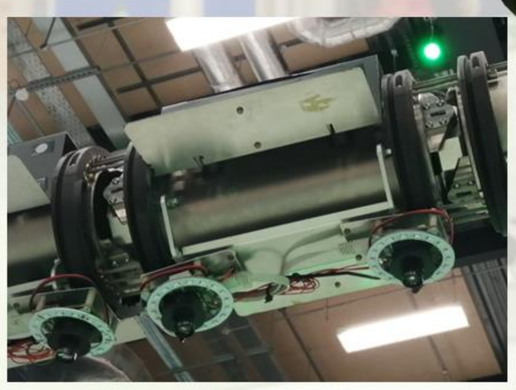

Fig.1 - Robot Mounted Cameras

6DoF Tracking System

The tracking system consists of a photogrammetric network of six ceiling-mounted cameras with light rings, (Fig. 2). Segments of the snake arm with equipped with sensor platforms are given unique constellations of circular retroreflective targets (as can be seen to the right) and a characterisation process is carried out to determine the location of the cameras relative to these targets.

With this arrangement, all targets across all segments of the snake can be measured at the same time, with the centre of the targets being located to a high degree of accuracy.

From this, a transformation is calculated and applied to the measurements made, independently aligning them With the global coordinate system.

A shared trigger system ensures that images are captured from all cameras, across both systems, simultaneously, guaranteeing that all data is from the same moment and undistorted by robot movement.

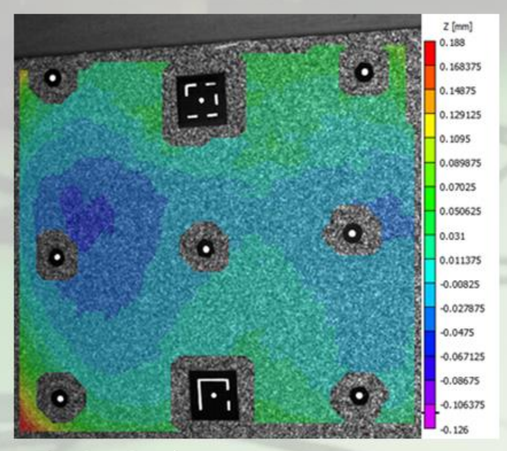

Fig.3 - Surface Measurement

Initial Results

Surface measurements have been made using this approach and processed using the VIC-3D DIC software for full-field measurement (Fig. 3). Fig. 4 shows the mean deviation between the location of points measured locally by the system and by using a laser tracker. Tests also show that robot segments can be tracked across the $10m^3$ operating volume with sub-mm accuracy.

This shows the potential for the system to achieve full-field, large volume, high accuracy measurement.

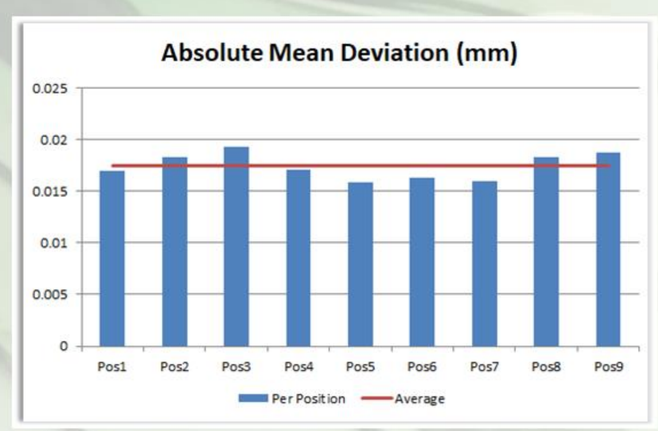

Fig.4 - Point Measurement Validation

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