3D Visual Inspection System

This novel technology can reconstruct the 3D shape of object with few shadow and obstruction regions. The shadow and obstruction are two major problems in nowadays active optical 3D measurement. **In this novel design, we use four combined 3D sensors instead of only one to overcome shadow or obstruction problems.**

A novel calibration method is invented to handle an accurate and flexible calibration of this four-sensor-based system. With easily and arbitrarily placing a calibration pattern within the system measuring region several times, the system can be calibrated and get ready to make measurements.

In addition, our data registration and stitching process will be much easier to perform, since the calibration is automatically completed within a common coordinates system. Thus, final results will be a whole dataset of 3D point clouds from four perspectives. The following advanced data registration and stitching will be consequently more convenient than the other competing methods, which requires highly accurate mechanical translation and rotation or feature point extraction.

An advanced phase invalidity identification algorithm is also proposed to improve the accuracy and precision of the resultant dataset. In these fringe pattern based technologies, fringe phase is a vital intermediate result. With our phase invalidity identification process, unreliable data points can be effectively identified out and removed during the intermediate process as well as the final 3D results. This procedure is important to ensure the measuring accuracy and precision.

Advantages and improvements over existing methods, devices or materials;

- **Proposed novel design with four combined 3D sensors is capable of providing more accurate 3D data without shadow and obstruction problems.**
- **Proposed novel system calibration method can provide accurate system calibration parameters in a flexible and convenient procedure.**
- **Proposed calibration process for each sensor can be complete within a common coordinate system. This provides an advantage that the data registration and stitching process is easier and straight forward.**
- **Proposed phase invalidity identification framework can effectively improve the accuracy and precision of the measurement.**
- **Proposed system is based on two CCD cameras and two LED-illuminated projectors, so the cost is less than other systems in the market.**

Technical description of the Invention;

The scope for this project is to develop a full-field four-sensor-based 3D shape measurement system and software to seamlessly integrate the data from the four sensors. Specific application for inspection of steeply inclined surfaces as well as full 360 degree views of thin objects will be demonstrated.

The proposed 3D shape measurement system is based on our existing compact profilometer and overcomes some of the limitations of the current system, such as problems in measuring steep profiles or full 360-degree profiles for thin samples. Since the aim is to integrate two such systems, an optical design which offers greatest flexibility and accuracy needs to be looked into. Stitching of the dataset from the four sensors so that there is a seamless overlap is also critical. Finally the industrial needs for robust, accurate and fast systems to satisfy need to be considered.

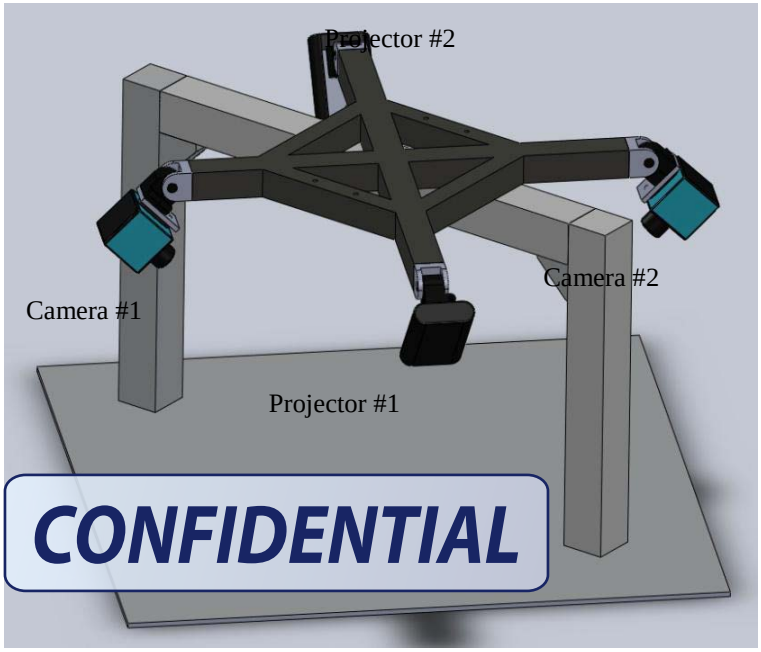

Figure 3. Proposed compact true 3D profilometer setup.

Our proposed four-sensor-based 3D measuring system as shown in Figure 3 can resolve this problem by measuring the target from four different perspectives, and then combine four sets of data together to achieve full 360-degree profile.

Novel fringe analysis algorithms are used to retrieve the reliable fringe phase and 3D values as well. Flexible calibration with stereovision method makes the system can be conveniently recalibrated if it is necessary. Proposed design effectively avoids the shadow and obstruction issues which are the major limitation of the current system in market. Hence the whole process consists of six steps named as fringe recording, fringe analysis, system calibration, 3D reconstruction, data registration, data visualization.

Examples of Height variations of Printed Circuit Boards for 3D visual inspection