NASA Langley's Photogrammetric Method for Calculating Relative Orientation

Highly accurate, flexible system measures relative dynamics in six degrees of freedom

NASA Langley Research Center has developed a novel method to calculate the relative position and orientation between two rigid objects using a simplified photogrammetric technique. The system quantitatively captures the relative orientation of objects in six degrees of freedom (6-DOF), using one or more cameras with non-overlapping fields of view (FOV) that record strategically placed photogrammetric targets.

This high-speed camera system provides an algorithmic foundation for various photogrammetry applications where detecting relative positioning is important. Originally developed to evaluate the separation stage of NASA's Max Launch Abort System (MLAS) spacecraft crew module (Figures 1 & 2), this technology has also been used to evaluate the effect of water impact on the MLAS crew module (above Figure) and for trajectory analysis of military aircraft.

Benefits

- **Short set-up time:** Overlapping camera FOV are not required, ideal where physical constraints may limit camera placement.
- **Flexibility:** Placement of camera and target locations is arbitrary, and multiple types of camera lenses may be used simultaneously.
- **Minimal user intervention:** Algorithm automatically calculates relative orientation after initial set-up.
- **Low cost:** Simplified photogrammetry system has minimal equipment requirements.
- **Adjustable accuracy:** Accuracy can be increased by adding additional cameras and photogrammetric targets to the system.
- **Quantitative data:** The system provides both quantitative and qualitative motion measurements.

partnership opportunity

Figure 1: NASA's Max Launch Abort System (MLAS) spacecraft

The Technology

The NASA technology uses a photogrammetry algorithm to calculate the relative orientation between two rigid bodies. The software, written in LabVIEW and MATLAB, quantitatively analyzes the photogrammetric data collected from the camera system to determine the 6-DOF position and rotation of the observed object.

The system comprises an arrangement of arbitrarily placed cameras, rigidly fixed on one body, and a collection of photogrammetric targets, rigidly fixed on the second body. The cameras can be either placed on rigidly fixed objects surrounding the second body (facing "inwards"), or can be placed on an object directed towards the surrounding environment (facing "outwards"). At any given point in time, the cameras must capture at least five non-collinear targets. The 6-DOF accuracy increases as additional cameras and targets are used. The equipment requirements include a set of heterogeneous cameras, a collection of photogrammetric targets, a data storage device, and a processing PC. Camera calibration and initial target measurements are required prior to image capture.

A nonprovisional patent application on this technology has been filed.

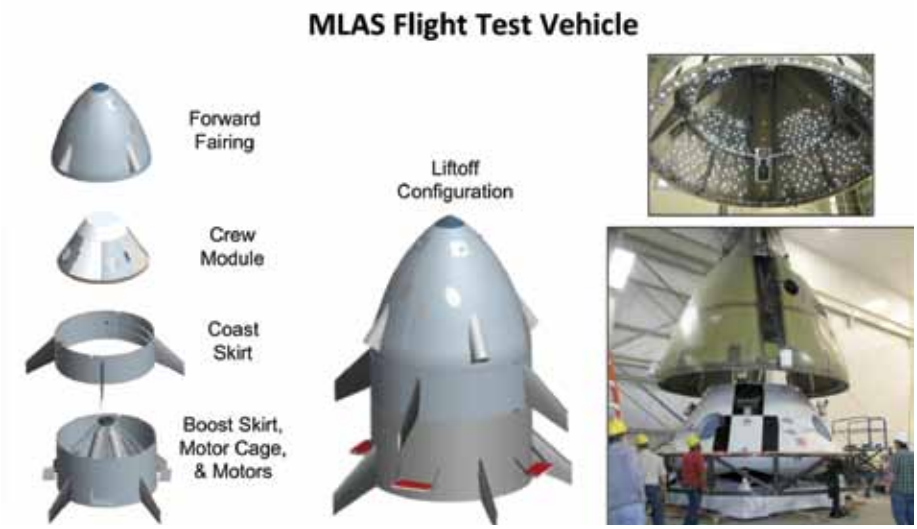

Figure 2: This photogrammetry technique was used to evaluate the crew module separation stage of NASA's MLAS flight vehicle.

Applications

- Astronomy – satellite-based star tracking
- Automobiles and other vehicles
  - car crash dynamics
  - vehicle separation tests
- Medical – computer-assisted surgery
- Military – ballistics testing
- Terrestrial surveying
- Wind tunnel testing

For More Information

If your company is interested in licensing or joint development opportunities associated with this technology, or if you would like additional information on partnering with NASA, please contact:

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