

In-Situ Recession Measurements by Photogrammetric Ablator Surface Analysis

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Speaker: Megan MacDonald

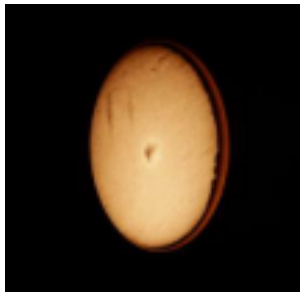
10/04/2014

Overview

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Motivation

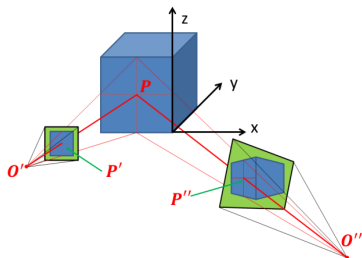
- Ablative material loss quantification with respect to surface recession.
- In-situ analysis of recession.
- Identification of influence of material defects.
- Analyse differences in ground testing compared to flight scenario.



Surface photography during test.

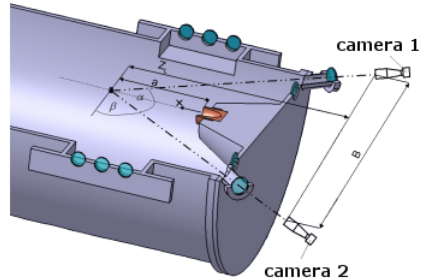
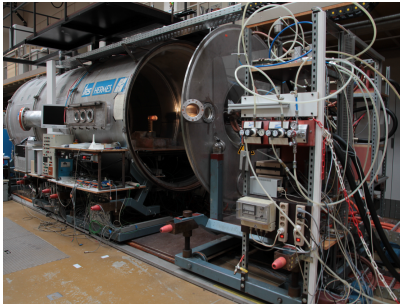
Theory

- Using the central projection, a 3D object point can be seen in two images.
- The needed information is the orientation of the sensor area (inner orientation) and the orientation of the camera in space (outer orientation).
- Connecting both images allows to derive where the lines overlap. This is the 3D position in space.
- More cameras increase the accuracy, because the overlap becomes more precise.



Central Projection: A 3D point P is found as a P' and P'' in the image data.

Experimental Setup



- Experiments in the plasma wind tunnel PWK1 at IRS.
- Two Canon EOS 60D DSLR cameras.
- Carbon preform material sample (MERSEN) with a density of 0.18 g/cm^3 .
- Surface temperature measurement using Pyrometry and Thermography.

Flow Condition

Parameter	Value
\dot{m}_{air}	18 g/s
p_{∞}	16.6 hPa
p_{tot}	24.3 hPa
P_{el}	162 kW
$\dot{q}_{coldwall}$	4.1 MW/m ²
h_{local}	68.4 MJ/kg

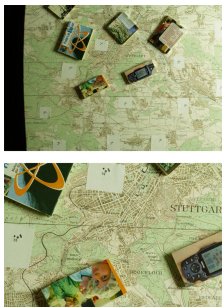
Flow Condition.

Parameter	Value
Focal length	300 mm
Resolution	17.9 MPix
Frame rate	3 fps
Exposure time	1/4000 s
Aperture	f/25
Filter	ND1.2

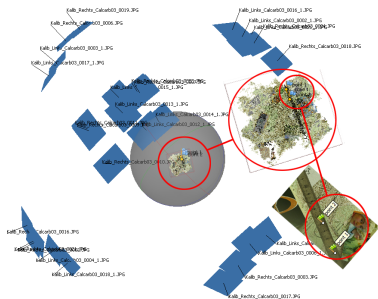
Camera Parameter.

- Heat flux, total pressure, and enthalpy correspond to a hayabusa flight condition at an altitude of 78 km.
- Plasma wind tunnel flow is subsonic.
- The combination of ND filter and short exposure time gives sufficient surface feature resolution for the photogrammetry.

Calibration



Calibration object.



Camera Calibration using AGISOFT.

- Three-dimensional object is positioned close to the measurement location.
- Pictures are taken for different object inclinations.
- Pictures are arranged by the software to calculate the camera orientation.
- Camera position must not be change!

Data Reduction

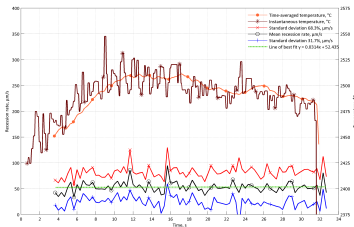
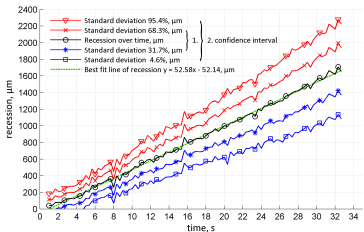


Surface Triangulation of the point cloud.

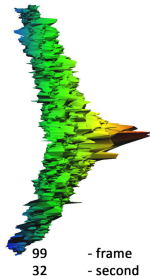
- The calibrated camera position is loaded in the software **SURE**.
- Acquired image pairs from plasma wind tunnel tests are analysed by **SURE**.
- **SURE** computes point positions from the image pair, so a 3D map is generated.
- The surface change is then identified from image pair to image pair.

Photogrammetric In-Situ Surface Analysis

Recession measurement



10-times



- Rate is derived from 3 sec., i.e. mean value of 9 frames.
- Rate is very constant.
- Mean rate ($52.5 \mu\text{m/s}$) is consistent with published values.
- Asymmetric recession due to sample holder.

Surface Analysis



- At the beginning the scratches are visible in photos and point cloud (upper figure).
- For later times (lower figure) scratch is only visible in point cloud.
- A lower recession has been measured, perhaps due to denser material, i.e. the scratch was probably a dent.

Summary

- Three-dimensional surface determination from stereoscopic image acquisition has been realized.
- Surface is resolved with 300 000 data points, i.e. 25 000 points/cm² (approx. 400 dpi).
- Recession rate has been derived from photogrammetric data sets to 52.5 μm/s for the carbon preform.
- Surface defects (scratches, dents) can be analysed.

Thank you.

Further questions, comments, ideas:

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...and thank you, Megan!