MatchID
Metrology beyond colors

THE UNIVERSITY of EDINBURGH | FASTBLADE

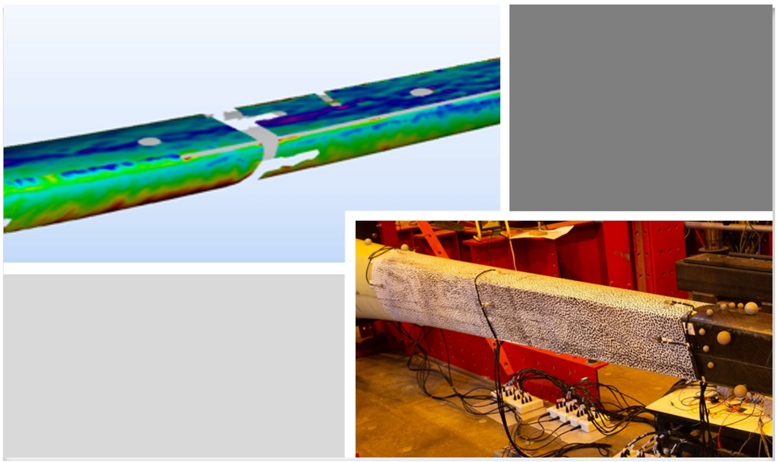
Application Note

Multi-Camera DIC: Deformation of a 6m wind turbine blade

Case Description

The FASTBLADE Structural Composites Research Facility at the University of Edinburgh has trialled and will adopt our Multi-Camera DIC solution on tidal and wind turbine blades. FASTBLADE is the world's first test facility that uses regenerative hydraulic technology to offer high-quality, low-cost fatigue testing of tidal blades and other composites structures for research and product development.

A sample section of a torsion box from a prototype scaled wind turbine blade was recorded by 6 cameras over its entire perimeter at various loading conditions. DIC strains were determined at the full 3D-reconstructed surface and benchmarked to strain gauge measurement results.



Experimental Setup

- **Cameras:** 6 Flir Pointgrey Blackfly S USB3 8.9MPx with 12mm Lenses
- Hardware synchronization
- **Field of View:** Cylindrical perimeter of a 250 mm diameter and 2.5m section

Analysis

- **Type:** Multi-Camera DIC
- **Calibration**: 150 target images orient every camera relative to each other in space
- **Reconstruction:** No prerequisites on overlapping regions for shape reconstruction

Results

- **3D Shape:** Accurate shape of the entire cylindrical sample section
- **DIC strain results** agree to traditional strain gauge values
- **Identification of non-linear strain behavior**

Why MatchID

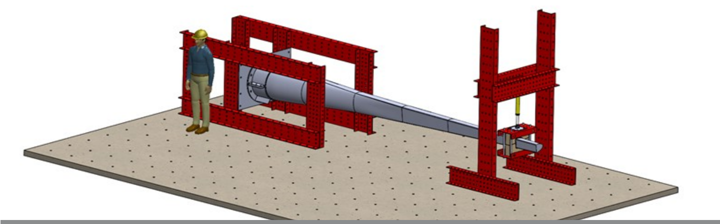
- **Multi-Camera** DIC for an unlimited amount of cameras adopting a flexible calibration strategy
- **No prerequisites on overlapping** speckled regions
- **Higher-order stereo shape functions** yielding a more accurate signal on curved surfaces
- Excellent **agreement with traditional strain gauges** and revealing non-linearities

Experimental Details

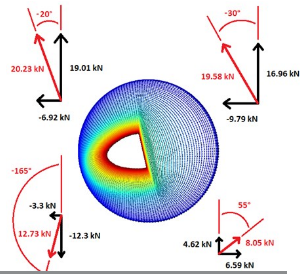
The turbine prototype is placed in a test bench. The root is clamped with a special designed fixture to guarantee minimum slippage. The loading is imposed by using a double-acting hydraulic actuator from a location close to blade tip. The actual force is recorded via a load cell. Strain gauges are placed at various locations in both the longitudinal and radial direction.

6 DIC cameras record a 2.5m sample section of the blade to extract full-field shape and deformation data during the entire event.

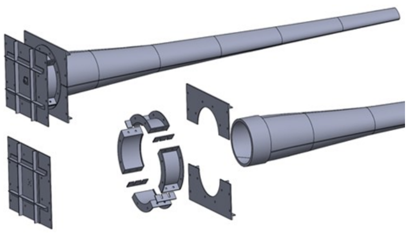
Both load and strain gauge signals are synchronized with the DIC images via a dedicated hardware protocol.



Schematics of the experiment setup

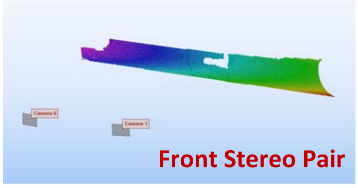


Load w.r.t. blade orientation

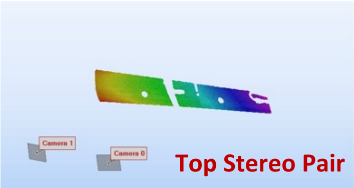


Root fixture design

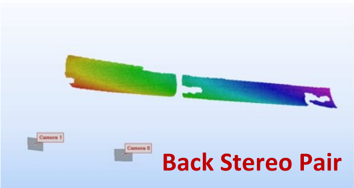
3D-Geometry Reconstruction



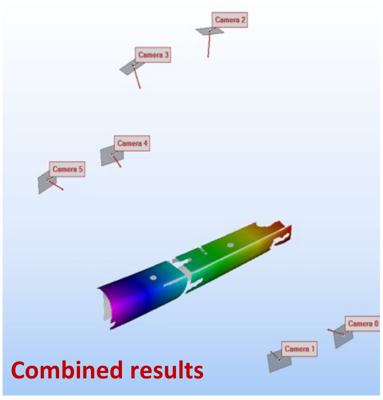
Front Stereo Pair



Top Stereo Pair



Back Stereo Pair



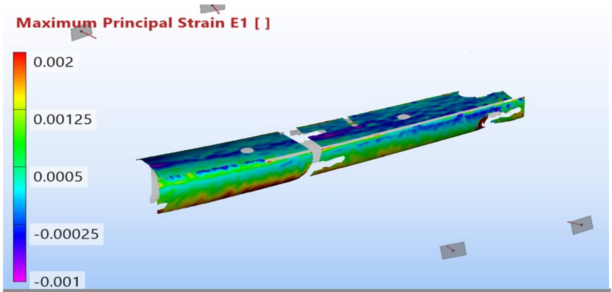
Combined results

The images are acquired using 6 synchronized cameras. This corresponds to 3 different stereo systems that observe different sides of the turbine blade. No overlapping prerequisites are put onto the various stereo pairs. They can be completely disentangled in space.

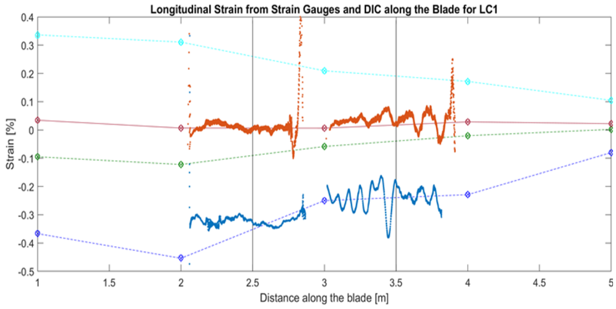
To reconstruct the 3D shape, all cameras are simultaneously calibrated. Finally, the geometric data of the stereo systems are combined into one general frame containing the actual shape at various load steps.

Deformation Results

Once the geometry is accurately known at various load steps, displacement and deformation fields can be calculated. The uncorrelated regions on the 3D shape below correspond to the strain gauge locations and the involved cabling, hereby hampering the optical access.



First principal strain of the blade section



A successful comparison between the strain gauge data (diamonds) and DIC strain along an extracted line is made. Moreover, thanks to DIC, the irregularities and non-linearities in strain are clearly revealed. This gives the engineer more profound insights on how to optimize the overall construction without the need of pre-knowledge where to inspect.