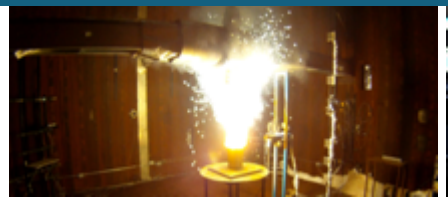
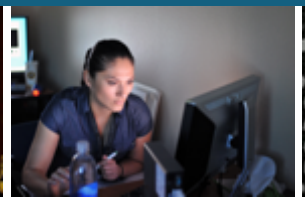
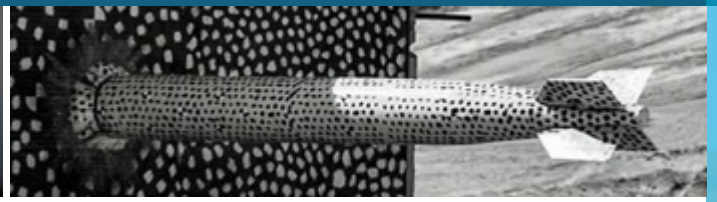
SAND2022-1207C

Sandia National Laboratories

Optical Techniques for Modal Analysis: Introduction







IMAC XL Short Course: Optical Techniques for Experimental Modal Analysis

Dan Rohe, Bryan Witt, and Phil Reu

U.S. DEPARTMENT OF ENERGY | NNSA

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Introductions

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About this course

Who is this course for?

Experimentalists…

With limited familiarity of cameras and basic imaging…

Seeking end-to-end guidance on applying DIC to structural dynamics testing…

And who are curious about advanced techniques to explore further.

About this course

Course Structure

Informal

Please ask questions (we'll try to moderate for time).

Evolving

Photogrammetry is growing; methods and applications will grow with it.

Developing

1st time offered! Trying to convey hands-on testing in a classroom (during COVID)

Practical

Basic idea is to get you running with enough information to be dangerous!

About this course

Imaging Basics

- Provide a basic understanding of imaging hardware terminology
- Discuss the basics of modern photography
- Introduction to camera models and projective geometry

Digital Image Correlation

- High-level overview of DIC
- Introduce important test parameters
- Discussions on proper lighting and patterning
- 2D vs. 3D (stereo) DIC

Practical Application

- How to plan for a successful test and select equipment
- Setting up a test and preparing the test object
- Strategies for noise reduction
- Combining and synchronizing cameras with other data acquisition systems
- Image processing, data post-processing, extracting modal parameters

Advanced Topics

- Primer on motion magnification
- Generating synthetic images
- Using a phase-stepping technique with low-speed cameras
- High-speed stereo radiographic DIC

Schedule

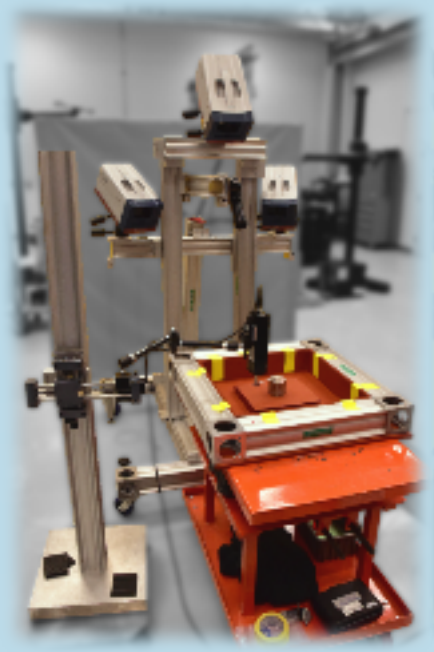
Time	Section
0800	Introduction
0830	Imaging Basics
1015	Morning Break
1030	Digital Image Correlation
1200	Lunch Break
1300	Practical Aspects of Optical Testing for Modal Analysis
1445	Afternoon Break
1500	Advanced Techniques
1630	Wrap-up
1700	Dismissal

Overview of two Optical Techniques

Optical Techniques

- **Two of the major technologies for optical modal methods:**

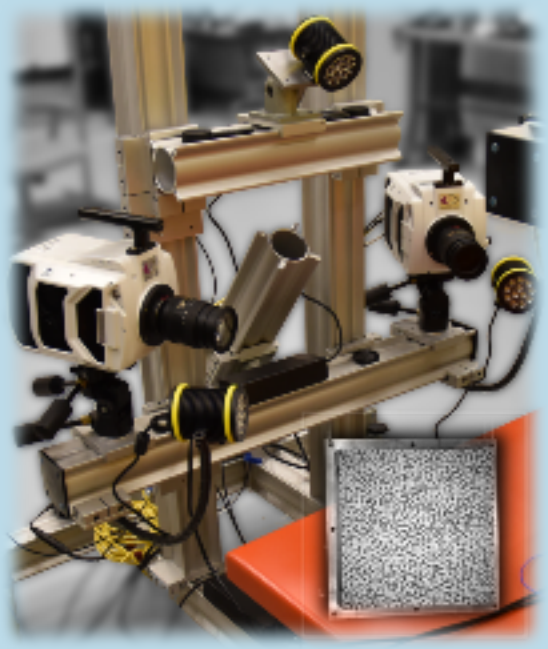
Laser Doppler Vibrometry



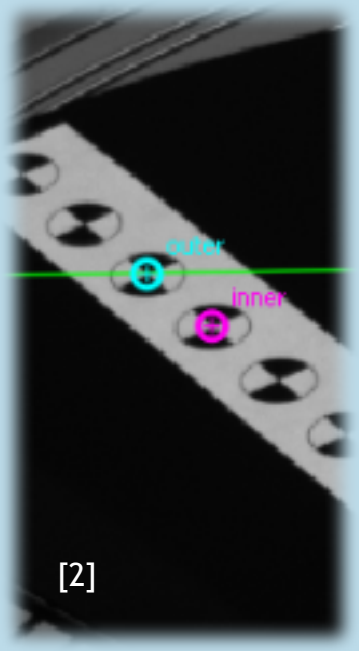
Scanning (SLDV)

Multi-Point (MPV)

Photogrammetry



Digital Image Correlation (DIC)



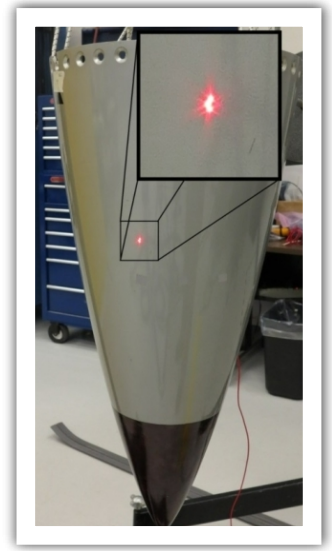
Discrete Point Tracking

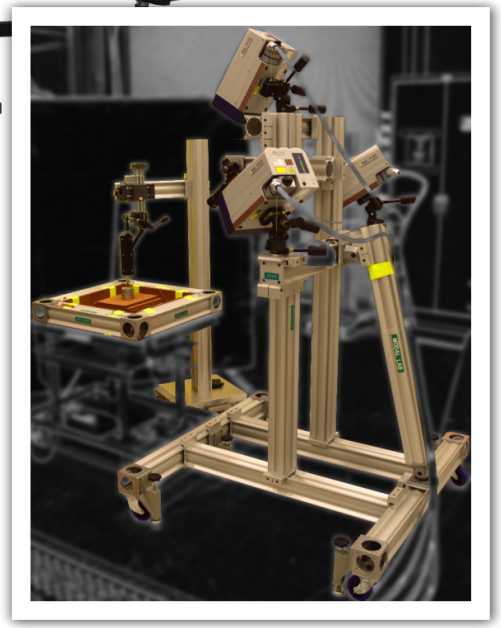
[2] Correlated Solutions VIC-3D (from https://www.correlatedsolutions.com/products/marker-tracking/

Optical Modal Methods: 3D Scanning Laser Doppler Vibrometry

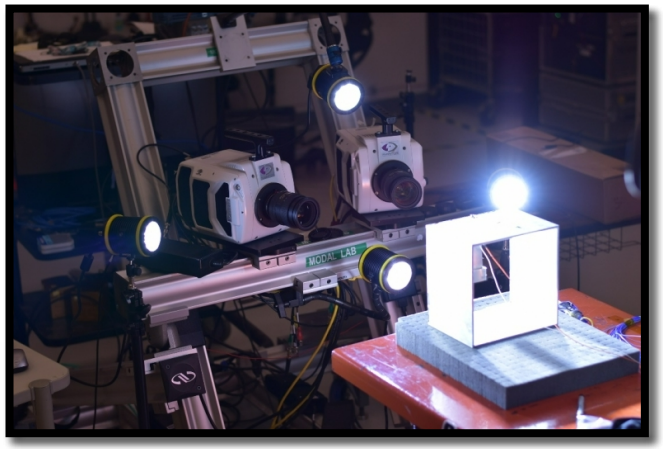
Benefits
- Non-contact
- Very small sensor footprint
- Approaching full-field measurements
- Precision pointing
- 3D test geometry automatically generated
- Fast fielding time
- Measure response frequencies in the kHz and MHz

Drawbacks
- Line-of-sight only
- Input must be repeatable, system can't change
- Small motions only
- LDV marginally noisier than most accelerometers



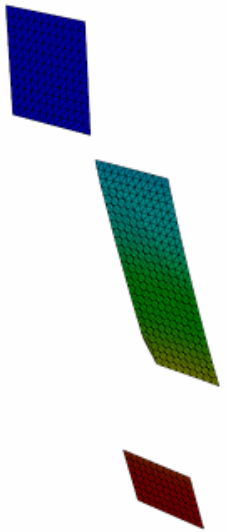


Optical Modal Methods: Digital Image Correlation (DIC)



Benefits
- Non-contact
- Small “sensor” footprint
- Full-field concurrent measurements
- Large deformations are permissible
- Precision triangulation (with stereo)
- Test geometry automatically generated (2D or 3D)
- Generally fast fielding time
- Flexibility in camera setup

Drawbacks
- Long data processing times and larger storage space
- Measurement resolution dependent of field of view
- Line-of-sight only
- Noisy measurements relative to other methods
- Currently no real-time test setup evaluations

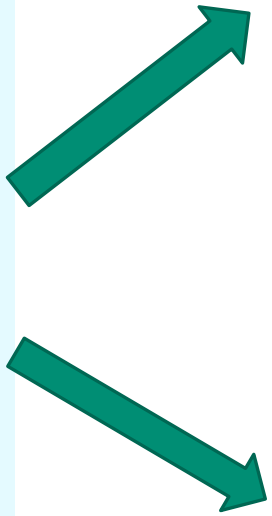


When to use Optical Techniques

When are optical methods best utilized?

When to use an optical method:

- ✓ Full-field data needed
- ✓ Part too small to attach accelerometers
- ✓ Extreme temperatures
- ✓ No time to perform normal test setup
- ✓ Test object standoff distance
- ✓ Accelerometer cable effects/routing
- ✓ When you're just done with channel tables, labeling cables, super glue, dead accelerometers, calibration sheets…



When to pick LDV over DIC:

- ✓ Small motions
- ✓ Repeatable excitations
- ✓ High frequency range of interest
- ✓ Need low-noise measurements

When to pick DIC over LDV:

- ✓ Large rigid body motion/deflection
- ✓ Need concurrent measurements (e.g. time varying system)
- ✓ Non-repeatable excitation
- ✓ Require high spatial density