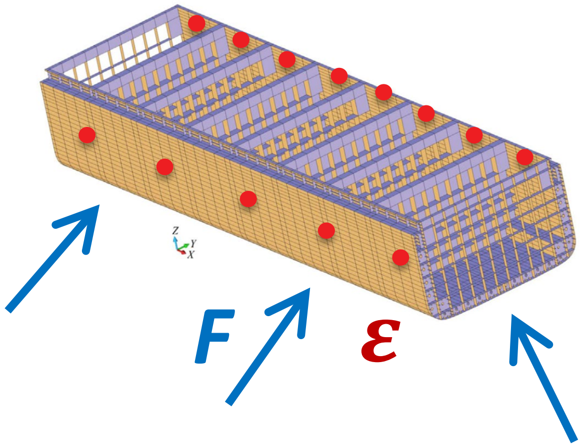
PROJECT: general (iFEM for Digital-Twin and SHM)

Method: the inverse FEM (iFEM)

dTHOR



- Material properties
- Loads

FEM

Measured strains in discrete positions

iFEM

Nodal displacements
+
Strains

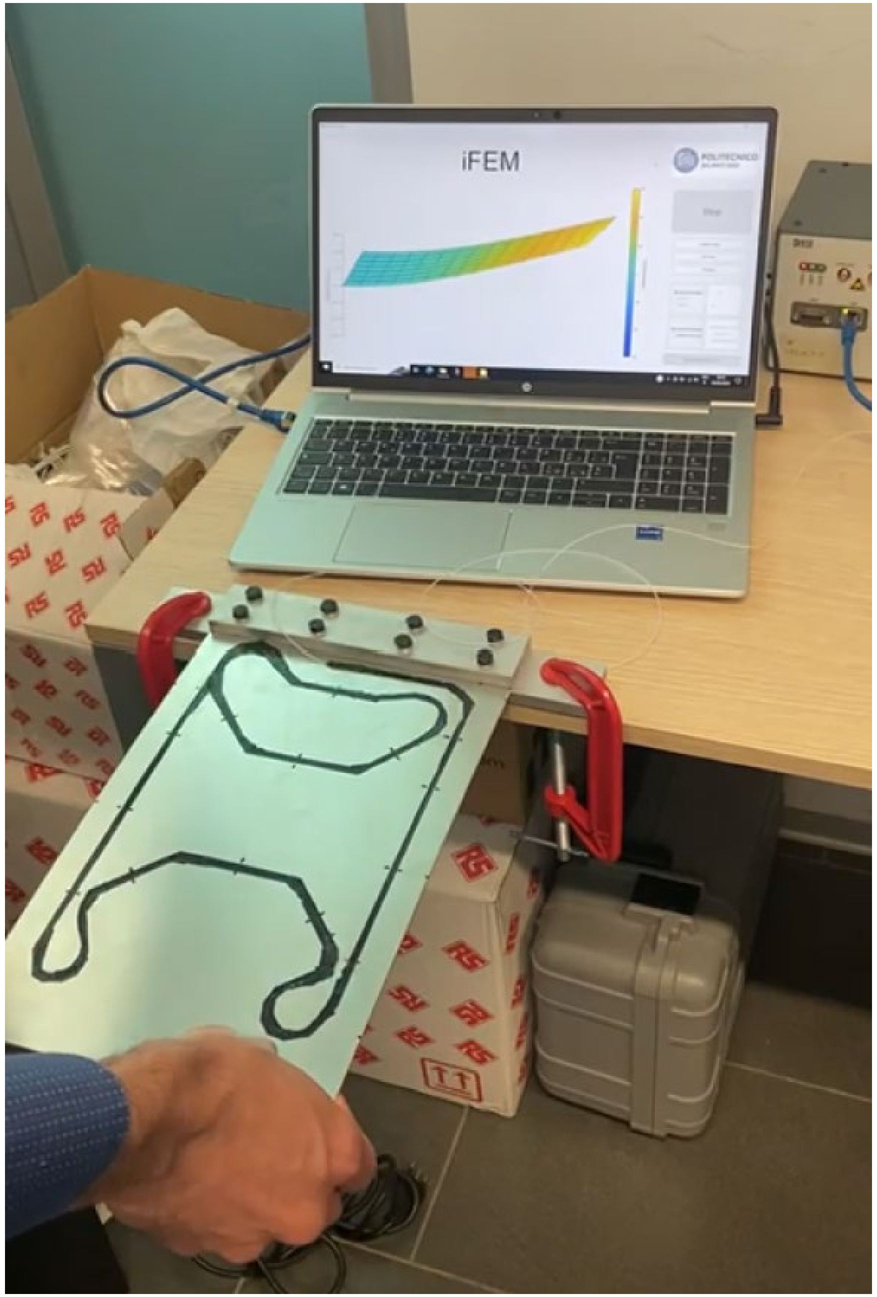
- Node coordinates
- Element connectivity and geometry
- Boundary conditions

Independent from loads and material properties

PROJECT: general (iFEM for Digital-Twin and SHM)

Method: the inverse FEM (iFEM)

- Fiber optic strain gauges are acquired in real time through Matlab and a Labview software
- Strains are processed in real-time by a iFEM code to reproduce the full-field displacement of the structure
- The full-field strain and stress can be also reconstructed



One step forward…

Method: the inverse FEM (iFEM)

PROJECT: general (iFEM for Digital-Twin and SHM)

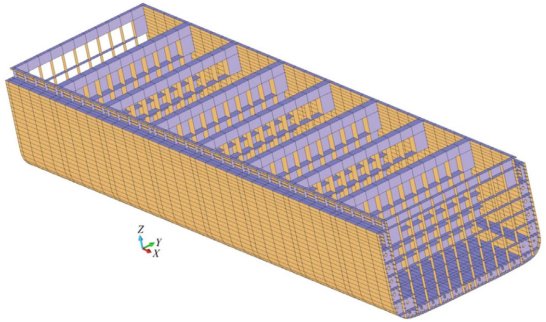
Title: iFEM-based hull shape sensing for damage identification

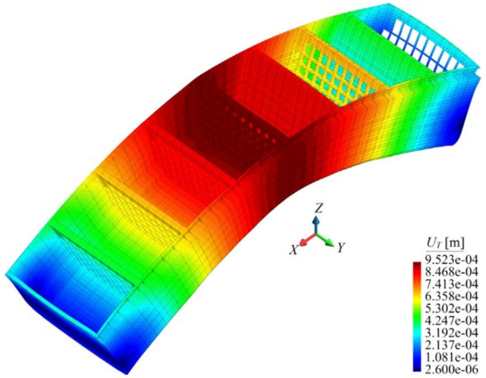
dTHOR

RESEARCH BACKGROUND:
The Inverse Finite Element method (iFEM) employing a network of strain sensors reconstructs the full-field displacement on beam or shell structures, independently of the loading conditions and of the material properties. The iFEM is thus suitable to monitor and keep track of the structural condition throughout the lifespan of the structure, enabling conditions-based maintenance policies.

RESEARCH ACTIVITIES:

- Develop an iFEM model of the hull of a naval unit
- Apply Anomaly Detection and Damage identification techniques
- Possibly validate the undamaged model with experimental data





METHODOLOGY: numerical – possibly experimental

DURATION: 9 months

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PROJECT: general (iFEM for Digital-Twin and SHM)

TITLE: Fiber-optic sensor based Shape Sensing and Damage Diagnosis of a pressure vessel with iFEM

RESEARCH BACKGROUND: The inverse Finite Element Method (iFEM) is a model-based technique to compute the displacement field of a structure from experimental strain measurements. Nowadays, it can be used also in an SHM framework to perform damage diagnosis. This work aims to perform damage detection (impact damages) and localization on a cylindrical section representative of a composite material pressure vessel.

RESEARCH ACTIVITIES:
1. Implementation of iFEM routines (Matlab and Python) for SHM
2. Development of the iFEM model
3. Experimental tests
4. Data analysis with the iFEM

METHODOLOGY: Numerical, Experimental

DURATION: 9 months

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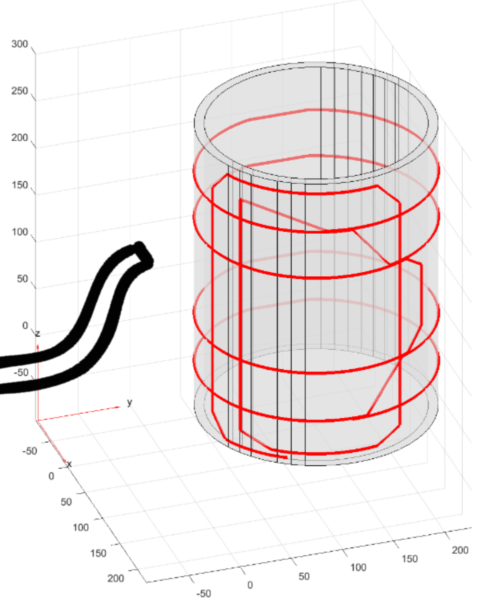
Displacement and strain field reconstruction on the whole structure

Damage diagnosis (SHM)



Fiber optic pattern with circumferential and axial strain measurements

Section of carbon fiber pressure vessel sensorized with a fiber optic for strain measurement

PROJECT: general (iFEM for Digital-Twin and SHM)

TITLE: Statistical damage diagnosis and prognosis with iFEM

RESEARCH BACKGROUND: The inverse Finite Element Method (iFEM) is a model-based technique to compute the displacement field of a structure from experimental strain measurements. Nowadays, it can be used also in a SHM framework to perform damage detection, however, a proper damage localization and size estimation is still not fully developed. This work aims to extend the iFEM to statistical damage diagnosis (localization and quantification) and prognosis, in particular for cracks and debonding damages.

RESEARCH ACTIVITIES:
1. Implementation of iFEM routines (Matlab and Python) for SHM
2. Finite Element Analysis (Abaqus) for the modelling of damaged structures
3. Testing and validation of the developed algorithms

METHODOLOGY: Numerical, experimental

DURATION: 9 months

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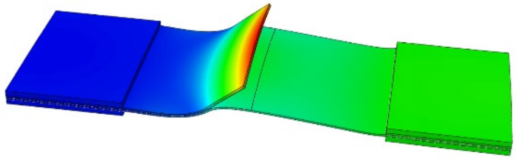
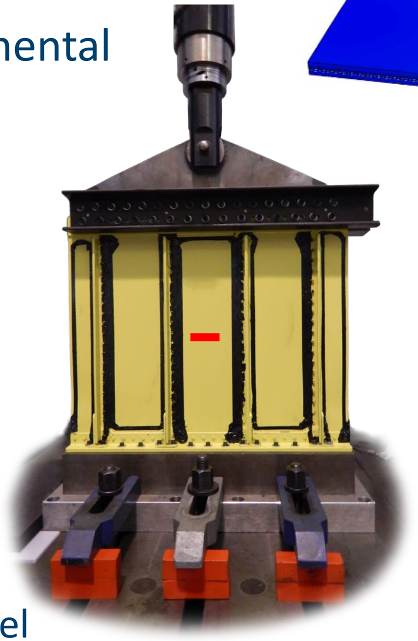
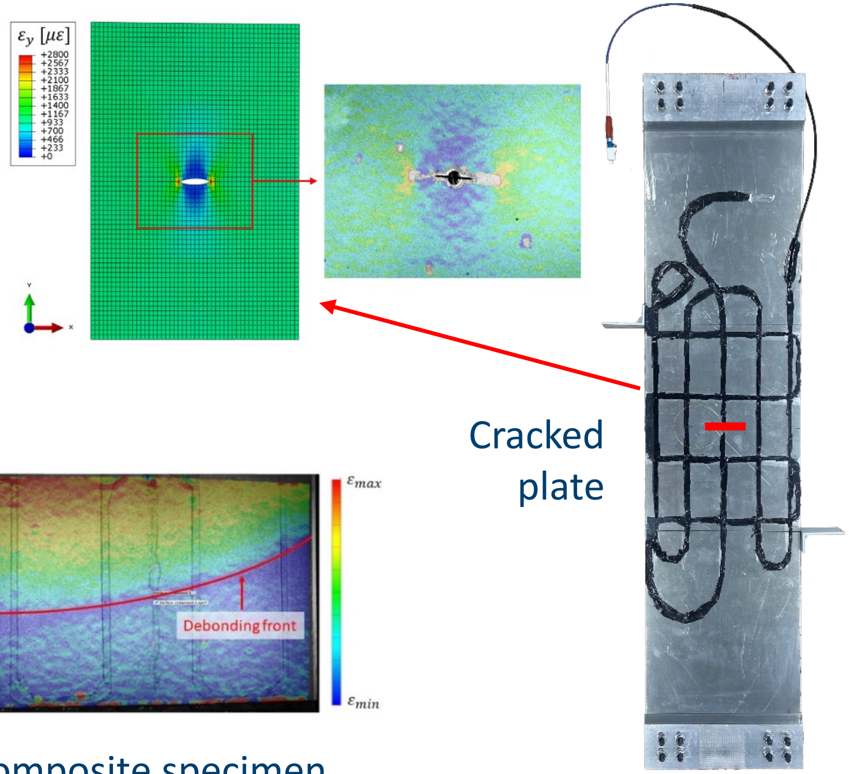
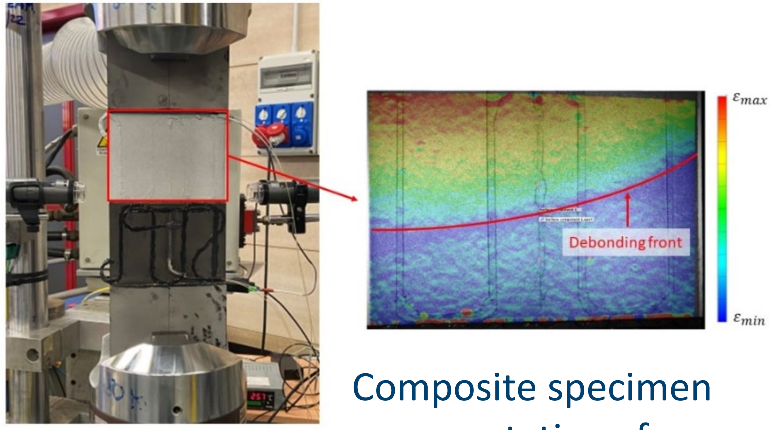




Aluminum aeronautical panel



Cracked plate



Composite specimen representative of a bonded repair patch

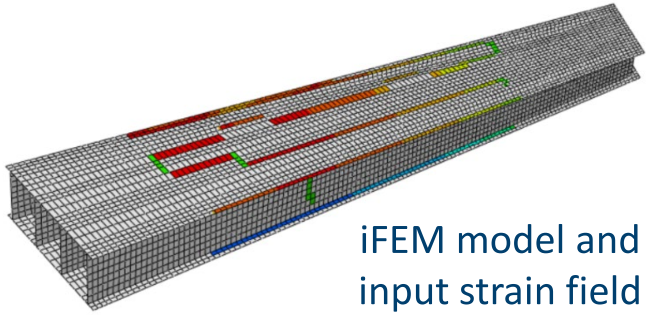
PROJECT: general (iFEM for Digital-Twin and SHM)

TITLE: Shape Sensing of a wing box with the iFEM

RESEARCH BACKGROUND: The inverse Finite Element Method (iFEM) is a model-based technique to compute the displacement field of a structure from experimental strain measurements. However, one main limitation is related to the high number of strain sensors required, in particular for complex structures. Thus, this work aims to develop an effective strain pre-extrapolation technique with the Smoothing Element Analysis (SEA) to increase the information level of the input strain field and thus compute a more accurate displacement field.

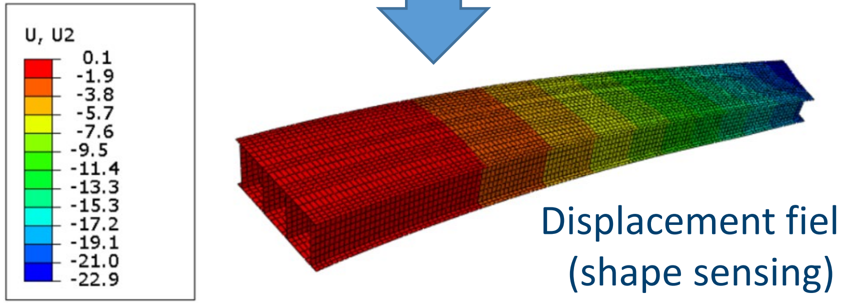
RESEARCH ACTIVITIES:
1. Implementation of iFEM routines (Matlab)
2. Development of iFEM models
3. Strain pre-extrapolation models with the SEA
4. Testing and validation of the developed algorithms

Real structure (wing box)



iFEM model and input strain field

Optimize the strain-pre extrapolation with the SEA (complex structure)



Displacement field (shape sensing)

METHODOLOGY: Numerical

DURATION: 9 months

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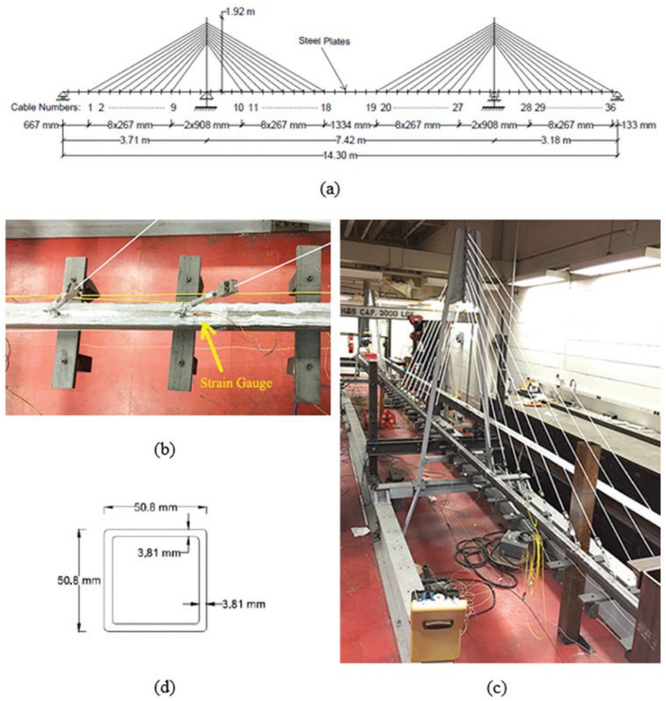
PROJECT: general (iFEM for Digital-Twin and SHM)

Title: Force reconstruction by calibration matrix and anomaly detection through iFEM on civil structures



RESEARCH BACKGROUND:

Detection and estimation of crack sizes in civil structures is an open issue which might be tackled with the inverse Finite Element Method. Reconstruction of forces in suspension cables in cable-stayed bridges would improve the state of the art Structural Health Monitoring techniques.

RESEARCH ACTIVITIES:

- Develop of both damaged and undamaged iFEM models of a beam and validate damage identification strategies on experimental data.
- Apply load reconstruction techniques on experimental data from a cable-stayed bridge.

METHODOLOGY: numerical – analytical

DURATION: 9 months

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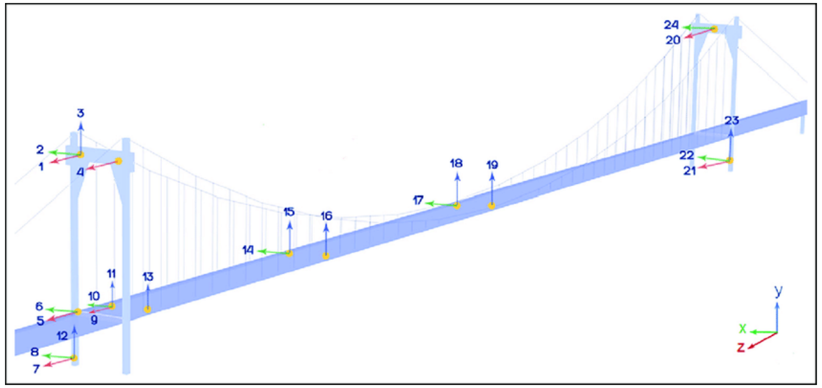

Collaboration: University of Illinois Chicago