VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Davide Mastrodicasa**

The public defense will take place on **Monday 12th January 2026 at 4 pm** in room **D.2.01** (Building D, VUB Main Campus)

To join the digital defense, please click here

DIGITAL IMAGE CORRELATION FOR STRUCTURAL DYNAMICS: LOW-SPEED CAMERAS AND ROTATING STRUCTURES

BOARD OF EXAMINERS

Prof. dr. ir. Lincy Pyl

Prof. dr. ir. Dimitrios Angelis

Prof. dr. ir. Christof Devriendt

Prof. dr. ir. Janko Slavič

Prof. dr. ir. Milena Martarelli

PROMOTORS

Prof. dr. ir. Wout Weijtjens

Dr. ir. Emilio Di Lorenzo

Dr. ir. Bart Peeters

Abstract of the PhD research

Structures such as aircraft components, wind turbine blades, and car tires experience vibrations during operation, and understanding these vibrations is crucial for ensuring safety, durability, and comfort. Traditionally, vibration characteristics have been studied using sensors like accelerometers and strain gauges attached to structures. However, these sensors face limitations, as they measure only specific points, are difficult to position on rotating or small structures, and are often costly or impractical for large-scale applications.
This research investigates new methods for studying structural vibrations using low-speed and high-speed cameras in combination with Digital Image Correlation (DIC), a non-contact, full-field optical technique that measures displacements on a structure's surface.

A primary focus of this research is overcoming the limited ability of low-speed cameras to capture high-frequency structural vibrations due to restricted frame rates. Two methodologies were developed to enable accurate modal characterization beyond the nominal Nyquist–Shannon sampling limit. The first exploits periodic excitation and signal reconstruction to synthetically increase the effective sampling rate, allowing high-frequency responses to be recovered from undersampled data. The second reconstructs high-frequency vibrations by exciting the structure with band-limited pseudorandom signals and processing down-sampled displacement data. A global Frequency Response Function (FRF) is assembled from overlapping excitation bands using a coherence-based strategy to retain the most reliable spectral information. To improve computational efficiency, a reconstruction approach originally formulated in the time domain was reformulated entirely in the frequency domain without loss of accuracy. Both methods were validated through simulations and experiments, demonstrating their robustness and effectiveness.

The second aspect of this research focuses on rotating structures, such as automotive tires and bladed disks, where large rigid-body motions (RBM) due to rotation obscure subtle structural vibrations. To address this challenge, DIC was integrated with specialized RBM compensation algorithms to decouple rigid-body motion from structural deformation, enabling accurate vibration analysis under realistic operating conditions. An additional challenge arises from the limitations of DIC, which requires small inter-frame motions and therefore relies on incremental formulations for rotating structures. Incremental DIC, however, accumulates errors over multiple rotations, leading to displacement divergence. To mitigate this effect, an image reordering approach based on angular position rather than acquisition time was developed, effectively simulating a single rotation and significantly reducing cumulative errors. Experimental validation on a bladed disk confirmed the effectiveness of this approach, with angularly ordered sequences showing a marked reduction in displacement divergence compared to time-ordered data.