Chair of Structural Mechanics
TUM School of Engineering and Design
Technical University of Munich

Study Project

Dynamic Substructuring and Force Identification via Virtual Point Transformation

Background and Motivation

Vibrations in complex mechanical systems are governed by the dynamic interaction between coupled components such as motors, mounts, and supporting structures. Quantifying the interaction is essential for accurate system modeling and noise and vibration optimization. Since interfaces between components are often inaccessible to direct measurement, *Dynamic Substructuring* provides a systematic framework to separate subsystems and reconstruct their dynamic behavior from experimental and numerical data.

In this project, you will analyze transfer path measurements of a motor–plate assembly, identify block and interface forces using the Virtual Point Transformation (VPT) method. The VPT converts distributed interface measurements into equivalent motions and forces at defined virtual points. This enables consistent identification and coupling of dynamic substructures from experimental or numerical data, for example to investigate how motor operating conditions influence the coupling dynamics of the system. [1]

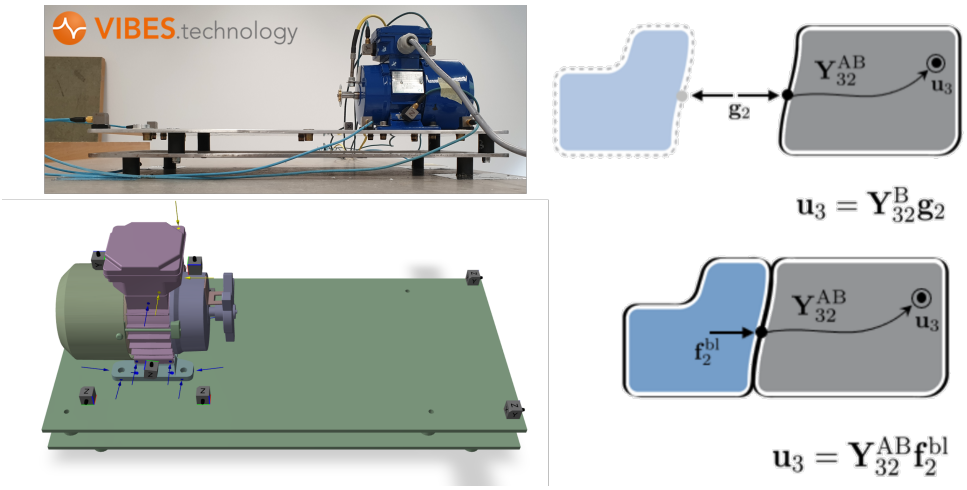

Figure 1: Experimental and virtual realizations of the motor-plate assembly. The motor's unbalance acts as a source of dynamic excitation for the plate. The coupling interface between the two components can be described by the corresponding *block* and *interface forces*. [2]

Project Tasks and Stages

1. Self-study on Dynamic substructuring, the Virtual Point Transmformation Method and matrix inverse method
2. Process measured and simulated transfer path analyses in DIRAC® and MATLAB®.
3. Compute block and interface forces in different motor operation conditions
4. Explore the impact of component modifications on the assembled system

Recommended Background and Skills

The project is most suitable for students who

- have a solid background in **structural dynamics**,
- are familiar with **numerical methods** for structural dynamics,
- possess solid programming skills in **MATLAB®** or **Python**,
- enjoy working **independently** and **systematically**, and are motivated to study relevant scientific literature in depth
- optionally, have first experience with **experimental techniques in structural dynamics**, such as **transfer path** or **modal analysis**

Students with a keen interest in vibroacoustics, structural dynamics, and computational methods will find this topic particularly interesting.

Supervisors

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References

[1] M. S. Allen and D. Rixen, *Substructuring in Engineering Dynamics: Emerging Numerical and Experimental Techniques*, ser. CISM International Centre for Mechanical Sciences, Courses and Lectures. Cham, Switzerland: Springer International Publishing, 2020, vol. 594.

[2] VIBES.technology, "Substructuring methods – methodology (online)," https://www.vibestechnology.com/academy/methodology/substructuring-methods/, 2025, accessed: 2025-11-03.