Project Proposal

Development of a Cost-Effective Camera-Based Measurement System for High-Speed Periodic Motion

General Information

Type:	Semester Project (10 ECTS)
Laboratory:	Laboratory for Applied Mechanical Design (LAMD)
Supervisors:	A. Artomov; Prof. J. Schiffmann
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Background

Our research at the Laboratory of Applied Mechanical Design (LAMD) centers on small-scale turbomachinery. These machines utilize aerodynamic bearings to support rotors spinning at high speeds (20,000 - 200,000 rpm). The clearance between the rotors and their bearing bushings is on the micrometer scale. To study the dynamic behavior of these rotors, we require precise measurement of their orbital displacements. Traditionally, expensive proximity probes have been used for such high-frequency, micrometer-range measurements. This project proposes investigating the feasibility of using industrial cameras as a cost-effective alternative to proximity probes for precise rotor displacement measurements. We aim to determine the applicability and limitations of this approach.

Objective

This project aims to investigate the feasibility of using a standard industrial camera as a cost-effective alternative to proximity probes for precise measurement of high-speed rotor movements in small-scale turbomachinery. Through this project, students will develop and test a camera system that analyzes video frames to determine target position and reconstruct its high-frequency motion. Figure 1 illustrates the example of an experimental setup for testing the measurement accuracy of a camera system. Additionally, students will establish guidelines for selecting cameras and lenses based on desired measurement accuracy.

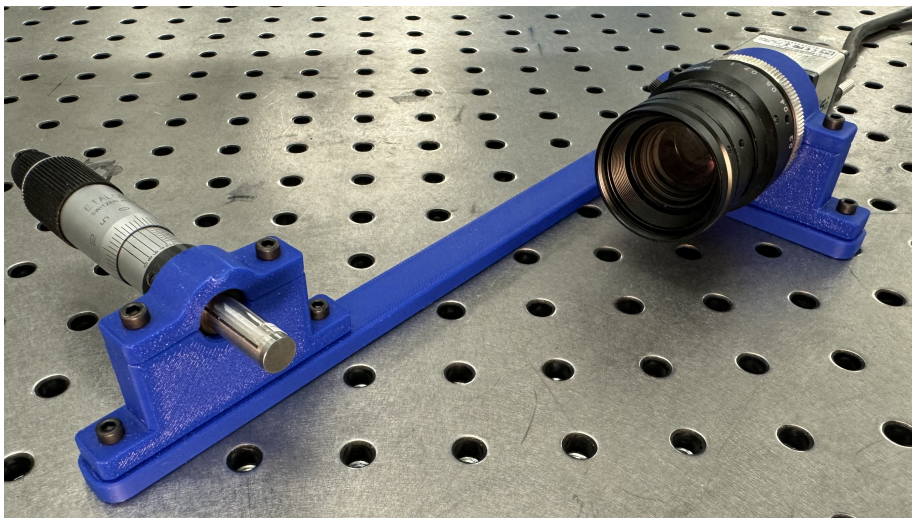

Figure 1: experimental setup for testing the measurement accuracy of a camera system

[1] The possibility to work from the EPFL main campus in Lausanne can be discussed

Tasks

1. **Literature review:**
   Conduct a comprehensive literature review to understand existing camera-based measurement systems.
2. **Camera calibration:**
   Calibrate the camera using a checkerboard pattern attached to a flat surface to negate image distortions introduced by a lens.
3. **Measurements with camera:**
   - Develop an image processing algorithm: This algorithm will analyze the captured video frames to precisely determine the target's displacement within each image.
   - Characterize camera accuracy: Evaluate the camera's performance by quantifying its measurement precision.
   - Establish camera and lens selection guidelines: Create guidelines to assist in selecting appropriate cameras and lenses based on desired measurement accuracy levels.
4. **Filming and reconstruction of the trajectory of high-speed movement:**
   - High-speed video capture: Capture a video of a target undergoing periodic motion, ensuring meticulous timestamping of each individual frame.
   - Trajectory reconstruction algorithm: Develop an algorithm to analyze the time-stamped frames and reconstruct the target's high-frequency periodic motion within the video
   - Frequency tracking characterization: Determine the range of frequencies a given camera can effectively track for moving targets.
   - Camera selection guidelines for frequency tracking: Establish guidelines for selecting cameras suitable for tracking signals of specific frequencies.

NB: adjustments may be required according to progress, results, and project duration.

Prerequisite knowledge

Python and/or Matlab