Project Proposal

LIP Calibration Rig: Digital Twin Enhancement and Automated Alignment System

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General Information

Type:	Semester Project [10 ECTS]
Laboratory:	Laboratory for Applied Mechanical Design (LAMD)
Supervisors:	Tristan Schwab; Prof. J. Schiffmann; Christophe Pham
Location:	Neuchâtel[1]
Contact:	tristan.schwab@epfl.ch
Website:	https://www.epfl.ch/labs/lamd/

Background

The LIP Calibration Rig is an in-house micron-resolution automated probe calibration tool for turbo-machinery metrology. This project will refine the digital twin in Solidworks, implement LiDAR sensing for automated object detection, and design a 10-100 micron-resolution probe translation stage to allow automatic alignment. Strong mechanical design skills, CAD experience, enthusiasm, and mechatronics proficiency are needed. French and working proficiency English is a plus.

Objective

Modernize the LIP Calibration Rig to achieve improved digital documentation, advanced automation through LiDAR integration, enhanced user interface, cost-effective design, and better accuracy with reduced setup time for all users. Develop a universal mount suitable for various probes 3mm-8mm in diameter.

Project Phases

Phase 1: Refine Digital Twin Assembly

1. **Audit and Document:** Identify discrepancies between digital model and physical rig; document as-built modifications and specifications
2. **Update Assembly:** Implement proper hierarchy, naming conventions, BOM, sourcing info, version control, and develop space-consolidated design

Phase 2: LiDAR Integration and Automated Alignment

3. **LiDAR System:** Select sensor, design mounting, integrate with architecture, develop detection algorithms
4. **Translation Stage:** Design precision mechanism for $\pm 10 - 100$ µm accuracy, select actuators, prototype
5. **Control Integration:** Integrate Arduino with NI hardware, develop Python interface, implement safety and error handling
6. **Testing:** Conduct accuracy verification, repeatability studies, user acceptance testing, document performance

[1] Work conducted at LAMD Neuchâtel. LAMD provides train ticket support to and from Neuchâtel

Key Constraints

- **Positioning:** $\pm 10 - 100$ µm accuracy and repeatability
- **Cost:** Justify modifications through cost-benefit analysis; prioritize commercial parts
- **Integration:** Seamless fit with existing hardware without major modifications
- **Usability:** Intuitive interface for varying experience levels
- **Serviceability:** Well documented usage, easy maintenance and plans for future upgrades

Tools and Equipment

Software: Solidworks, Python, Arduino IDE (C++), MATLAB
Hardware: LiDAR sensors, precision 3-axis stages, metrology probes, Arduino/NI hardware, LAMD 3D printer and machine shop

Stretch Goals

- Automated calibration sequences with error detection and self-correction
- Real-time monitoring and visualization of probe position
- Remote access for system control to monitor results
- Data logging system for calibration history and export

Timeline (14 Weeks)

- **Weeks 1–2:** Familiarization, assembly audit, methods review
- **Weeks 3–5:** Digital twin refinement, BOM/documentation, preliminary stage design
- **Weeks 6–8:** LiDAR selection/integration, mounting fixtures, finalize stage design
- **Weeks 9–11:** Prototype fabrication, system integration, Python interface
- **Weeks 12–14:** System testing, validation, final documentation and report

Regular weekly meetings with supervisors and engineers ensure progress tracking and guidance on design decisions.

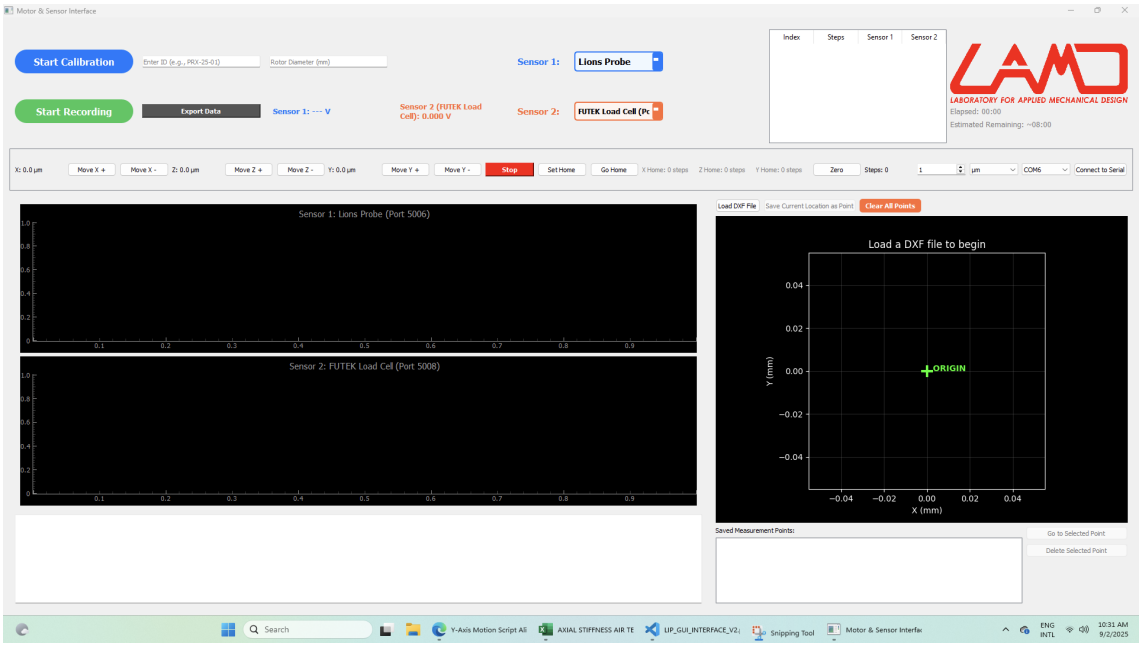

Figure 1: Current State of Interface

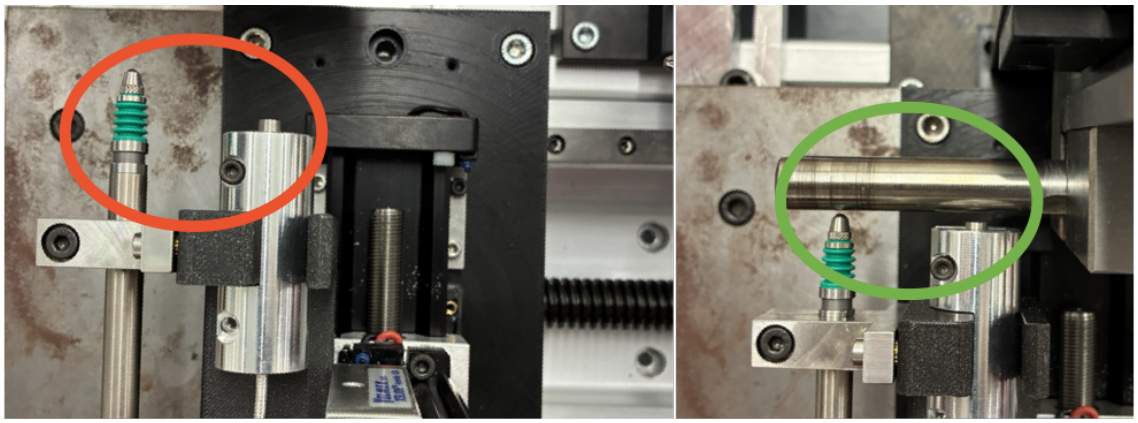

Figure 5

Figure 2: TESA Probe Alignment with Lions Probe

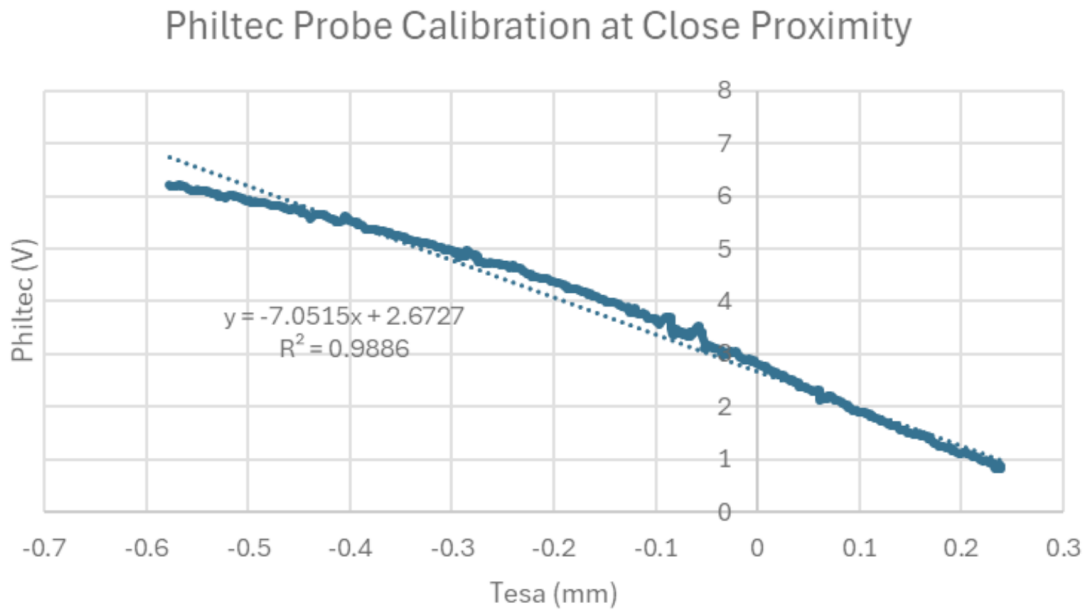

Figure 3: Example Probe Calibration