Master Theses 2013 : Active Structures Laboratory

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1. Photoconductive materials for control of deformable mirrors

Objective: Investigate the possibility to simplify the electrical connections of actuator arrays by using photoconductive materials such as BSO (Bismuth Silicon Oxide) controlled optically.

Work to be done: State of the art review. Electromechanical modeling of the photoconductive materials. Application to electrostatic actuation and piezoelectric actuation. Numerical examples.

Reference: U. Bortolozzo et al. "Continuous photocontrolled deformable membrane mirror", *Applied Physics Letters,* 96 (251108)(2010)

Supervisor: André Preumont (andre.preumont@ulb.ac.be)

2. Active stabilization of divergent vibrations in helicopters

Objective: The aerodynamic coupling between the fuselage and the rotor of an helicopter may be responsible of divergent vibration in some particular flight conditions. The purpose of this project is to investigate the possibility to eliminate this divergent vibration using an electromagnetic inertial actuator. This project is part of a collaboration with **Eurocopter**.

Work to be done: Develop a model coupling the structure (finite elements), the electromagnetic actuator (Matlab) and the control. Design of the electromagnetic actuator with special attention to robustness. Closed-loop analysis. Behavior in degraded mode (if the controller is turned off, the actuator should behave like a passive dynamic vibration absorber).

Supervisor: André Preumont (andre.preumont@ulb.ac.be)

3. Vibration isolation of a gravitational wave detector

According to Einstein's general theory of relativity, astronomical events like coalescence of black holes and supernovas generate gravitational waves which distort space. Several instruments have been constructed to detect these waves on Earth. The basic principle of these detectors is to measure extremely precisely the distance between far away mirrors, which must be extremely well isolated from environmental disturbances. This stability is achieved by combining several isolation stages. The objective of the thesis is to identify possible margins of improvement of the current design. A particular attention will be paid to increase the stability of the superstructure supporting the isolation stages. The work will include the development of simplified mathematical model of the suspension chain, and will be completed by the construction of a scaled demonstrator to validate the concepts proposed.

Collaboration: Massachusetts Institute of Technology (MIT, USA).

[Contact: Christophe.collette@ulb.ac.be]

4. Active stabilization of a future linear particle collider

In the future Compact LInear Collider (CLIC) currently under study at CERN, electrons and positrons will be accelerated in two linear accelerators to collide at the interaction point with an energy of 0.5-3 TeV. In order to reach this objective, the electromagnets focusing the particle beams must be extremely stable, at the sub-nanometer level. The objective of the thesis is to develop a control strategy to stabilize the electromagnets and steer the beams to allow the collisions. The work includes modeling efforts, and the development of a scaled test bench to demonstrate the feasibility of the strategy.

Collaboration: European organization for nuclear Research (CERN, Switzerland)

[Contact: Christophe.collette@ulb.ac.be]

5. Design of an inertial sensor

The measurement of low frequency and small amplitude absolute displacements with a high accuracy is critical in two scientific disciplines. The first one is the study of the internal structure of telluric planets, like the Earth or Mars. The second one is the development of attitude control strategies and active vibration isolation. So far, these signals are measured by sophisticated sensors like seismometers, which are known to be very expensive, fragile, temperature sensitive, heavy and unusable in magnetic field environments. On the top of that, they have a limited resolution, and can hardly fulfill the always more stringent precision requirements. This is especially valid in frontier science facilities, like future particle colliders and gravitational wave detectors. The objective of the thesis is to develop a new lightweight and low noise inertial sensor, based on an optical technology. The work includes modeling efforts, CAD design and many experiments.

Collaboration: European organization for nuclear Research (CERN, Switzerland)

[Contact: Christophe.collette@ulb.ac.be]

6. Vibration Damping of a Bladed Drum

Constant growth of energy prices and demand for air transport encourage development of more economical and ecological airplanes. To meet these requirements, innovative structures are being designed for both the fuselage and the engines. The BLUM (bladed drum) is one of the latest innovations of the jet engine rotor structure manufactured by SAFRAN Techspace Aero. This new monolithic design has a mass reduced by nearly 25% which leads to significant increase of the energy efficiency of the engine. However, the absence of friction makes it very lightly damped which leads to high vibration amplitudes of the blades and as a consequence to fatigue phenomena. The purpose of this internship is to study a vibration damping strategy using piezoelectric materials on an existing model of the BLUM. The validation of the proposed techniques can be envisaged on an experimental setup.

Contact: Bilal Mokrani (bmokrani@ulb.ac.be)

7. Design of a control mechanism for a hummingbird robot

Drones (Micro Air Vehicles) are becoming a popular low-cost solution for video surveillance and aerial photography. For further miniaturization a concept of flapping wings, inspired by insects and hummingbirds, is being actively researched.

The goal of this thesis is to improve/redesign a control mechanism based on SMAs (Shape Memory Alloys) that generates control moments by modifying the wing kinematics. The work will include design of the mechanical and electrical part of the system as well as experiments with the rapid-prototyped mechanism.

[Contact: matej.karasek@ulb.ac.be]

8. Hardware in the loop simulations with a hummingbird robot

Drones (Micro Air Vehicles) are becoming a popular low-cost solution for video surveillance and aerial photography. For further miniaturization a concept of flapping wings, inspired by insects and hummingbirds, is being actively researched.

The thesis goal is to develop a hardware in the loop simulation of flight control of a hummingbird robot. The robot prototype, attached to a force sensor, should generate moments necessary to stabilize the simulated flight. The flight dynamics simulation will run on a real time DSP processor. The work will include dynamic system modeling, control design and experiments with the robot prototype.

[Contact: matej.karasek@ulb.ac.be]

9. Deformable mirror for adaptive optics

The upper layer of the atmosphere are constantly disturbed by turbulences that degrade the astronomical observations. *Adaptive optics* allows ground-based telescopes to compensate in real-time these optical aberrations thanks to a reflection on a *deformable mirror*. A demonstrator of a concept of segmented deformable mirror is being developed currently at the Active Structure Laboratory.

In this framework, the proposed master thesis aims at studying numerically and experimentally the shape and position control of such a mirror.

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