Research topics in Structural Dynamics at ULB

Prof A. Deraemaeker
Prof C. Collette

Mechanical Engineering
Civil Engineering

- Develops instrumentation and strategies for actively measuring and controlling the vibrations of structures.
- Internationally renown expertise in high precision control of large instruments dedicated to experimental physics:
  - gravitational wave detectors
  - particle colliders
  - segmented ground and space telescopes
  - satellites and light sources
10. Research Topics

Active isolation

![Active isolation diagram](image)

Active Damping

![Active Damping image](image)

Tools and methods

<table>
<thead>
<tr>
<th>Numerical mechatronic models</th>
<th>Design and fabrication of prototypes</th>
<th>Vibration testing</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Numerical mechatronic models image" /></td>
<td><img src="image" alt="Design and fabrication of prototypes image" /></td>
<td><img src="image" alt="Vibration testing image" /></td>
</tr>
</tbody>
</table>
Active isolation of drone cameras

• Single-axis isolation system (1 dof)

• Multi-axis isolation system (6 dof)

Conventional system uses passive isolation

Quality of the images captured affected by the vibrations from the drone

Solution: Active isolation

Passive isolation degrades the high frequency performance

Source of disturbance: drone

Actuator

Sensor

System to be stabilized: camera

Image to be captured

[Moht Verma]
Active isolation in gravitational wave detectors

Gravitational waves

6 dofs isolation system developed

Principle of a gravitational wave detector

High precision / Low frequency sensors

Commercial sensor

PML sensor

- High precision interferometer
- Under vacuum (low damping)
- Low resonant frequency

[Binlei Ding]
Translation/tilt gravity decoupling

- Disturbances from rotations/translations
- Active hexapod to reject disturbances
10. Research Topics

### Damping of bladed structures

- Light weight/low damping
- Vibrations -> Fatigue / noise radiation

### Active vibration damping

- Diagram showing active vibration damping system

### Optimal control laws for linear systems

- Diagram showing control system for linear systems

[Ahmad Paknejab, Guoying Zhao]
Optimal control laws for non-linear systems

Non-linear active control

Linear active control

Hybrid vibration control

- Failsafe
- Low power consumption

[Ahmad Paknejab, Guoying Zhao]
Optimisation of mechatronics systems

- Sensors and actuator types/positions?
- Control strategy?
- Integrated mechatronics models
- Robust optimisation strategies

[Shashank Pathak, Dimitri Piron]

Prof A. Deraemaeker

Develops instrumentation and strategies for wave-based structural health monitoring of concrete structures and vibration damping with special emphasis on:

- Numerical modeling of piezoelectric structures
- Piezoelectric transducers development
- SHM data processing and decision algorithms
- Design of tuned mass dampers
### Tools and methods

<table>
<thead>
<tr>
<th>Numerical models</th>
<th>Design and fabrication of prototypes</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D elements</td>
<td>Multi-layer plate elements</td>
<td></td>
</tr>
<tr>
<td>Multi-layer plate elements</td>
<td>Multi-layer plate elements</td>
<td></td>
</tr>
</tbody>
</table>

#### The Structural Dynamics Toolbox (under Matlab)

Piezoelectric module co-developed with SDTools (E. Balmès)
The Structural Dynamics Toolbox (under Matlab)

Complex models (1 million+ DOFS.)

Modeling of embedded piezoelectric transducers for concrete monitoring

Embedded piezoelectric transducers
Modeling of embedded piezoelectric transducers for concrete monitoring

- Improved transducers (patent)
- Development of shear wave transducers
- Improvement of wave propagation models in concrete

Structural Health Monitoring

10%
Structural Health Monitoring

Wave-based Structural Health Monitoring
Wave-based Structural Health Monitoring

Application in the Rogier Tunnel in Brussels
Application in the Rogier Tunnel in Brussels

Tuned vibration absorbers

Variability due to the environment ($T^\circ$, humidity)
- Effect on performance of TMD?
- Robust design of TMD?

Other criteria for optimisation
- Response spectra
- Realistic input spectra (wind, earthquake)