Quelques activités de recherche en robotique à l’ULg

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Séminaire Liège Créative
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Multibody & Mechatronic Systems

- System approach in mechanical applications
- Numerical methods: modelling, control & optimization
Research topics in robotics

Flexibility of robot structural components
- Modelling
- Control design
- Optimization

Modelling mechatronic systems

- Finite element approach developed since 1985 for flexible multibody systems
- Integrated control / FEM analysis

Collaboration with LMS Samtech (SAMCEF-MECANO) & Open Engineering (OOFELIE)
Modelling mechatronic systems

Pre-design → Detailed design → Final verification → Tests

- Structural mechanics
- MBS
- Control
- Multiphysics interactions
- Contact

Why using detailed models?
- Performance analysis
- Dynamic load evaluation
- Final design verification

With courtesy of SAMTECH

Control of flexible robots: Samii & FlexCell

Robot on a flexible support
Collaboration with Georgia Tech

Pick & place machine
Collaboration with KULeuven

With courtesy of SAMTECH
Control of flexible robots

Control/structure interactions are avoided if

\[ \omega_{\text{control}} < \frac{\omega_{\text{vibration,1}}}{s} \]

typical value: \( s = 3 \)

Consequences:

- limitation of the motion bandwidth
- stiff (and heavy) mechanical design requirement

\[ \Rightarrow \text{Motion and vibration control is required for} \]

high-speed and lightweight applications

Control design: Ralf

Collaboration with Georgia Tech

Real-time model of the flexible robot
Control design: Ralf

Model-based motion and vibration control

Fast control off
Simulation

Fast control on
Experiment

Optimal control: Adept Quattro

20-g acceleration
Collaboration with
LIRMM, Fatronik, KULeuven

Model-based optimal control
(feed-forward)

Reduced model
Optimization

Classical topology optimization:

Equivalent static-load approach:

Flexible MBS approach:

Emerging area: Medical applications

RheoKnee

Rewalk

Laboratory of Human Motion Analysis at ULg

Manus chair

Da Vinci surgical robot
Summary

Detailed models in robotics are useful for
- mechanical design verification and optimization,
- advanced model-based control,
- performance analysis and optimization,
especially for high-speed and lightweight applications.

New modelling tools are now needed for robots in close interactions with the environment and the user:
- contact and manipulation,
- teleoperation and comanipulation,
- assistive and therapeutic robots,
- etc.

Merci de votre attention !

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