Seismic mitigation using advanced control strategies

PI: Ovidiu PRODAN
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Motivation

• Development of better vibration mitigation techniques of structures is an on-going challenge

• Proposed approach: an emerging control strategy

• Fractional order controllers advantages: robustness, efficiency, few research in civil engineering applications up to date
Summary

- Design and construction of a laboratory scaled steel structure
- Design and implementation of novel control strategies for seismic mitigation based on fractional calculus (comparisons with classical control strategies)
- Experimental testing and validation of results
- Extension to adjacent fields (Smart Beam, Airplane Wing)
Challenges

• Implementation problems (numerical issues related to Fractional Order Elements approximations)
• Controller tuning: based on complex nonlinear equations
• 2D laboratory structure design, scaling and construction
• Structural parameter identification
Research Team

- Interdisciplinary project:
  - Automation Dept.:
    - Silviu Folea
    - Cristina I. Muresan
  - Structural Mechanics Dept.:
    - Ovidiu Prodan
Previous research

• Research grant TUCN 2013-2014:
  • Efficient use of energy in reducing the structural response to exceptional loading using viscoelastic dampers and advanced fractional order control methods
• Director: Cristina I. Muresan (Aut. Dept.)
• Research Team:
  • Ovidiu Prodan (Struct. Mech. Dept.)
  • Silviu Folea (Aut. Dept.)


4. Prodan, O., Muresan, C.I. (2014), Seismic mitigation via fractional order active control, Eurosteel, 10-12 September, Naples, Italy (**International Conference**)


7. Design and implementation of an active fractional order control strategy for a three floor steel structure - *Journal of Process Control*, under review (**ISI impact factor 2.653**)
Results

Conferences:

• 4th International Conference on Mechanics, Simulation and Control, 21-22 June, Moscow, Russia (ISI PRO)
• IEEE International Conference on Automation, Quality and Testing, Robotics AQTR, 22-24 May, Cluj-Napoca, Romania (ISI PRO)
• Eurosteel, 10-12 September, Naples, Italy (BDI)
• The 3rd International conference on Control, Mechatronics and Automation will be held in Barcelona, Spain during December 21-22, 2015 (ISI PRO)

1 invited lecture:

• “Fractional calculus in control applications”, University of Cambridge, UK, April 7-10, 2015

1 research mobility:

• Swiss Federal Institute of Technology, EPFL, Lausanne, Earthquake Engineering and Structural Dynamics Laboratory EESD, February - December 2014
• EPFL Internal Grant (16.000 CHF)
1 Bachelor thesis, Automation Dept., July 2014
• Title: Active vibration control strategies, student: Robert Balan-Rus

2 Bachelor theses, Automation Dept., July 2015
• Title: Active vibration control strategies for one story structures, student: Remus Bizu
• Title: Vibration suppression of a smart beam with integer and fractional order controllers, student: Izabela Birs
Student Involvement

Bachelor thesis due in June 2016:
• Active vibration control strategies for three storey structures: Boca Diana, Greta Han, Automation Dept.
• Vibration mitigation in aeroplane wings: Andrei Molnar, Automation Dept.

Master thesis due in June 2016:
• Monitoring system for three story structures against seismic phenomena: Balan-Rus Robert, Automation Dept.
• Building seismic response and structural health monitoring: Serban Ursu, Structural Mechanics Dept.

Master thesis due in June 2017:
• Fractional order active control strategies for vibration suppression in smart beams: Isabela Birs, Automation Dept.
Associated Results

Associated events:
• FSS 2015 International Conference (http://fss-conference.com/organizing-committee.php)

2 Research grant proposals UEFISCDI:
• Novel Fractional Order Control Strategies for Vibration Suppression in Aeroplane Wings, score: 94.5
• inQuake – Instability of Reinforced Concrete Walls to Earthquake Loading, score: 79
Current research grant


Research team:
**Automation Dept.:** Cristina I. Muresan, Silviu Folea, Eva Dulf, Gabriel Harja

**Structural Mech. Dept.:** Ovidiu Prodan, Cristian Miculas
Current research grant

Objectives:

Objective 1: Development of a complete and up-to-date study of the state of the art regarding vibration suppression in aeroplane wings (construction, modelling, control);

Objective 2: Design and construction of an experimental unit for the study of vibration suppression;

Objective 3: Development of a dynamic model for aeroplane wings (using fractional calculus and experimental identification);

Objective 4: Development of novel robust fractional order control strategies for vibration suppression.

Publication:

- Eva-H. Dulf, Cristina I. Muresan, Robust controller design using fractional calculus and Hinf norm, International Journal of Robust and Nonlinear Control, under review (ISI impact factor 3.176)
- Cristina I. Muresan, Silviu Folea, Ovidiu Prodan, Design and Experimental Validation of an Optimal Fractional Order Controller for Vibration Suppression, paper submitted at The International Conference on Control, Decision and Information Technologies, Malta, April 6-8, 2016 (BDI)
THANK YOU!