ME-428

Data-driven design & fabrication methods

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Cursus	Sem.	Type
Mechanical engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	3
Withdrawal	Unauthorized
Session	Summer
Semester	Spring
Exam	During the semester
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Project	1 weekly
Number of positions	

Il n'est pas autorisé de se retirer de cette matière après le délai d'inscription.

Summary

There is an increasing need for data-driven methods for automated design and fabrication of complex mechanical systems. This course covers methods for encoding the design space, optimization and search approaches and digital fabrication methods.

Content

Introduction and background to the need for automated design and fabrication, and existing approaches including a comparison to biological systems.
Methods for *encoding design spaces* to allow for design exploration, including graph grammars and other forms representation such as genome/DNA. Approaches for extracting the key design parameters and reducing the dimensionality of the parameter space using methods such as PCA, parametrization methods and also sensitivity analysis.
Optimization and search approaches including genetic algorithms, Bayesian exploration and optimization, and also methods for multi-objective optimization problems.
Introduction to the range of computational design tools including: s*imulation tools and approaches* including multi-body simulation, FEA, CFD and approaches such as system identification for transfer to the real world.
Fabrication & Making. Translating designs into the real world through 'compilation', including G-code and other methods of communicating design.
Applications & State-of the Art demonstration of data-driven design in research and industrial applications.

Keywords

Design, Manufacturing, Optimization, Data-driven methods, Fabrication, Robotics

Learning Prerequisites

Recommended courses

- Systèmes mécatroniques
- Mechanical product design and development

Important concepts to start the course

- Some working knowledge of python/Matlab
- Interest and awarness of mechanical or mechatronic design
- Experience of mechatronic systems and their fabrication, for example 3D printing and using microcontrollers and actuators would be benefical

Learning Outcomes

- Select appropriately methods of encoding for design spaces of different dimensionality and type of problem, and implement methods of extracting the key parameters
- Implement different optimization methods
- Compare and contrast the relative performance of different optimization approaches and select appropriate techniques for different applications
- Describe different simulation tools and approaches for computational design
- Design and design appropriate fabrication tools and â##compilersâ## for automated design
- Design a data-driven approach for a real world scenario and implement the approach
- Justify choice of fabrication methods for a given task

Transversal skills

- Continue to work through difficulties or initial failure to find optimal solutions.
- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Make an oral presentation.
- Summarize an article or a technical report.

Teaching methods

The course will use a mix of both tradiational teaching methods for more theory oriented lectures and also active learning including group debates, reviews and also in-class questions for more indepth exploration of topics. For some lectures there will be some preparatory work (e.g. reading papers, watching videos) to allow for in lecture exploration.

Expected student activities

- Individual programming exercises and report on encoding design spaces and implementing and contrasting various optimization methods
- Participation in active learning aspects of the class icluding debates, discussions and other participary activities
- Group project on using the methods presented to perform some data-driven design of a product/system, with final presentation and report. This will be more open ended and research focused. There will be the opportunity to fabricate and physically test the designs developed.

Assessment methods

- **30% Individual Report.** Students will be asked to implement a number of the data-driven design techniques to contract their effectivness and reflect on the useage of different approaches.
- **70% Group Project (20% Intial Presentation, 20% Final Presentation, 30% Final Report).** Students will be be asked to select from a number of 'open' design challenges and asked to work in teams to develop a method to both optimize or select approiate methods of finding an appropiate design,

Supervision

Assistants	Yes
Forum	Yes
Others	There will be a Slack forum for the course to allow for questoins to be asked and also to facilitate group work.

Resources

Bibliography

Suggested books/reading will be added.

Notes/Handbook

Will be provided during the course.

Moodle Link

- https://go.epfl.ch/ME-428