Advanced Design Concepts and Practice (ADCP)

ADCP 2013 Summer Workshop

Venue: JIasuo Hotel, Tsinghua University, Beijing, China

Time: 9.30am-17.30pm, 16 August 2013

Keynote Speaker

Dr. Panos Y. Papalambros

Professor of University of Michigan

Lecture Topic

Design Science and Optimization: Analysis-based Design of Products and Systems

Invited Presentations

Professor Ming Xinguo, Institute of computer integrated manufacturing, Shanghai Jiaotong University

Professor Rong Yiming, Manufacturing Engineering Institute, Tsinghua University

Dr. Du Jianbin, School of Aerospace, Tsinghua University

Dr. Li Pingke, Department of Industrial Engineering, Tsinghua University

Dr. Zhang Peng, Institute of Innovative Design, Hebei University of Technology

Dr. Zhao Jingshan, Design Institute, Tsinghua University

Chair

Professor Ji Linhong, Tsinghua University

Workshop Manager:

Dr. Hou Yuemin, Room 3408, Design Institute, Tsinghua University

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Introduction to the Workshop

The first Advanced Design Concepts and Practice (ADCP) workshop was held in Beijing on July 6-8th of 2011. The second ADCP Workshops was held in Karlsruhe, Germany, on May 8th of 2012. In 2012, two web-based ADCP 2012 workshops also were organized. One is the Summer Workshop held at TU Delft on August 17th and the other is the Fall Workshop held at Tsinghua University on November 8th. The goal of the series of workshops is to bring advanced theories, methods, technology and tools to the multi-field design and simulation of complex equipments and products. This Summer Workshop aims at offering a discussion platform for the latest research on advanced design concepts and practice with a focus on computational design.

Introduction to the keynote speaker

Dr. Panos Y. Papalambros
Professor of University of Michigan
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Professor Panos Y Papalambros is the Donald C. Graham Professor of Engineering and Chair of the Integrative Systems + Design Division at the University of Michigan. He is also a Professor of Mechanical Engineering, Professor of Architecture, and Professor of Art and Design. He holds a diploma in mechanical and electrical engineering from the National Technical University of Athens and M.S. and PhD degrees in mechanical engineering from Stanford University. He is co-author of the textbook *Principles of Optimal Design: Modeling and Computation* (1988, 2000). His research and teaching interests include design science, design optimization, and product and systems design. He was the founding director of the Design Science Doctoral Program at the University of Michigan.

Lecture

Design Science and Optimization: Analysis-based Design of Products and Systems

Dr. Panos Y. Papalambros

Professor of University of Michigan

Design Science studies the creation and embedding of artifacts in our lives and the attendant consequences for users and society, integrating quantitative and qualitative analysis techniques from a diversity of other fields, including engineering, business, behavioral and social sciences, computer science and industrial design. This talk presents an analytical approach to product and system design based in part to the mathematical optimization paradigm, along with implications for design research and education. A brief overview of the Integrative Systems + Design Division and the Design Science PhD Program at the University of Michigan will be also offered.

Program

Friday August 16th, 2013 9.30am-17.15pm		
Time	Topics	Speakers
9.30-9.45am	Welcome and Introduction	Chair, Ji Linhong Tsinghua University
9.45-11.30am	Design Science and Optimization: Analysis-based Design of Products and Systems	**Keynote speaker** Professor Panos Y. Papalambros, University of Michigan, Abstract
11.30-11.45am	Coffee Break	
11.45-12.15am	Design of Value Chain for Industrial Product Service System (IPS2)	Ming Xinguo, Shanghai Jiaotong University Abstract
12.15-2.00pm	Lunch	Xichunyuan Restaurant Tsinghua University
2.00-2.30pm	Digital Manufacturing Technology in Product Development and production Design	Rong Yiming Tsinghua University Abstract
2.30-3.00pm	Topology Optimization of Vibro-acoustic structures	Du Jianbin Tsinghua University, Abstract
3.00-3.30pm	Linear systems on max algebra	Li Pingke Tsinghua University, Abstract
3.30 – 3.45pm	Coffee break	Break
3.45-4.15pm	Concept Design of Mechanisms —From Qualitative Decision to Quantitative Analysis	Zhao Jingshan Tsinghua University, Abstract
4.15-4.45pm	D-Robots (Design Robots) for Gene transcription in designing	Hou Yuemin Tsinghua University, Abstract
4.45-5.30pm	Discussion	Chair Ji Linhong
5.30pm	Adjourn	

Presentation Abstracts

Topology Optimization of Vibro-acoustic structures

Jianbin Du

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Vibration and noise control has been regarded as one of the most important problems in engineering for a long time. One way to achieve such a goal is to perform passive design with the help of systematic optimization techniques. For example, sound radiation from a vibrating structure may be reduced by optimization of the stiffness, mass and damping of the structure, i.e., structural and material design plays a very important part in passive control of noise and vibration. The methods of topology optimization have been developed to a great extent since 1988, and have been applied to various engineering fields during the last decades. As compared with the traditional size/parameter and shape optimization, topology optimization provides the designers a design space with substantial more freedom at the very beginning stage of the design, which implies that the structures or the materials may be used in a more efficient way.

The presentation is focused on the problem of topological design of continuum structures in consideration of vibro-acoustic criteria. The design objective is minimization of the sound power flow or sound pressure generated by the vibrating structures in the acoustic medium. The design variables are the volumetric densities of material in the admissible design domain. Black and white design may be achieved when the design variables take the values zero or one. An upper bound on the volume fraction of the prescribed material is given, which plays the role of the global design constraint. A high frequency boundary integral equation is employed to calculate the sound radiation from the surface of the structure. This way the acoustic analysis and the corresponding sensitivity analysis can be carried out in a very efficient manner. Penalization models with respect to the transfer matrix of the acoustic pressure and/or the damping matrix are proposed to eliminate intermediate material densities, which have been found to appear obstinately in some of the high frequency designs. The influences of the frequency and the damping on optimum topologies are investigated by numerical examples. Some interesting features on vibro-acoustic topology designs are revealed and discussed.

Up to now, most of the research concerning structural vibro-acoustic topology optimization has concentrated on the macro scale, i.e. the macro structural layout or material distribution. However, if we look into in detail some acoustic structures or materials used in engineering, a pattern of composites with periodic microstructure can be often found. Therefore, it is natural to extend the models for structural vibro-acoustic topology optimization to the micro scale, or even an integration of the two scales. In the presented model, the macrostructure is excited at a single or a band of excitation frequencies by a time-harmonic external mechanical loading with prescribed amplitude and spatial distribution. The microstructure composed of two different solid isotropic material phases is assumed to be identical from point to point at the macro level. The homogenization method is employed to calculate the macro equivalent material properties of the periodic microstructure. The optimum layout of the microstructure is obtained by using the method of multiple-scale analysis and sequential convex programming algorithm (MMA). Several numerical examples are presented to validate the proposed model and method.

Linear systems on max algebra

Li Pingke, Department of Industrial Engineering, Tsinghua University

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Max algebra provides a modeling language for some problems in combinatorial optimization, discrete event systems, and fuzzy control.

Recently, interesting connections between linear systems on max algebra and some different problems in other areas have beem discovered.

This talk introduces linear systems on max algebra and the associated optimization problems, and discusses their recent advances as well as some open problems.

Concept Design of Mechanisms—From Qualitative Decision to Quantitative Analysis

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This talk focuses on the concept design of mechanisms, and discusses the method from the qualitative interpretation of a mechanism to quantitative analysis of the kinematics and geometry, and dynamics of its structure. Through examples of foldable wind turbine tower, industry robot for autonomous painting, structure design of wing of the flying robot and some complex spatial manipulator, it presents the general procedure from the decision of qualitative analysis to the establishment of quantitative equations. This design process can be generalized to other mechanism products.

Innovative Design Mechanism based on DCC and TRIZ

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The obstacle is that functional periodicity is difficult to obtain when Complexity Theory based on Axiomatic Design is used to eliminate system's complexity. There are several kinds of characteristics in the complex problem. It is the key for the characteristics to help designers obtain the simple functional periodicity. But if the features are not obvious or the simple functional periodicity obtained by the characteristics can not eliminate the complexity, the combined functional periodicity should be introduced to eliminate the system's complexity. This paper proposes a new design process which combines Complexity Theory with Theory of Inventive Problem Solving (TRIZ). The design process can help designers obtain combined functional periodicity of the system. A case study shows the application of the process.

D-Robots (Design Robots) for Gene Transcription in Designing

Hou Yuemin, Design Institute, Tsinghua University

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To achieve design automation is difficult for novel design of complex mechanical systems. However, part of design activities can be formulated as routine actions, which can be executed by an entity like a robot to assist designers in conceiving and analysis. D in the D-Robot refers to design, including a series of design activities. D-Robot acts like a designer that is good at a narrow but specified design tasks, such as design rules for specified equipments and design tasks like drawing, FEM analysis, 3D modelling, making the bill of material, simulation and the like.

This talk presents D-Robots for computational synthesis by automating part of computing and drawing tasks. The configuration of D-Robots is a combination of industrial robots and agent systems. The role of D-Robots is investigated based on a six stage design framework, which simulates the developmental process of biology and describes the design process using concepts in embryogenesis. The presented work uses D-Robots to execute the gene transcription mechanisms for Function transformation, Property Transformation, Specification Transformation, Feature Transformation and Measurement. The configuration and the action planning of D-Robots are discussed and design cases are presented.

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