Abstracts of the presentations at

The First International Seminar on Applied Analysis and

Synthesis of Complex Systems (ASCS)

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Some Factors Affecting the Air-Sea Gas Transfer -Towards Modeling of Turbulent Transport Phenomena in Atmosphere-Ocean System-

Satoru Komori (Kyoto University, Jp.)

Our fluid-mechanics group aims to develop reliable models for describing turbulent transport phenomena appearing in atmosphere and oceans in order to improve the reliability of predictions for global warming. In particular, it is of importance to precisely estimate heat and mass exchange rates between atmosphere and oceans by clarifying the mechanism of heat and mass transfer across the air-sea interface, since very rough sub-models that never reflect the physical heat and mass transfer processes have been used in conventional general circulation models (GCM). This kind of research on the atmosphere-ocean system is also a very challenging subject for our mechanical engineers who have professional expertise in fluid mechanics and thermal engineering. This talk will introduce our experimental and numerical approaches for clarifying turbulent CO_2 transfer mechanism across the sheared wavy air-water interface and for estimating CO_2 exchange rate between atmosphere and oceans. In addition, some factors affecting the CO_2 transfer across the air-sea interface will be discussed together with laboratory measurements in a wind-wave tank.

Dynamical and Complex Behaviors in Control Systems and Human-Machine Co-Adaptive Systems

Tetsuo Sawaragi (Kyoto University, Jp.)

Fundamentals of complex functional mechanical systems are macroscopic phenomena of complex systems consisting of microscopic elements, mostly via nonlinear,

large-scale interactions. Such phenomena can be observed or created in every aspect of modern science/technology. They typically present collective behavior such as self-organization, pattern formation, learning etc., which does emerge out of interactions among individuals with an ability of creating variabilities. Our group aims at clarifying fundamental principles in such phenomena as well as utilizing and synthesizing the knowledge derived out of them to realize the adaptability of the mechanical artifacts to the environmental disturbances. In this lecture, a number of our group's ongoing works are presented including the design and analysis of novel control mechanisms for autonomous robots, biological systems, mechanical artifacts and more general human-in-the-loop systems.

Analysis and Design of, and Displays for, Complex Human-Machine Interactions

Gunnar Johannsen (University of Kassel, Germany)

Complex technical systems (so-called machines) range from small appliances via machine tools, reactors, vehicles, robots, medical equipment, integrated production units, and bioengineering processes, to large-scale plants and networks. In all cases, human personnel interact and cooperate with these machines. The structures and functionalities of such human-machine systems and interactions are explained in this lecture, referring to various levels of responsibility, flexibility, and autonomy. Functional and cognitive task analyses as well as various modeling techniques are used as means for understanding complex human-machine interactions and for designing appropriate information displays. A human-centered design technique is introduced which is based on task models, user object models, technical systems models, and user interaction models. A systems engineering life-cycle methodology, including prototyping and evaluation, is pursued in this design technique. The design of auditory and visual human-machine interfaces is exemplified in the lecture. Auditory displays for mobile service robots in a supermarket scenario are briefly introduced. The design of visual/graphical displays is demonstrated for a chemical process with a new interactive evolutionary optimization technique based on genetic algorithms. Graphical elements from component-oriented, ecological, multi-flow-oriented, and virtual-3D-process visualizations can be combined, under the consideration of human user preferences.

Haptics and Control in Human Interactive Telepresence Systems

Martin Buss (Technische Universität München, Germany)

Multi-modal telepresence systems are to enable human operators to become present in

remote or inaccessible environments through communication and a suitable telerobotic system. The active manipulation and task solving capabilities of human operators can be transferred to remote environments. Multi-modality includes the visual, auditory, and haptic channel. Haptics (force and tactile feedback) includes an energy exchange between the telerobot/environment and the human operator/human system interface. From a control perspective this means that a control loop is closed over the communication network with the human operator being part of this loop. The presentation will focus on key issues in haptic telepresence and teleaction systems from a control point of view. The major challenges of time-delay (latency) in the communication network and transparency issues are discussed. Mechatronic solutions to haptic interfaces and telerobots as well as prototypical experiments with telepresence and teleaction systems are presented.

Momentum and Heat Transport Mechanisms of Fluid Motion in a Rotating Annulus

Masato Nagata (Kyoto University, Jp.)

Fluid motions induced by thermal buoyancy in a rotating system and in the presence of a mean zonal shear have been of considerable interest to geophysical fluid dynamicists and astrophysicists. In this paper, we analyze the momentum and heat transport mechanisms due to the interaction between convection and the Taylor vortices between two coaxial differentially rotating cylinders fixed at different temperatures. We attempt to apply the results of our analysis to geophysical problem.

On the Exact Stabilization of an Uncertain Dynamics

Arkady Kryazhimskiy and Vyacheslav Maksimov (IIASA)

The study is motivated by the problem of stabilizing the concentration of atmospheric carbon, which is widely discussed in the context of global warming nowadays. A key difficulty in the design of stabilization strategies is the uncertainty of the underlying physical model. In the present paper, a general problem setting is suggested and a relevant analytic framework elaborated. Analysis employs specific qualitative features of an uncertain dynamics, including automatic stabilization of the trajectories in the absence of input disturbances. An asymptotic version of Krasovskii's extremal shift control principle is developed and model-robust stabilizing a state coordinate at a

prescribed level are constructed.

Bone Functional Adaptation by Remodeling through Hierarchical Mechanical Systems from Cell to Tissue

Taiji Adachi (Kyoto University, Jp.)

At the tissue level, living bone dynamically adapts its internal structure by remodeling to accomplish its mechanical function as a load bearing structure under the influence of mechanical environment. This functional adaptation by remodeling is accomplished by complex coupled osteoclastic resorption and osteoblastic formation at the cellular level. In this presentation, how mechanical viewpoints can approach to better understanding of the adaptive bone remodeling mechanism through the hierarchical mechanical function-structure relations from cell to tissue will be discussed, and some computational simulation results on this point will be presented.

From "Function Designing" to "Bio-Environment Designing"

Naohide Tomita (Kyoto University, Jp.)

As living tissue maintains its shape and function by adaptive self-remodeling, it is difficult to design an artificial shape and a function in the body. Our theme is the "in-vivo environment designing" which is the key factor for successful tissue-engineering treatment. Several biological, clinical and mathematical approaches to the "in-vivo environment designing" will be introduced in the presentation. We want to discuss how to design the proper environments and how to control the shape and the function of living tissues, especially with respect to the following issues;
1.Effect of mechanical environment on differentiation of embryonic stem cells, and
2.Total Joint Regeneration system as an environment-designing treatment.

A Structured Modeling Technology

Marek Makowski (IIASA)

This talk presents the methodological background and implementation of a structured modeling environment developed to meet the requirements of modeling activities undertaken to support intergovernmental negotiations aimed at improving European air quality. Although the motivation for the reported work came from the actual complex application presented in the paper, the actual scope of the talk covers a wide range of issues related to model-based decision-making support. The talk starts with a summary

of the context of modeling composed of: the role of models in decision-making support; modeling paradigms; and state-of-the-art of modeling complex problems. The modeling process is then characterized, and the requirement analysis for implementation of structured modeling is specified. The main part of the paper presents the structured modeling technology which was developed to support the implementation of the structured modeling principles for modeling complex problems.

Structural Topology Optimization for the Design of Novel Mechanical Structures

Shinji Nishiwaki (Kyoto University, Jp.)

A structural topology optimization methodology for the design of mechanical structures having new types of functions such as kinematic functions and dynamic functions is developed. This methodology is applied to various designs such as compliant mechanisms, mechanical resonators, vibromotors, mechanical filters in MEMS, actuators with piezoceramics, and sensors using piezoelectric and piezoresistive effects.

Design of an Adaptive Control System by Modular Learning: Flight Control of an Autonomous Unmanned Helicopter

Hiroaki Nakanishi (Kyoto University, Jp.)

Designing control system for complicated mechanical systems by training of intelligent system is developed. We propose a method to design robust control systems against stochastic uncertainties by use of off-line training of neural networks. On-line training is also important for control system because it enables to compensate undesirable effects which are not modeled or sudden changes of the controlled object and the environment. Therefore, a method to design an adaptive control system by modular learning. Numerical simulations and experimental results of flight control of an autonomous unmanned helicopter demonstrate the effectiveness of proposed methods.