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Abstract: Preventive maintenance (PM) can slow the deterioration process of a repairable system and restore the system to a younger state. The proposed PM model of this paper focuses on the restoration effect of degradation rate reduction which can only relieve stress temporarily and slow the rate of system degradation while the hazard rate is still monotonically increased. This PM model considers a deteriorating but repairable system (or equipment) with a finite life time period. This PM model is modified based on an original degradation-rate-reduction PM model over a finite time span of which the searching range for the optimal solution of the time interval between each PM is limited. It is demonstrated that the proposed degradation-rate-reduction PM model over a finite time period can have a better optimal solution than the original PM model. The algorithm of finding the optimal solution for the modified PM model is developed. Examples are provided and are compared with the corresponding original PM model.

Application of Artificial Neural Network State Feedback Controller to Torque Ripple Minimization of PMSM

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Keywords: Artificial Neural Network, Adaptive State Feedback Controller, Permanent Magnet Synchronous Motor, Torque Ripple.

Abstract: This paper deals with the problem of torque ripple minimization of permanent magnet synchronous motor. The novelty of the presented approach lays in precisely maintain the level of the voltage source inverter DC voltage demanded for proper operation of the motor. An additional voltage matching circuit with state feedback controller is introduced in order to control of the inverter DC voltage. In the proposed solution model of a plant (i.e. permanent magnet synchronous motor fed by voltage source inverter with additional voltage matching circuit) is non-linear and non-stationary. An adaptive state feedback controller is developed by using an artificial neural network, which approximates non-linear control gain surfaces. A simple adaptation algorithm based on 2 low-order low-pass filters is used. Simulation results illustrate the proposed approach in comparison to typical drive with voltage source inverter and stationary state feedback controller.

Particle Swarm Optimization Based Model Predictive Control for Constrained Nonlinear Systems

Jean Thomas

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Keywords: Particle Swarm Optimization, Model Predictive Control, Optimization, Nonlinear Systems, Constrained Systems, Linear Induction Motor.

Abstract: Particle Swarm Optimization (PSO) is an effective optimization technique that can efficiently solve nonlinear and non-convex optimization problems, however, system constraints like output and states constraints cannot be considered. On the other hand, Model Predictive Control (MPC) is an efficient optimization technique that can offer the optimal solution while respecting the given constraints; however, for constrained nonlinear/non-convex optimization this turned out to be a complex problem and in many cases, it became inapplicable in real-time due to the computation burden. This paper presents a Particle Swarm Optimization based Model Predictive Control for constrained nonlinear systems. It is a simple control algorithm that offers a sub-optimal solution, in reasonable time, for nonlinear systems while respecting the given constraints. The proposed technique can consider both hard and soft constraints. The new developed technique is not considered as a computation burden, and on-line application is possible. An application of the proposed technique to a speed control of linear induction control is presented.

Improving Lidar Data Evaluation for Object Detection and Tracking Using a Priori Knowledge and Sensorfusion

David Wittmann, Frederic Chucholowski and Markus Lienkamp

Technische Universität München, Munich, Germany

Keywords: Object Detection, Tracking, Lidar, Sensor Evaluation, Sensor Fusion, A Priori Knowledge.

Abstract: This paper presents a new approach to improve lidar data evaluation on the basis of using a priori knowledge. In addition to the common I- and L-shapes, the directional IS-shape, the C-shape for pedestrians and the E-shape for bicycles are introduced. Considering the expected object shape and predicted position enables effective interpretation even of poor measurement values. Therefore a classification routine is utilized to distinguish between three classes (cars, bicycles, pedestrians). The tracking operation with Kalman filters is based on class specific dynamic models. The fusion of radar objects with the used a priori knowledge improves the quality of the lidar evaluation. Experiments with real measurement data showed good results even with a single layer lidar scanner.

Adaptive LQG/LTR Control; Discontinuity Issue

Dariusz Horla and Andrzej Krolikowski

Poznan University of Technology, Poznan, Poland

Keywords: LQG Control, Loop transfer Recovery, Adaptive Control.

Abstract: An adaptive LQG control with no control cost is considered. In such case the loop transfer recovery (LTR) effect can be obtained. The control problem is handled using discrete-time state-space model and the parameter estimation is performed for corresponding ARMAX model which can be represented in innovation state-space form. Thus the direct estimation of model parameters is possible by means of standard ERLS procedure and the adaptive control is implemented through *certainty equivalence principle*. In such a situation the problem of solution continuity of Riccati equation can arise for nonminimum-phase systems. Computer simulations of third-order systems modeled by a second-order minimum-phase and nonminimum-phase models are given to illustrate the robustness and performance properties of the adaptive controller, particularly with respect to the modelling error parameter η.

The Dependence of Piezoresistivity of Elastomer/Nanostructured Carbon Composites on Dynamic Mechanical Load Frequency

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Rigas Technical University, Riga, Latvia

Keywords: Dynamic Mechanical Loading, Piezoresistivity, Nanostructured Carbon Composites, Sensor Materials, Piezoresistive Sensor.

Abstract: The aim of this article is to determine piezoresistive sensitivity of elastomer nanostructured carbon composites at dynamic loading tests and show the piezoresistive effect correlations to various frequencies of applied mechanical force in a manner

that could provide a parameter of the highest detectible dynamic load frequency. This parameter is crucial when determining sensor's usability in possible applications. There are only few articles on conductive polymer composite sensitivity in dynamic mechanical loading tests.With this article we are trying to estimate the values of dynamic loading frequencies in which sensor would be functional.

Development of Therapeutic Expression for a Cat Robot in the Treatment of Autism Spectrum Disorders

Bo Hee Lee, Ju-young Jang, Keum-hi Mun, Ja Young Kwon and Jin Soun Jung

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Keywords: Autism Spectrum Disorder, Social Interactions, Treatment Behaviour, Face Mechanism, Therapeutic Expression, Hand Gesture, Controller and Sensor.

Abstract: The purpose of this research is to develop a therapeutic expression for the use of early treatment that will improve the social interactions of children with autism spectrum disorders (ASD). In order to satisfy the purpose, we choose a cat character after surveying requirements and summarize the required actions for a treatment as hugging, eye contacts, copies of body movements and reactions to negative behaviours. The robot has a face mechanism that can express the emotion and a body mechanism to perform hand gesture. We also designed a system controller and sensor interfaces to control its body or interact with children. All the use history of the robot is stored at the memory device to analyze the play patterns of the patient and also used to make the treatment program that can be utilized in the specialized clinic. In this study, the therapeutic expression for the treatment of ASD is suggested and ported in a cat robot, and verified with real action experiment of those functions. This study is kinds of preliminary result before developing a treatment therapy for ASD children using perfect cat robot that has outer skin and furry coat, and followed by expression research for the suitable program that can be applied in the real treatment field.

Keynote Lecture **ICINCO**
12:00 - 13:00 **Room Hörsaal FH 5**

Off-road Robotics - Perception and Navigation

Karsten Berns

University of Kaiserslautern, Kaiserslautern, Germany

Abstract: The research area of off-road robotics is focusing on autonomous or semiautonomous vehicles able to navigate in rough terrain without a predefined trail. Typical examples are agriculture and forestry machines or planetary rovers. A detail environmental perception and navigation strategies under the consideration of soil conditions have to be examined for developing an adequate control concept for such vehicles. In the talk first our behavior based control concept is introduced which is basis for the implementation of the control strategies Then different perception algorithms are presented for classifying soil conditions, detecting objects or tracing dynamical obstacles. Thereafter, the hierarchical structured control modules of the behavior based control architecture will be discussed according to the navigation requirements of these vehicles. The talk will end with the presentation of different off-road vehicles and their applications like an excavator, a tractor, and a rescue robot which are developed at the RRlab of the University of Kaiserslautern during the last years.

Parallel Session 8 **ICINCO**
14:30 - 16:00 **Room Hörsaal FH 2**
Intelligent Control Systems and Optimization

Document Clustering Using Multi-Objective Genetic Algorithms with Parallel Programming Based on CUDA

Jung Song Lee, Soon Cheol Park, Jong Joo Lee and Han Heeh Ham

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Keywords: Document Clustering, Genetic Algorithms, Multi-Objective Genetic Algorithms, GPGPU, CUDA.

Abstract: In this paper, we propose a method of enhancing Multi-Objective Genetic Algorithms (MOGAs) for document clustering with parallel programming. The document clustering using MOGAs shows better performance than other clustering algorithms. However, the overall computation time of the MOGAs is considerably long as the number of documents increases. To effectively avoid this problem, we implement the MOGAs with General-Purpose computing on Graphics Processing Units (GPGPU) to compute the document similarities for the clustering. Furthermore, we introduce two thread architectures (Term-Threads and Document-Threads) in the CUDA (Compute Unified Device Architecture) language. The experimental results show that the parallel MOGAs with CUDA are tremendously faster than the general MOGAs.

Reconfigurable CAN in Real-time Embedded Platforms

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Keywords: Microcontroller, Networked STM32F4, CAN,Multi-Agent-Architecture, Reconfiguration, Real-time, framepacking.

Abstract: This paper deals with the dynamic reconfiguration of the frame packing as well as the traffic of real-time packets on a CAN network. This network is assumed to link distributed reconfigurable STM32F4 microcontrollers that can automatically add-remove-update periodic and aperiodic OS tasks at run-time. These tasks may exchange messages to be loaded in packets and to be sent on the network. After the addition of a pair of dependent tasks on two microcontrollers, a message should be added on CAN and should respect a corresponding deadline related to these tasks. After several additions of messages, some deadlines may be violated and the CAN may not support the added messages. In addition, the frame packing should be adapted at run-time to any reconfiguration scenario in the different microcontrollers. We propose a multi-agent based architecture to check the correct transmission of messages. If some deadlines are violated, these agents propose technical solutions for the feasibility of the whole system. They can suggest first the modification of periods or deadlines of tasks and messages. They can propose also the removal of some OS tasks or messages from the controllers according to their priorities. We propose in addition new solutions to construct the dynamic frame-packing while the bandwidth is minimized. A tool is developed at LISI and Cynapsys to support the different contributions of this paper.

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