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A METHOD TO SYNTHESIZE HIGH-PRECISION MOTION CONTROL SYSTEMS FOR UNDERWATER MANIPULATOR

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Abstract
The development of a method to synthesize combined systems that provide high-precision motion control of multi-joint manipulators mounted on underwater vehicles is presented. This method consists of the following steps. (1) A preliminary analytical calculation of the external torques that occur in all the degrees of mobility of moving underwater manipulators is performed using a recurrent algorithm for solving the inverse dynamics problem. (2) Additional diagnostic observers are then synthesized using the manipulator electric drive's dynamic models and taking into account the analytically estimated external torques. These observers can precisely determine the values of unexpected variations in viscous and coulomb friction torque in all the drives. (3) After that, the precisely identified torque effects on the drives of all the degrees of manipulator's mobility are fully compensated by the adaptive compensator devices that provide stabilization of the dynamic properties of these drives at the nominal level. Results of a numerical simulation showed a significant increase in accuracy of various technological operations performed with an underwater manipulator when the synthesized system was used. 35 refs.
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Key Words: *Underwater Multi-Joint Manipulator, Underwater Vehicle, Identification, High-Precision, Observer*

Pages 637-648

NUMERICAL MODEL FOR WORM GEAR PAIR INSPECTION BASED ON 3D SCANNED DATA

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Abstract
Gear inspection is an important aspect for evaluating gear geometry and ensuring that specified dimensional requirements are met. It is commonly carried out via tactile measurement methods which are characterized by relatively slow data acquisition and inability to provide three-dimensional data of the entire inspected object. In this paper, an alternative method based on three-dimensional optical scanning is employed for the inspection of a worm gear pair. Apart from assessing most common errors such as pitch deviations and runout, a nonlinear quasi-static finite element analysis based on worm gear pair scan is developed to estimate the transmission error. Furthermore, transmission error and initial worm wheel contact pattern are evaluated under running-in load and various assembly errors which resemble realistic working conditions. Depending upon the specific assembly error, transmission error can be either increased or decreased. Variation of initial contact patterns between observed worm wheel tooth flanks can vary up to 50 %. The results suggest that geometrical deviations have a considerable impact on initial contact patterns. 32 refs.
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Key Words: *Gear Inspection, Worm Gear Pair, Worm Wheel, Transmission Error, 3D Optical Scan, Contact Pattern*

Pages 649-660

ROLE OF OPERATOR TRAINING SIMULATORS IN HYDROCARBON INDUSTRY – A REVIEW

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Abstract
Control room operators in the hydrocarbon industry monitor large scale process data and take corrective actions using multifaceted control systems. Simulator training provides them an understanding of how to accurately identify process upsets and quickly respond to process control issues before they escalate to shut down of units. Although operator training simulators are widely used in the industry, they are not regularly updated to latest features and become obsolete due to different stakeholder issues. The objective of this review is to examine these attributes in the literature to identify key perceptions about simulator training and suggest appropriate resolutions. The findings accentuate the need to develop training simulators integrated with the actual process configuration, accurate process modelling, precise feedback mechanism, training data analysis in conjunction with operations and continuous learning assessment showing embedded training value to the organization. This approach of using instructional design and pedagogical methodology can contributes for effective usage of simulators and might help to minimize human errors in the hydrocarbon industry. 35 refs.
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Key Words: *Operator Training Simulator, Simulator Configuration, Human Error, Training Transfer*

Pages 661-671

CODEVS: AN EXTENSION OF DEVS FOR INTEGRATION OF SIMULATION AND MACHINE LEARNING

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Abstract
When we model a system to analyse it, there are two main methods we can use. First, there are knowledge-based simulation modelling methods using system operations, such as discrete event system specification (DEVS). Conversely, there are data-driven modelling methods using data analysis without explicit system knowledge, such as machine learning. These two models can be used appropriately in situations where it is difficult to model sufficiently with one method, and through this, the advantages of each method can be maximised. In other words, for this, a method is required to specify one system by using two methods at the same time. Therefore, in this paper, we introduce an extension of DEVS formalism, called Cooperative DEVS (CoDEVS), which enables representation of both a simulation model and a machine learning model. It consists of a simulation model, data model, and interface models that convert events between the simulation and data models. We also introduce a modified simulation algorithm that can interpret the new formalism and simulate a distributed file system to show the validity of the proposed work. 31 refs.
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Key Words: *DEVS Formalism, Cooperative DEVS (CoDEVS), Machine Learning, Data Modelling, Simulation Modelling*

Pages 672-683

SIMULATION BASED RESOURCE CAPACITY PLANNING WITH CONSTRAINTS

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Abstract
The research work represents the development of a new decision-making model intended for the resource capacity planning depending on the production system constraints. A mathematical decision model for medium and short-term (dynamic) workers allocation was developed. A simulation study of the dynamic events and the response of the decision-making algorithm to achieve the optimal workers allocation was conducted. The results show that the resource capacity planning has a high importance as the constraints faced by workers in production systems become more severe. The results demonstrate the high ability to terminate production capacity while ensuring smooth, efficient operation of the production system. Presented method can be used in everyday workers allocation in different types of production systems. 25 refs.
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Key Words: *Simulation Modelling, Mathematical Modelling, Resource Capacity Planning, Constraints Theory, Decision-Making Algorithm*

Pages 684-695

NUMERICAL SIMULATION OF COARSE PARTICLE TWO-PHASE FLOW IN TWO-STAGE VORTEX PUMP

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Abstract
Vortex pumps are finding increasing use where abrasive fluids in petrochemical applications must be handled when pressure is readily available for transporting mixed materials in pumping applications. Related research on fine particle two-phase flow cannot meet the actual production requirements. Therefore, the characteristics of solid–liquid two-phase flow with high solid-phase content in pumps must be investigated. In this study, a two-stage vortex pump with a high demand for passing and steady ability is designed. The external characteristics of the pump, internal pressure field, velocity field, and solid distribution law are explored through high solid concentration and size changes. Results show that the shear stress transport turbulence model is found to be appropriate for the computational fluid dynamics analysis of the characteristics of the vortex pump well. The particle velocity and pressure at the monitoring point at the tongue of the volute are higher, thereby aggravating the wear. With the increase in particle volume concentration, the energy exchange between the media increases, and the hydraulic loss of the flow field increases. 35 refs.
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Key Words: *Vortex Pump, Two-Phase Flow, Particle Diameter, Particle Concentration*

Pages 696-706

NUMERICAL MODEL APPLICATION TO PREDICT THE SOUND QUALITY OF AN INSTRUMENT

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Abstract
It is well known that in an acoustic guitar, the hollow wooden body of the guitar, which forms the resonating chamber, plays an important role in the sound produced. In an electric guitar, the influence of the solid guitar body is not so crucial, yet some influence of the vibroacoustic material properties is expected but has not been scientifically confirmed so far. The aim of the research presented in this paper was to confirm the hypothesis and to investigate the influence of the material used for the solid body of an electric guitar on the final sound image. An experimental numerical model of the electric guitar was created to show how designers can be assisted with a tool that allows them to plan the characteristics of the sound to be produced at the design stage, when the material and shape for the body of the guitar have been determined. In order to develop a relevant numerical model of the electric guitar, we built a test bench to validate the numerical model. The results of the numerical simulation of the decay of the string vibrations as a function of the body material used agree well with the results of the experimental measurements, confirming the adequacy of the numerical model presented. 16 refs.
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Key Words: *Numerical Analysis, Simulation, Electric Guitar, Wooden Solid Body, Vibroacoustic Properties*

Pages 707-718

DATA-DRIVEN ROBUST MODEL FOR CONTAINER SLOT ALLOCATION WITH UNCERTAIN DEMAND

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Abstract
The global container transportation market is complex and changeable, resulting in high uncertainty of container cargo demand. Effective container slot allocation (CSA) decisions are difficult for shipping companies to make. A data-driven robust model was developed for optimizing the CSA under highly uncertain cargo demands to maximize the revenues of shipping companies. The features of the empty container transportation were integrated into the model due to the imbalance of container import and export. The Copula method was employed to construct the uncertain set to deal with the limited historical demand information. Moreover, the model can be transformed into a simple and manageable robust optimization problem by introducing the protection level. Finally, the effectiveness of the optimal robust CSA policy was verified by numerical examples. Results demonstrated that the robust optimization model effectively balances the relationship between the revenue and the risk preference of shipping companies and maximizes the revenue by using limited cargo demand information. The optimal robust slot allocation policy is more stable under the heavy tail cargo demand. 27 refs.
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Key Words: *Copula Method, Data-Driven, Robust Optimization, Container Slot Allocation*

Pages 719-729

A MULTI-OBJECTIVE GENETIC ALGORITHMS APPROACH FOR MODELLING OF ORDER PICKING

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Abstract
Because the proportion of working-age people in the EU is shrinking, it is necessary to help employers to be able to install various aids to maintain the health of employees, especially in very demanding manual jobs. Well-being is thus becoming just as important as cost reduction. One such area is man-to-goods manual order picking. The paper proposes genetic algorithms (GA) to assist logistics managers in deciding about the most optimal pattern of stacking items in storage locations in storage racks. During the peak season, it makes sense to arrange items in terms of the minimum consumption of time when taking them manually out of the shelves and in periods of lower demand in terms of minimum chances of injury to employees and their low energy consumption. Based on experimental data, several models for predicting time, health risk, and energy consumption at order picking were developed by the GA. The results showed that GA is a powerful tool for resolving the storage assignment problems in terms of optimization according to individual criteria (time spent, risk of injury, or energy consumed) or searching for a common optimal solution. 35 refs.
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Key Words: *Order Picking, Productivity, Energy Expenditure, Health Risk, Modelling and Optimization, Genetic Algorithm*

Pages 730-741

CONGESTION RISK PROPAGATION MODEL BASED ON MULTI-LAYER TIME-VARYING NETWORK

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Abstract
To quantify the responses of drivers to traffic information and the congestion evacuation effect on the basis of traffic guidance information, a multilayer network congestion risk propagation model of urban roads was built to analyse the influence of the advanced traveller information system (ATIS) penetration rate, group behaviours of drivers, and traveller flow distribution features on the traffic congestion risk propagation of urban roads. Meanwhile, the dynamic evolutionary characteristics of group behaviours of drivers in a road network under the guidance of traffic information were analysed with the microscopic Markov chain approach (MMCA). A simulation analysis of the artery network in the fourth ring of Beijing was also carried out. Results demonstrated that the influence of traffic information and drivers' information reinforcement psychology on congestion risk propagation depend on the aggregation effect caused by traffic information. Increasing the ATIS market penetration rate and drivers' acceptance of information is beneficial to relieve traffic congestion as long as the drivers' aggregation effect is within a critical range. 19 refs.
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Key Words: *Urban Traffic, Congestion Propagation Analysis, Microscopic Markov Chain, Traffic Information, Group Behavioural Characteristics of Drivers*

Pages 742-753

A SIMULATION METHOD FOR RAIL TRANSIT SIGN OPTIMIZATION

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Abstract
The guidance signs in rail transit stations directly affect the smoothness and effectiveness of passengers' travel. The reasonable layout of guidance signs plays a role in the station system, which can reasonably guide passengers' walking routes in the station, reduce their walking time, realize effective traffic guidance in the station, and bring great convenience to passengers' travel. In this paper, the simulation selects Beijing rail transit Xizhimen station as an example for analysis, introduces the Xizhimen junction station, and analyses the passenger flow line of Xizhimen station. Based on this, the values of various parameters required for the practical application of the mathematical model were determined, so as to obtain a complete design model for the optimization of the layout of guide signs, and Anylogic software was chosen to solve the model. Finally, the optimized location of the optimized sign is restored to the actual situation of Xizhimen Station to verify the validity of the model. 19 refs.
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Key Words: *Urban Rail Transit, Guidance Sign, Layout Optimization, Simulation*

Pages 754-765

ELECTRIC VEHICLE CHARGING STATION LAYOUT BASED ON PARTICLE SWARM SIMULATION

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Abstract
The construction layout of charging piles restricts the rapidly development of EVs. To address this area, this paper first simulates the current layout of charging piles in Beijing and finds that there is an unbalanced distribution problem of oversupply and idle resources. Then, based on the current situation, this study takes the total charge station construction cost as the objective function and unfolds in three levels, using MIP for conditional constraints. Finally, an improved particle swarm algorithm is employed to simulate electric vehicles by generating demand points in the region to obtain the optimum location of charging stations. This method overcomes the limitation of using static data in traditional research, and the simulation can reflect the dynamic law of electric vehicle operation, which is more consistent with the real situation. The calculation results show that the method adopted in this study can reasonably plan the layout of charging stations, relieve the charging pressure of some charging stations, and minimize the overall service cost of new charging stations based on the continuation of the existing layout. 27 refs.
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Key Words: *Electric Car, Charging Station Layout, Simulation, PSO*

Pages 766-777

ANALYSIS OF THE FORCE RESPONSE OF A DOUBLE-CANOPY HYDRAULIC SUPPORT UNDER IMPACT LOADS

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Abstract
Hydraulic support is an important support equipment used in coal mining. However, it is easily damaged under impact loads. To improve its support stability, the force response of the hydraulic support was investigated by applying different impact load on the double-canopy. Dynamic simulation model based on rigid-flexible coupling was established. In the simulation, the base was treated as rigid, other parts were treated as flexible, and the cylinders were replaced using a stepless variable stiffness system. A parallel static load was applied to the canopies, stiffness characteristics of the support was tested. The force transmission law of the support joints was obtained by applying impact loads to different positions on the canopies. The results indicate that the support shows obvious variable stiffness characteristics under parallel static loads, the rear canopy bears a higher load than the front canopy. The support joints show different sensitivity to the impact load, the joint between the canopy and goaf shield is the most sensitive (up to 4.95). This study is useful to improve the anti-impact performance and structure optimization of hydraulic support systems. 22 refs.
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Key Words: *Hydraulic Support, Impact Load, Force Response, Double-Canopy*

Pages 778-789

MANUFACTURING CAPACITY EVALUATION OF SMART JOB-SHOP BASED ON NEURAL NETWORK

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Abstract
Most Chinese enterprises lack a systematic and scientific planning for intelligent manufacturing development. Therefore, this paper tries to evaluate the manufacturing capacity of smart job-shop based on improved backpropagation neural network (BPNN). Firstly, the core production factors affecting the manufacturing capacity improvement of smart job-shop were summarized, and a multi-level scale was developed for the manufacturing capacity of smart job-shop. Next, the production cost of smart job-shop was modelled, and a smart job-shop manufacturing capacity evaluation framework was established based on job-shop scheduling evaluation. After that, the sparrow search algorithm (SSA) was optimized by firefly algorithm to improve the initial weights and thresholds of traditional BPNN, and the improved BPNN was applied to evaluate the manufacturing capacity of domestic enterprises. The proposed model was proved effective through experiments. 27 refs.
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Key Words: *Smart Job-Shop, Manufacturing Capacity, Backpropagation Neural Network (BPNN), Firefly Algorithm, Sparrow Search Algorithm (SSA)*

Pages 790-801

DEMAND PREDICTION AND ALLOCATION OPTIMIZATION OF MANUFACTURING RESOURCES

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Abstract
Big data analysis, Internet technology, and cloud computing are being integrated to the allocation of production and manufacturing (P-M) resources, promoting the transformation, upgrading, and innovative development of traditional job-shop P-M resource allocation. However, the existing studies have not fully considered the demand dynamicity of production materials. To solve the problem, this paper attempts to predict the demand and optimize the allocation of job-shop P-M resources. Firstly, a demand prediction model was established for job-shop P-M resources, which can simultaneously capture the static and dynamic spatial dependence of P-M resource volume. Based on the demand prediction, the authors detailed an allocation optimization strategy for job-shop P-M resources, and defined the objective function and constraints. The proposed model was proved effective through experiments. 23 refs.
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Key Words: *Intelligent Manufacturing, Allocation Optimization, Demand Prediction, Production and Manufacturing (P-M) Resources*