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MODELLING GOAL SELECTION OF CHARACTERS IN PRIMARY GROUPS IN CROWD SIMULATIONS

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Abstract
This work presents an agent based behavioural model that simulates decision making ability of individual characters of primary social groups in crowd simulations. The proposed approach includes a decision function which is used by each character in order to select the most appropriate goal from a list of predefined goals. This decision function selects a goal for an agent by evaluating attractions to goals, distance to goals, decisions of fellow companions in the agent's group, and attractions towards such companions. The behavioural realism of this model was evaluated through a series of experiments that compared parameters of real world scenarios with their simulated counterparts. The level of realism at which the model simulates characters is suitable for crowd simulations in entertainment related applications such as video games and movies. Further, the profiling of the algorithm shows that the approach is capable of being deployed in real-time applications such as video games. 20 refs.
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Key Words: *Artificial Intelligence, Multi-Agent Systems, Virtual Reality, Crowd Simulation, Primary Groups, Social Groups*

Pages 597-610

SIMULATION FOR IMPROVING THE PERFORMANCE OF SMALL AND MEDIUM SIZED ENTERPRISES

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Abstract
The success of small and medium enterprises to adapt to constant changes in the environment largely depends on the different strategies and management decisions taken by managers at the operational level. This paper is searching for a tool that would allow managers at all levels to consider the effects of their decisions on the success of the enterprise as a whole. In this sense, the application of system dynamics developed one modular simulation model of business processes of SMEs. Developed model recognizes the specificities of SMEs, such as a large range of products, the use of a wide variety of materials, production in small batches and requests for reduction of lead time (Lead Time). The effects of various strategies and management decisions can be observed by monitoring the dependence of performance measures of simulated process on values of model parameters. Through four experiments the effects of changes in inventory management policies, the availability and size of the lot were simulated. The results of experiments showed that the variation of the model parameters should be oriented simultaneously towards several of the aforementioned directions. 22 refs.
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Key Words: *Simulation, Optimization, SMEs, Performance*

Pages 611-622

SIMULATION MODEL FOR JOB SHOP PRODUCTION PROCESS IMPROVEMENT IN MACHINE PARTS MANUFACTURING

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Abstract
Job shop production system is characterized by manufacturing feature with low volume and high variety of product designs. It is a process with high flexibility which produces a wide variety of products in low quantities and high divergence. Generally, a job shop production line follows sequence of orders with specific process flow for each particular job. In each work station, special skills of workers are required to perform explicit tasks. Due to these distinctive process characteristics, effective production planning is crucial for job shop manufacturing process. Ineffective production planning may cause several types of waste in production line. This study proposed simulation modeling for job shop production process in machine parts manufacturing. Simulation models present the great benefits to assist in performance improving, problems solving, including a great help in decision making. The experimental results of the study showed that group technology, plant layout, job enlargement, and capacity expansion accomplished the definite value in reducing operating cost and increasing average worker utilization, thereby increasing the efficiency of the system. 14 refs.
(Received in November 2015, accepted in May 2016. This paper was with the authors 1 month for 1 revision.)

Key Words: *Job Shop Process, Process Improvement, Simulation, Layout, Capacity, Job Enlargement*

Pages 623-636

INTEGRATION OF PRE-SIMULATION AND SENSORLESS MONITORING FOR SMART MOULD MACHINING

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Abstract
A smart mould machining system, which detects machining status and controls the CNC through pre-simulation and real-time data, was developed. Pre-simulation predicts cutting forces, and inserts the best feed rate and virtual load on each line of the NC data. The active feed rate reduced machining by up to 36 %, without increasing the maximum cutting forces. The actual cutting load was computed from spindle load data and a friction load compensation algorithm. Collision and tool wear were detected by comparing the actual and virtual load, with the time synchronised by using tool position data. The system machined an automotive grill mould cavity for 34 hours without the supervision of a worker, because pre-simulation had stabilized the milling process and monitoring would have stopped the process if the actual load was different to the virtual load. Pre-simulation has been verified by thousands of mould makers and integrated with sensorless monitoring in an open CNC. 27 refs.
(Received in November 2015, accepted in April 2016. This paper was with the author 1 month for 1 revision.)

Key Words: *Smart Mould Machining, Pre-Simulation, Feed Rate Control, Sensorless Monitoring, Tool Wear, Open CNC*

Pages 637-648

AN APPROACH TO MODELLING OF PERSONALIZED BONE GRAFTS BASED ON ADVANCED TECHNOLOGIES

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Abstract
Personalized bone grafts are one of the best examples of the latest achievements in the biomedical engineering. In the area of maxillofacial bone tissue reconstruction or jaw bone augmentation, their application has for some time been on the rise, and its ever increasing significance is driven by the growing technical support. One of the key segments is the bone graft modelling customized to suit patient's specific needs, since it greatly determines not only the future anatomic functionality but also the acceptance probability of the graft by the bone tissue. With the graft geometry importance in mind, presented in this paper is an approach to personalized bone graft modelling. The approach is based on application of modern computer-aided systems and methods, and enables efficient geometric design while minimizing the risk of errors during modelling and placement stages. Verification is based on a case study of a personalized bone graft designed for a patient requiring mandible augmentation. 22 refs.
(Received in January 2016, accepted in June 2016. This paper was with the authors 2 months for 2 revisions.)

Key Words: *Modelling, Simulation Analysis, Personalized Bone Graft*

Pages 649-662

TOOTH PROFILE MODIFICATION AND SIMULATION ANALYSIS OF INVOLUTE SPUR GEAR

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Abstract
The spur gear mechanism with the standard involute profile may generate noise and shock because of tooth structure and transmission principle, resulting in substantial transmission errors. These limitations can be effectively resolved through tooth profile modification. To address the defects and deficiencies of existing tooth profile modification methods in terms of the modification principle and effect assessment, this study proposes an adaptive method of tooth profile modification with alterable tooth profile for spur gear mechanism. A corresponding simulation method for evaluating the modification performance of the gear transmission was introduced in detail. The final shape parameters of the modification profile were determined by orthogonal experiments. Simulation results show that tooth profile modification for involute spur gear does not affect bending and contact stresses. The process can also effectively improve the stability of transmission. The impact and noise of gear pair with tooth profile modification significantly decreased during meshing. The proposed method exhibits stronger adaptability compared with other existing methods of tooth profile modification. Moreover, the proposed method can adaptively determine the optimal modification parameters based on different conditions and obtain the ideal modification effect. 19 refs.
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Key Words: *Tooth Profile Modification, Transmission Error, Impact, Parametric Modelling, Simulation Analysis*

Pages 663-675

ESTIMATION OF MACHINING TIME FOR CNC MANUFACTURING USING NEURAL COMPUTING

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Abstract
An approach to solving the problem of machining time estimation in production of complex products within CNC machining systems is presented in the paper. Heuristic analysis of the process is used to define the attributes of influence to machining time. For the problem of estimating machining time the following „Neural Computing techniques“ are used: Back-Propagation Neural Network, Modular Neural Network, Radial Basis Function Neural Network, General Regression Neural Network and Self-Organizing Map Neural Network. Real data from the technological process obtained by measuring are used to design the model used in investigation. The established model is used to carry out the investigation aimed at learning and testing different algorithms of neural networks and the results are given by the RMS error. The best results in the validation phase were achieved by Modular Neural Network (*RMSE*: 1.89 %) and Back-Propagation Neural Network (*RMSE*: 2.03 %) while the worst results were achieved by Self-Organizing Map Neural Network (*RMSE*: 10.05 %). 26 refs.
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Key Words: *Process Planning, Machining Time, Neural Networks, Estimation, CNC Manufacturing*

Pages 676-687

THERMAL MANIKIN AND ITS STABILITY FOR ACCURATE AND REPEATABLE MEASUREMENTS

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Abstract
Thermal manikins are used for testing the thermal insulation of different types of protective clothing. Data about thermal insulation is required when new protective clothes are designed or for the optimization of the existing ones. Thermal insulation usually plays an important role when researching or developing optimal protective clothing used in hot environmental conditions. The aim is to develop protective clothing that will ensure the lowest possible thermal load for the user. To get accurate information about thermal insulation, the measuring system for its determination should be stable. One of the possibilities is to use a thermal manikin presenting the anatomic shape of the human body. The measurement accuracy and stability of the measuring system based on the thermal manikin are investigated and assessed on the basis of statistical analysis. Accurate measurements can be ensured with statistics. Only accurate data has an application value for the industrial development. 28 refs.
(Received in February 2016, accepted in June 2016. This paper was with the authors 1 month for 1 revision.)

Key Words: *Thermal Insulation, Thermal Manikin, Measurement Validity and Reliability, System Stability Assessment*

Pages 688-698

SIMULATION OF NON-OVERLOAD CHARACTERISTICS OF SERIAL-PARALLEL CENTRIFUGAL PUMPS

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Abstract
Serial-parallel centrifugal pumps (SPCPs) are a new type of pump with two working conditions: high head with low flow and low head with high flow. However, the motor of SPCPs is easily burned because of its various operating conditions. To clarify the effect of the flow field on the non-overload characteristics of SPCPs, revealing the non-uniformity of the flow distribution is necessary. This study derived the velocity triangle theory of the pump, and a numerical simulation by 3D models was conducted to investigate the internal flow patterns of SPCPs. The magnitude of the flow deviation angle at different cross-sections was calculated to evaluate the non-overload characteristics under different operating conditions. The results showed that the formula of the maximum shaft power and the local flow rate were two important parameters of the non-overload interpretation of the pump. The simulated results were in good agreement with the experimental results at the designed flow rate. In addition, the flow deviation angle under the serial operating condition, which was more likely to achieve the non-overload characteristics, was evidently higher than that under the parallel operating condition. The conclusions solved the issue on the theoretical design of the non-overload characteristics considered in a non-uniform flow in SPCPs. 18 refs.
(Received in April 2016, accepted in June 2016. This paper was with the authors 1 month for 1 revision.)

Key Words: *Serial-Parallel Centrifugal Pumps, Non-Overload Characteristics, Numerical Simulation, Parametric Modelling, Flow Deviation Angles*

Pages 699-710

SIMULATING THE DEMAND RESHAPING AND SUBSTITUTION EFFECTS OF PROBABILISTIC SELLING

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Abstract
This paper addresses the effect of probabilistic selling on inventory decisions and the expected profit through demand reshaping and demand substitution. By considering a scenario with two higher-priced specific products and one lower-priced probabilistic product, we construct a new newsboy-type inventory model with demand reshaping and substitution. A simulation study is implemented to explore extensively the effects of demand uncertainty, demand correlation, price sensitivity and price discount on the inventory decisions and profitability of probabilistic selling. Finally, we provide insightful managerial implications of the nature of inventory management mechanism of probabilistic selling. 18 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Inventory, Probabilistic Selling, Demand Substitution, Demand Reshaping*

Pages 711-720

INTEGRATED OPTIMIZATION MODEL FOR PRODUCTION PLANNING AND SCHEDULING WITH LOGISTICS CONSTRAINTS

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Abstract
Production planning and the development of manufacturing production scheduling are two important operational management tasks. The results of these tasks will strongly influence the development of corporate profits, as well as the efficiency of utilization of resources. Considering the production scheduling problems in production plans can effectively avoid conflicts between the specific implementation production plan and the actual situations, and ultimately maximize resource utilization efficiency. This paper attempts to establish an integrated optimization model of production planning and scheduling with consideration of logistics constraints. A modified heuristic algorithm is proposed to solve this problem. In the final portion of this paper, a simulation analysis is given to demonstrate the outstanding advantage of the model and the algorithm, which gives further thought for the production planning. 25 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Production Planning, Scheduling, Logistics Capability, Integrated Optimization Model, Particle Swarm Optimization*

Pages 721-731

THE OPTIMAL SCHEDULING MODEL FOR AGRICULTURAL MACHINERY RESOURCES WITH TIME-WINDOW CONSTRAINTS

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Abstract
Scheduling harvesting operations is very important for the agricultural machinery centres and the farmers in order to finish the harvesting work effectively. Most machinery owners schedule their farm machinery according to their own experiences, resulting in a big waste of agriculture resources. This paper attempts to schedule the use of agricultural machinery from the machinery resource centres under multi-farmland, multi-type situations considering time, spatial and weather factors as well as road factors in order to maximize efficiency of resource utilization. A modified fuzzy hybrid genetic algorithm is proposed to establish this scheduling model. An empirical study of an agricultural machinery association in Anhui province in China is illustrated and the results show that the models and the scheduling algorithm proposed in this study can improve the efficiency of utilization of the agricultural machinery resource centres and reduce the costs of agricultural machinery usage. 22 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Scheduling Operations, Agricultural Machinery, Time Window, Multi-Type Machinery*

Pages 732-741

PRODUCTION LOGISTICS SIMULATION AND OPTIMIZATION OF INDUSTRIAL ENTERPRISE BASED ON FLEXSIM

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Abstract
This paper proposes the research method to comprehensively apply the time Petri net model and the Flexsim simulation model by taking interior assembling and production logistics system of an automobile manufacturing assembly workshop as the application background, and taking improvement for the production efficiency and production value of the logistics system as the target. Using this method, we can simulate the actual production logistics, analyse the results and identify bottleneck problems, and propose targeted optimization methods to improve processes, reduce waste, improve efficiency, and prove the rationality and validity of the research method. 22 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Production Logistics System, Simulation, Petri Net, Flexsim, Optimization*

Pages 742-753

VEHICLE ROUTING PROBLEM WITH TIME WINDOWS USING MULTI-OBJECTIVE CO-EVOLUTIONARY APPROACH

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Abstract
This paper introduces a novel multi-objective algorithm (HMPSO) based on discrete particle swarm optimization (PSO) to solve vehicle routing problems with time windows (VRPTW). The presented HMPSO algorithm was combined with an advanced discrete PSO based on set and variable neighbourhood searches to find Pareto optimal routing solutions. These consisted of a complete routing schedule for serving the customers to minimize the two aims of travelling distance and number of vehicles. To increase the discrete PSO efficiency, a novel decoding scheme based on set was designed, and the variable neighbourhood local search was employed to explore new solutions. The experiment results were showed for a set of the Solomon's 56 VRPTW. The HMPSO algorithm was compared with some algorithms published in papers with the computational evaluations clearly supporting the high performance of the proposed HMPSO algorithm against other algorithms, and confirming that the HMPSO is an efficient algorithm because of a reasonable computational time and cost in solve VRPTW. 38 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Multi-Objective Optimization, Discrete Particle Swarm Optimization, Variable Neighbourhood Search, Vehicle Routing Problem with Time Windows*

Pages 754-765

MODELLING THE DYNAMICS AND SECONDARY DEFORMATION BEHAVIOUR OF THE STRIP WITH LOCAL WAVES IN COILING PROCESS

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Abstract
With the introduction of 3D elastic-plastic deformation, and strip plastic flow factor concept, to analysis of the influence of strip local high points on the ridge-buckle behaviour in coiling process, an elastic-plastic coiling stress and ridge-buckle value model that can be used for online calculation was established. According to comparison and analysis of the influencing factors, uneven distribution of radial and circumferential stress caused by local waves is an important cause of strip ridge-buckle, and the ridge-buckle value increases with increases of local wave size, coil diameter and coiling tension, and significantly with decreases in the strip thickness. The influence of waves with different locations on the ridge-buckle value was analysed. Based on comparison of analysis results obtained by an elastic ridge-buckle value model and ANSYS FEM (finite element method), the accuracy and feasibility of this model have been proved, which will provide theoretical and model support for subsequent reduction of the ridge-buckle defects brought by local waves. 18 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Local Waves, Elastic-Plastic Deformation, Plastic Flow Factor, Ridge-Buckle, ANSYS FEM*