International Journal of Simulation Modelling – **Volume 18, Number 1**

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A REACTIVE SCHEDULING APPROACH BASED ON FUZZY INFERENCE FOR HYBRID FLOWSHOP SYSTEMS

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Abstract
Hybrid flowshops consist of multiple production stages each of which has multiple parallel machines. Scheduling of hybrid flowshops is a NP-hard even in its simplest form. The presence of uncertainty in real-world problems forces the decision makers to reconsider their scheduling decisions in reactive manner. In this study, we proposed a proactive-reactive scheduling approach which allows to be changed dispatching rule set applied in time. The methodology consists of three parts: Shop Floor Management system with a triggering mechanism based on fuzzy inference system, performance prediction of the alternative dispatching rule sets based on Taguchi design, simulation, artificial neural networks, and a multi-criteria decision making methodology for determining new scheduling dispatching rule set. The proposed approach is applied on a real world problem from literature and the results are compared with static approach. 35 refs.
(Received in May 2018, accepted in October 2018. This paper was with the authors 2 months for 1 revision.)

Key Words: *Hybrid Flowshop, Real-Time Scheduling, Fuzzy Inference System, Simulation*

Pages 19-32

DIGITAL VALUE STREAM MAPPING USING THE TECNOMATIX PLANT SIMULATION SOFTWARE

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Abstract
Value Stream Mapping is a common and widely used method of industrial engineering. It creates a comprehensive overview of the possibilities of improving the production flow of the company as a whole and eliminates the introduction of incremental measures that would reduce the flexibility of the system as a whole. This article presents a method for optimizing material and information flows in a production company in the context of the Industry 4.0. The aim of the article is to emphasize the potential of software tools in synergy with the classical tool of lean manufacturing – Value Stream Mapping (VSM). For this purpose, the case study is focused on digital VSM in environment of the simulation software TX Plant Simulation. The transformation of the classical digital approach allows dynamic evaluations based on real discrete simulation of events and a simple evaluation of optimized variants. 30 refs.
(Received in June 2018, accepted in September 2018. This paper was with the authors 2 weeks for 2 revisions.)

Key Words: *Value Stream Mapping, Simulation Software, Discrete Event Simulation, Value Added*

Pages 33-46

AMS: A NEW PLATFORM FOR SYSTEM DESIGN AND SIMULATION

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Abstract
A new platform for event-based simulation is presented in this work based on a new proposed programming language. The platform supports modelling of any system as stages. The resources reside in what the language calls pools. The language supports topology description of the system as connections between stages and pools. It provides flexibility to choose the needed distribution for every stage, the type of data passed from a stage to another and the output statistics at the end of execution. One of the capabilities of this new platform is to optimize resources needed in the system through multiple simulation iterations. Optimization is based on a previously proposed reward system that balances between three satisfaction factors: patient, owner and resource. Accordingly, new resource allocations are suggested for system enhancement. The compiler of the language takes an English-like text and converts it into a Petri net. A case study is presented to improve the main performance measures of an emergency department located in Lebanon: patient length of stay, utilization rates and queues waiting times. 18 refs.
(Received in July 2018, accepted in December 2018. This paper was with the authors 2 weeks for 1 revision.)

Key Words: *Optimization, Petri Nets, Programming Language, Satisfaction Factors, Simulation*

Pages 47-58

USING QUEUING SIMULATION MODEL IN PRODUCTION PROCESS INNOVATIONS

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Abstract
Investment decision dilemmas were since late 60's of previous century interesting for research from the perspective of financial dilemmas, while later, with arising uncertainty and dynamic of business environments, stochastic decisions problems needed more in-depth and complex considerations. High technology flexibility and multiple variation production process with significant losses related to resetting machine on one hand and great investment costs for new technology on the other hand, makes technology investment decisions in contemporary business environment multifarious. In this paper, we are presenting the case of optimizing investment decision dilemma in multiple variation production process. Using a discrete event simulation model we test two alternatives regarding the impact on predefined production indicators: 1) optimal grouping of the different products on an existing machine, 2) additional identical machine and optimal sorting of products between the existing and additional machine. In the paper, we determine indicators that should be monitored in investment decision dilemmas and design simulation model that can be used to calculate aforementioned indicators. 34 refs.
(Received in July 2018, accepted in October 2018. This paper was with the authors 1 month for 1 revision.)

Key Words: *Production Process, Assembly, Optimisation, Innovations, Discrete Event Simulation Model*

Pages 59-71

SIMULATION OF PHOTOGRAMMETRY-BASED 3D DATA ACQUISITION

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Abstract
The paper presents a simulation approach to photogrammetry-based three-dimensional (3D) data acquisition. Photogrammetry requires capturing of series of overlapping photos with certain properties from which 3D reconstruction is later obtained. Scanning a building or a human or jewellery requires different numbers of cameras, setup parameters, spatial orientations, etc. Without precise information on how to effectively take photos, obtaining them can be tedious work without any guarantees that it will provide sufficient 3D reconstruction quality. The proposed simulation approach aims to ease the aforementioned burdens and contributes by improving the process of photogrammetry-based 3D data acquisition. The presented simulator is tested in the context of the development of a 3D scanning system for human body scanning and avatar creation. The experiments confirm that the proposed method leads to an improved quality of 3D object reconstruction in comparison to previous practice in the field of 3D human scanning. Further, it lowers the cost and shortens the time required for the industrial process of construction of 3D scanning systems, thus confirming the value and validity of the presented approach. 28 refs.
(Received in September 2018, accepted in January 2019. This paper was with the authors 2 weeks for 1 revision.)

Key Words: *Simulation Software, 3D Data Acquisition, Photogrammetry, Human Body Scanning, Avatars*

Pages 72-85

ECO-DESIGN OF FIXTURES BASED ON LIFE CYCLE AND COST ASSESSMENT

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Abstract
The paper presents the new model for eco-design of fixtures based on life cycle and cost assessment. Four fixture types with different mechanical and physical properties as well as different manufacturing costs have been evaluated. The life cycle results show that the environmental impact is closely related to the mass of steel needed for fixture manufacture. On the other hand, the fixture with the largest environmental impact had the smallest total fixture cost and vice versa. The results show that it is possible to implement environmental and cost analysis in fixture design process and to enable comparative analysis of fixture constructions by three standpoints, technical, environmental and economic. 34 refs.
(Received in September 2018, accepted in January 2019. This paper was with the authors 1 month for 1 revision.)

Key Words: *Eco-Design, Eco-Efficiency, Fixtures, Life Cycle Assessment*

Pages 86-99

SIMULATION OF CROWD EVACUATION BEHAVIOUR IN OUTDOOR PUBLIC PLACES – A MODEL BASED ON SHANGHAI STAMPEDE

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Abstract
The crowd motion in complex sites is a critical basis of analysing the law of crowd evacuation behaviour. However, few studies comprehensively considered the overall effect of pedestrians and the microscopic features of individuals. To find out the behavioural law of pedestrians in outdoor public places during evacuation, the simulation system proposed in this study utilized the measured geographic data of the Shanghai Bund where a serious stampede accident occurred on December 31, 2014. The behavioural parameters were first established including the pedestrian's shoulder widths and walking speeds. Afterwards, the crowd motion in Shanghai Bund was simulated based on Pathfinder platform. Results show as the following: (1) there exist "walking-along-the-sides effect", "imitation effect" and "non-optimal effect" in the evacuation process; (2) the time of crowd evacuation varies according to physiological characteristics, movement trajectories, and destinations. These conclusions may provide recommendations for crowd evacuation in public places. 26 refs.
(Received in September 2018, accepted in January 2019. This paper was with the authors 1 month for 2 revisions.)

Key Words: *Outdoor Public Places, Crowd Evacuation Effects, Pathfinder, Shanghai Stampede*

Pages 100-111

FORCE TRANSMISSION ANALYSIS OF SLIDING BLOCK-TYPE HYDRAULIC SUPPORT UNDER IMPACT LOADS

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Abstract
In thin coal seams mining, the structure and support performances of traditional hydraulic support are strictly limited by the working environment. The new type sliding block-type hydraulic support is dedicated for thin coal seams mining. In order to comprehensively evaluate the load-bearing performance of this support, this study investigated the force state of key parts under the effect of impact loads. First, the numerical analysis model of the support was built in ADAMS software. Then, under the pressure action of the top plate, six key points on the top surface of the top beam were selected and applied with impact loads. Linear slippage pairs between sliding block and base in the model were set as different friction coefficients. Force changes at different hinge joints under various impact loads were obtained, and the influence of different friction coefficients of the sliding block on force transmission was explored. Results indicate that hinge joints are sensitive to impact loads in different degrees and thus exert dissimilar influences on the friction coefficient of the sliding block. This study is helpful for structural optimization and strength design of sliding block-type support. 18 refs.
(Received in October 2018, accepted in January 2019. This paper was with the authors 1 month for 1 revision.)

Key Words: *Impact Load, Sliding Block, Hinge Joint Force, Friction Coefficient, Hydraulic Support*

Pages 112-124

A CYBER-PHYSICAL SYSTEM FOR SMART FIXTURE MONITORING VIA CLAMPING SIMULATION

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Abstract
This paper presents a cyber-physical fixturing system (CPFS) that provides a new way for smart fixture monitoring in milling processes through cloud based simulation and optimization applications. The purpose of the CPFS is to improve the fixture-workpiece stability and thus to prevent deformations of the machined thin-wall workpiece by controlling the simulated clamping and reaction forces at locators. An equilibrium analysis is employed to model and simulate the behaviour of the fixture-workpiece system with respect to the actual cutting tool position. The simulation is incorporated with an optimization routine to minimize the clamping and locating forces. The smart fixture condition monitoring system is developed by connecting the machine tool to the simulation resources in the fixturing platform which performs instant fixture condition monitoring based on signal processing, cutting force signal feature extraction, fixture layout simulations, clamping forces optimization, simulation of clamping/locating forces and process corrective control actions. A prismatic workpiece with slot milling operation is considered to validate the proposed CPFS system. 32 refs.
(Received in October 2018, accepted in December 2019. This paper was with the authors 1 month for 1 revision.)

Key Words: *End Milling, Fixture Condition, Smart Monitoring, On-Line Simulation, Optimization, Clamping/Locating Forces*

Pages 125-137

IMPROVING THE ORDER PICKING EFFICIENCY BY OPTIMISING THE ORDERS' SEQUENCE

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Abstract
One particular activity that substantially affects the efficiency of material flow within supply chains, and which is located within the distribution centre, is order picking. The performance of an order picking system is typically determined by batching, picking sequence, storage policy, zoning, layout design, picking equipment and design of picking information. The main research problem in this paper was to investigate whether the sequence of order execution can have an effect on the performance of the order picking system. The original bound cavities method has been developed, which defines the sequence of execution of received orders in "pick and pass" systems, where the tendency is to perform zone changes in places where there is a continuity of no items for extraction. The paper shows the total picking time and time saving calculations, as well as benefits of its use, which are proven through simulation models of a zone order picking system with two and three pickers. 24 refs.
(Received in October 2018, accepted in January 2019. This paper was with the authors 1 month for 1 revision.)

Key Words: *Order Picking, Simulation, Logistics, Order Execution, Picking Time*

Pages 138-149

ENERGY-SAVING OPERATION OF MULTISTAGE STOCHASTIC MANUFACTURING SYSTEMS BASED ON FUZZY LOGIC

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Abstract
The energy-saving operation of manufacturing systems is becoming increasingly significant due to the pressures of social sustainability and cost reduction. One method of saving energy in manufacturing systems is reducing the idle times of machines, which are non-value-added activities but consume non-negligible energy. Based on real-time data of manufacturing systems, this paper proposes a fuzzy control method to switch a machine into sleep/off mode when the idle state is about to arise and turn the machine on when production has to be resumed. A basic control module of a manufacturing system is described, considering stochastic failure of machines. The fuzzy rules for energy-saving operation are presented by analysing the buffer levels of machines based on production knowledge. Simulation studies are carried out to validate and illustrate the effectiveness of the method both for serial and parallel manufacturing systems. The proposed fuzzy control method is a simple and preferable way to achieve the energy-saving operation of unreliable manufacturing systems. 30 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Energy-Saving Operation, Fuzzy Logic, Multistage Manufacturing System*

Pages 150-162

GRINDING METHOD, TRAJECTORY PLANNING AND SIMULATION OF A 3 DOF KNEE GRINDING ROBOT

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Abstract
This paper aims to improve the accuracy of robot-assisted grinding in total knee arthroplasty (TKA). For this purpose, a 3 DOF knee grinding robot was designed, combining the merits of series robot and parallel robot. The kinematics equations of the robot were derived by the vector method and the workspace of the robot was identified through Monte-Carlo method. Then, the grinding method of the robot was developed according to the procedure of the TKA. Specifically, the grinding trajectory was planned considering the implant selected for the patient. First, the plane and boundary equations of the implant were determined; then, the femur was ground into the desired shape; after that, the implant was cut off with a ball cutting tool vertically to the depth equal to the row spacing. To validate the trajectory planning method, a simulation analysis was performed on the planned trajectory. The results prove the feasibility and efficiency of the proposed method. The research findings shed new light on the robot-assisted TKA. 15 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Knee Grinding Robot, Kinematics, Workspace, Grinding Method, Trajectory Planning*

Pages 163-174

SCHEDULING OPTIMIZATION OF CLOUD RESOURCE SUPPLY CHAIN THROUGH MULTI-OBJECTIVE PARTICLE SWARM OPTIMIZATION

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Abstract
The cloud manufacturing, a new service-oriented manufacturing mode, has become a hotspot in manufacturing industry. Considering supply chain scheduling optimization as a multi-objective optimization problem, this paper combines the fuzzy correlation entropy (FCE) and particle swarm optimization (PSO) into an FCE-based multi-objective optimization approach, in which the fitness of the FCE coefficient is taken as that of the multi-objective PSO to guide the algorithm evolution. After that, the discrete event simulation of the optimization process was carried out on FlexSim software. The simulation results show that the proposed algorithm outperforms the traditional supply chain scheduling algorithms in stability and effectiveness. The research findings shed new light on the scheduling optimization of cloud resource supply chain. 18 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Cloud Manufacturing, Supply Chain, Multi-Objective Particle Swarm Optimization (PSO), Fuzzy Correlation Entropy (FCE), Discrete Event Simulation*

Pages 175-186

AN IMPROVED GENETIC SIMULATED ANNEALING ALGORITHM FOR STOCHASTIC TWO-SIDED ASSEMBLY LINE BALANCING PROBLEM

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Abstract
Considering the random makespans of assembly jobs, this paper develops a mathematical model of stochastic two-sided assembly line balance problem (STALBP) and designs an improved genetic simulated annealing algorithm (IGSAA) based on priority coding. Firstly, a coding method was proposed based on priority value. Then, the job assembly sequence was derived from the chromosome coding sequence, and the job allocation positions were determined, forming a specific allocation plan. After that, the author designed the corresponding decoding method. To enhance the local search ability of the genetic algorithm (GA), the simulated annealing operation was introduced after the mutation, reversing the individuals in the temporary child population. Next, the superiority of the IGSAA was verified by a set of standard examples, and an actual loader assembly line with normally distributed job makespans was balanced by the proposed algorithm. The research findings provide a valuable reference for the balancing of assembly lines. 17 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Stochastic Two-Sided Assembly Line Balance Problem (STALBP), Improved Genetic Simulated Annealing Algorithm (IGSAA), Makespan, Assembly Job, Previous Job*

Pages 187-196

OPTIMIZATION AND SIMULATION OF JOB-SHOP SUPPLY CHAIN SCHEDULING IN MANUFACTURING ENTERPRISES BASED ON PARTICLE SWARM OPTIMIZATION

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Abstract
The production scheduling of supply chain is the key to the improvement of production efficiency and resource utilization in manufacturing enterprise. For effective scheduling of job-shop production, this paper puts forward a scheduling optimization method for job-shop supply chain based on particle swarm optimization (PSO), and proves that the PSO is feasible and valid to solve production scheduling problems through example analysis. In addition, a simulation system was established based on the intelligent algorithm and Microsoft SQL Server Platform to solve production scheduling problems. The research shows that the PSO can effectively overcome the nonconvergence problem in production scheduling, and rapidly obtain the optimal solution for job-shop scheduling; the PSO outperforms a common genetic algorithm in the convergence to the optimal solution. The research findings provide a valuable theoretical reference for manufacturing enterprises to solve and optimize production scheduling problems. 19 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Job-Shop, Supply Chain, Job-Shop Scheduling, Particle Swarm Optimization (PSO), System Simulation*