Reconstructing individual hand models from motion capture data
Yui Endo, Mitsunori Tada and Masaaki Mochimaru, pages 1-12. DOI: 10.7315/JCDE.2014.001
Abstract
In this paper, we propose a new method of reconstructing the hand models for individuals, which include the link structure models, the homologous skin surface models and the homologous tetrahedral mesh models in a reference posture. As for the link structure model, the local coordinate system related to each link consists of the joint rotation center and the axes of joint rotation, which can be estimated based on the trajectories of optimal markers on the relative skin surface region of the subject obtained from the motion capture system. The skin surface model is defined as a three-dimensional triangular mesh, obtained by deforming a template mesh so as to fit the land-mark vertices to the relative marker positions obtained motion capture system. In this process, anatomical dimensions for the subject, manually measured by a caliper, are also used as the deformation constraints.
Key Words
Digital human modeling; Digital hand; Motion capture; Joint center estimation

As-built modeling of piping system from terrestrial laser-scanned point clouds using normal-based region growing
Kazuaki Kawashima, Satoshi Kanai and Hiroaki Date, pages 13-26. DOI: 10.7315/JCDE.2014.002
Abstract
Recently, renovations of plant equipment have been more frequent because of the shortened lifespans of the products, and as-built models from large-scale laser-scanned data is expected to streamline rebuilding processes. However, the laser-scanned data of an existing plant has an enormous amount of points, captures intricate objects, and includes a high noise level, so the manual reconstruction of a 3D model is very time-consuming and costly. Among plant equipment, piping systems account for the greatest proportion. Therefore, the purpose of this research was to propose an algorithm which could automatically recognize a piping system from the terrestrial laser-scanned data of plant equipment. The straight portion of pipes, connecting parts, and connection relationship of the piping system can be recognized in this algorithm. Normal-based region growing and cylinder surface fitting can extract all possible locations of pipes, including straight pipes, elbows, and junctions. Tracing the axes of a piping system enables the recognition of the positions of these elements and their connection relationship. Using only point clouds, the recognition algorithm can be performed in a fully automatic way. The algorithm was applied to large-scale scanned data of an oil rig and a chemical plant. Recognition rates of about 86%, 88%, and 71% were achieved straight pipes, elbows, and junctions, respectively.
Key Words
Laser scanning; Object recognition; As-built model; Piping system; Point clouds

Parametric surface and properties defined on parallelogrammic domain
Shuqian Fan, Jinsong Zou and Mingquan Shi, pages 27-36. DOI: 10.7315/JCDE.2014.003
Abstract
Similar to the essential components of many mechanical systems, the geometrical properties of the teeth of spiral bevel gears greatly influence the kinematic and dynamic behaviors of mechanical systems. Logarithmic spiral bevel gears show a unique advantage in transmission due to their constant spiral angle property. However, a mathematical model suitable for accurate digital modeling, differential geometrical characteristics, and related contact analysis methods for tooth surfaces have not been deeply investigated, since such gears are not convenient in traditional cutting manufacturing in the gear industry. Accurate mathematical modeling of the tooth surface geometry for logarithmic spiral bevel gears is developed in this study, based on the basic gearing kinematics and spherical involute geometry along with the tangent planes geometry; actually, the tooth surface is a parametric surface defined on a parallelogrammic domain. Equivalence proof of the tooth surface geometry is then given in order to greatly simplify the mathematical model. As major factors affecting the lubrication, surface fatigue, contact stress, wear, and manufacturability of gear teeth, the differential geometrical characteristics of the tooth surface are summarized using classical fundamental forms. By using the geometrical properties mentioned, manufacturability (and its limitation in logarithmic spiral bevel gears) is analyzed using precision forging and multi-axis freeform milling, rather than classical cradletype machine tool based milling or hobbing. Geometry and manufacturability analysis results show that logarithmic spiral gears have many application advantages, but many urgent issues such as contact tooth analysis for precision plastic forming and multi-axis freeform milling also need to be solved in a further study.
Key Words
Spiral bevel gear; Mathematical modeling; Parametric surface; Geometrical characteristics; Manufacturability
• Development of integrated design methodology for various types of product–service systems
  Tuan A. Tran and Joon Y. Park, pages 37-47, DOI: 10.7315/JCDE.2014.004
  
  Abstract
  We propose a new generic design methodology for different types of PSS. Product – Service System (PSS) has received much attention recently from academia and industry because of its benefits. PSS can provide customers values and functionalities, as well as physical products, to fulfill economic, social and environmental goals. Many methodologies have been proposed for designing PSSs. Most of the existing methodologies are domain specific and were proposed to solve specific problems in certain projects. Some methodologies are generic but they provide neither guideline to practitioners and designers nor reflect the differences in various PSS types. As a generic approach to guide practitioners and designers in designing PSS effectively, the proposed methodology also takes into account user involvement, business model and organizational structure. The proposed methodology is demonstrated through design examples of different types of PSSs.
  
  Key Words
  PSS; Product service system; Design methodology; Product service integration; Integrated design methodology

• Automatic detection of the optimal ejecting direction based on a discrete Gauss map
  Masatomo Inui, Hidekazu Kamei and Nobuyuki Umezu, pages 48-54. DOI: 10.7315/JCDE.2014.005
  
  Abstract
  In this paper, the authors propose a system for assisting mold designers of plastic parts. With a CAD model of a part, the system automatically determines the optimal ejecting direction of the part with minimum undercuts. Since plastic parts are generally very thin, many rib features are placed on the inner side of the part to give sufficient structural strength. Our system extracts the rib features from the CAD model of the part, and determines the possible ejecting directions based on the geometric properties of the features. The system then selects the optimal direction with minimum undercuts. Possible ejecting directions are represented as discrete points on a Gauss map. Our new point distribution method for the Gauss map is based on the concept of the architectural geodesic dome. A hierarchical structure is also introduced in the point distribution, with a higher level.
  
  Key Words
  Ejecting direction; Undercut detection; Injection molding; Feature recognition; Concurrent engineering; CAD

• Novel computational approaches characterizing knee physiotherapy
  Wangdo Kim, António P. Veloso, Duarte Araújo and Sean S. Kohles, pages 55-66. DOI:10.7315/JCDE.2014.006
  
  Abstract
  A knee joint’s longevity depends on the proper integration of structural components in an axial alignment. If just one of the components is abnormally off-axis, the biomechanical system fails, resulting in arthritis. The complexity of various failures in the knee joint has led orthopedic surgeons to select total knee replacement as a primary treatment. In many cases, this means sacrificing much of an otherwise normal joint. Here, we review novel computational approaches to describe knee physiotherapy by introducing a new dimension of foot loading to the knee axis alignment producing an improved functional status of the patient. New physiotherapeutic applications are then possible by aligning foot loading with the functional axis of the knee joint during the treatment of patients with osteoarthritis.
  
  Key Words
  Instantaneous axes of the knee (IAK); Cylindroidal coordinates; Perception-action coupling manifold; Gibson

• Development of educational software for beam loading analysis using pen-based user interfaces
  Yong S. Suh, pages 67-77. DOI: 10.7315/JCDE.2014.007
  
  Abstract
  Most engineering software tools use typical menu-based user interfaces, and they may not be suitable for learning tools because the solution processes are hidden and students can only see the results. An educational tool for simple beam analyses is developed using a pen-based user interface with a computer so students can write and sketch by hand. The geometry of beam sections is sketched, and a shape matching technique is used to recognize the sketch. Various beam loads are added by sketching gestures or writing singularity functions. Students sketch the distributions of the loadings by sketching the graphs, and they are automatically checked and the system provides aids in grading the graphs. Students receive interactive graphical feedback for better learning experiences while they are working on solving the problems.
  
  Key Words
  Beam loading analysis; Pen-based interface; Education software; Shape matching
Volume 1, No. 2

• Voronoi diagrams, quasi-triangulations, and beta-complexes for disks in $\mathbb{R}^2$: the theory and implementation in BetaConcept.
i
Jae-Kwan Kim, Youngsong Cho, Donguk Kim and Deok-Soo Kim, pages 79-87. DOI:10.7315/JCDE.2014.008

Abstract

Voronoi diagrams are powerful for solving spatial problems among particles and have been used in many disciplines of science and engineering. In particular, the Voronoi diagram of three-dimensional spheres, also called the additively-weighted Voronoi diagram, has proven its powerful capabilities for solving the spatial reasoning problems for the arrangement of atoms in both molecular biology and material sciences. In order to solve application problems, the dual structure, called the quasi-triangulation, and its derivative structure, called the beta-complex, are frequently used with the Voronoi diagram itself. However, the Voronoi diagram, the quasi-triangulation, and the beta-complexes are sometimes regarded as somewhat difficult for ordinary users to understand. This paper presents the twodimensional counterparts of their definitions and introduce the BetaConcept program which implements the theory so that users can easily learn the powerful concept and capabilities of these constructs in a plane. The BetaConcept program was implemented in the standard C++ language with MFC and OpenGL and freely available at Voronoi Diagram Research Center (http://voronoi.hanyang.ac.kr).

Key Words

Voronoi diagram of disks; Additively-weighted Voronoi diagram; Quasi-triangulations; Beta-complexes; Beta-shapes; Spherical atoms; GUI program

• Quadrilateral mesh fitting that preserves sharp features based on multi-normals for Laplacian energy,

Yusuke Imai, Hiroyuki Hiraoka and Hiroshi Kawaharada, pages 88-95. DOI: 10.7315/JCDE.2014.009

Abstract

Because of the cost of performance testing using actual products is expensive, manufacturers use lower-cost computer-aided design simulations for this function. In this paper, we propose using hexahedral meshes, which are more accurate than tetrahedral meshes, for finite element analysis. We propose automatic hexahedral mesh generation with sharp features to precisely represent the corresponding features of a target shape. Our hexahedral mesh is generated using a voxel-based algorithm. In our previous works, we fit the surface of the voxels to the target surface using Laplacian energy minimization. We used normal vectors in the fitting to preserve sharp features. However, this method could not represent concave sharp features precisely. In this proposal, we improve our previous Laplacian energy minimization by adding a term that depends on multi-normal vectors instead of using normal vectors. Furthermore, we accentuate a convex/concave surface subset to represent concave sharp features.

Key Words

CAD model; Hexahedral mesh; Sharp feature; Fitting algorithm; Multi-normalvectors

• Direct construction of a four-dimensional mesh model from a three-dimensional object with continuous rigid body movement,

Ikuru Otomo, Masahiko Onosato and Fumiki Tanaka, pages 96-102. DOI: 10.7315/JCDE.2014.010

Abstract

In the field of design and manufacturing, there are many problems with managing dynamic states of three-dimensional (3D) objects. In order to solve these problems, the four-dimensional (4D) mesh model and its modeling system have been proposed. The 4D mesh model is defined as a 4D object model that is bounded by tetrahedral cells, and can represent spatio-temporal changes of a 3D object continuously. The 4D mesh model helps to solve dynamic problems of 3D models as geometric problems. However, the construction of the 4D mesh model is limited on the time-series 3D voxel data based method. This method is memory-hogging and requires much computing time. In this research, we propose a new method of constructing the 4D mesh model that derives from the 3D mesh model with continuous rigid body movement. This method is realized by making a swept shape of a 3D mesh model in the fourth dimension and its tetrahedralization. Here, the rigid body movement is a screwed movement, which is a combination of translational and rotational movement.

Key Words

Four-dimensional mesh model; Three-dimensional mesh model; Fourth dimension; Rigid body movement

• A multi-user selective undo/redo approach for collaborative CAD systems,

Yuan Cheng, Fazhi He, Bin Xu, Soonhung Han, Xiantao Cai and Yilin Chen, pages 103-115. DOI: 10.7315/JCDE.2014.011

Abstract

The engineering design process is a creative process, and the designers must repeatedly apply Undo/Redo operations to modify CAD models to explore new solutions. Undo/Redo has become one of most important functions in interactive graphics and CAD systems. Undo/Redo in a collaborative CAD system is also very helpful for collaborative awareness among a group of cooperative designers to eliminate misunderstanding and to recover from design error. However, Undo/Redo in a collaborative CAD system is much more
Abstract

Youn-Kyoung Joung and Sang Do Noh, pages 140-151. DOI: 10.7315/JCDE.2014.014

Intelligent 3D packing using a grouping algorithm for automotive container engineering,
Youn-Kyoung Joung and Sang Do Noh, pages 140-151. DOI: 10.7315/JCDE.2014.014

Storing, and the loading and unloading of materials at production sites in the manufacturing sector for mass production is a critical problem that affects various aspects: the layout of the factory, line-side space, logistics, workers' work paths and ease of work, automatic procurement of components, and transfer and supply. Traditionally, the nesting problem has been an issue to improve the efficiency of raw materials; further, research into mainly 2D optimization has progressed. Also, recently, research into the expanded usage of 3D models to implement packing optimization has been actively carried out. Nevertheless, packing algorithms using 3D models are not widely used in practice, due to the large decrease in efficiency, owing to the complexity and excessive computational time. In this paper, the problem of efficiently loading and unloading freeform 3D objects into a given container has been solved, by considering the 3D form, ease of loading and unloading, and packing density. For this reason, a Group Packing Approach for workers has been developed, by using analyzed truck packing work patterns and Group Technology, which is to enhance the efficiency of storage in the manufacturing sector. Also, an algorithm for 3D packing has been developed, and implemented in a commercial 3D CAD modeling system. The 3D packing method consists of a grouping algorithm, a

Key Words
Undo/Redo; Collaborative CAD; Intention preservation; Configuration management

Abstract

Kwanghee Ko and Takis Sakkalis, pages 116-127. DOI: 10.7315/JCDE.2014.012

Characterization of machining quality attributes based on spindle probe, coordinate measuring machine, and surface roughness data,
Tzu-Liang Bill Tseng and Yongjin James Kwon, pages 128-139. DOI: 10.7315/JCDE.2014.013

Orthogonal projection of points in CAD/CAM applications: an overview,
Kwanghee Ko and Takis Sakkalis, pages 116-127. DOI: 10.7315/JCDE.2014.012

Abstract

Machining quality; Coordinate measuring machine (CCM); Design of experiment (DOE); Vertical machining center (VMC); Dimensional accuracy; Surface roughness

Orthogonal projection; Point projection; Curve projection; Registration; Minimum distance; Directed projection

Orthogonal projection of points onto conics along with reviews on orthogonal projection of points onto surfaces in implicit and parametric form. Except for conics, computation methods are classified into two groups based on the core approaches: iterative and subdivision based. An extension of orthogonal projection of points to orthogonal projection of curves onto surfaces is briefly explored. Next, the discussion continues toward orthogonal projection of points onto point clouds, which spawns a different branch of algorithms in the context of orthogonal projection. The paper concludes with comments on guidance for an appropriate choice of methods for various applications.

Key Words
Orthonormal projection; Point projection; Curve projection; Registration; Minimum distance; Directed projection

Abstract

This study investigates the effects of machining parameters as they relate to the quality characteristics of machined features. Two most important quality characteristics are set as the dimensional accuracy and the surface roughness. Before any newly acquired machine tool is put to use for production, it is important to test the machine in a systematic way to find out how different parameter settings affect machining quality. The empirical verification was made by conducting a Design of Experiment (DOE) with 3 levels and 3 factors on a state-of-the-art Cincinnati Hawk Arrow 750 Vertical Machining Center (VMC). Data analysis revealed that the significant factor was the Hardness of the material and the significant interaction effect was the Hardness + Feed for dimensional accuracy, while the significant factor was Speed for surface roughness. Since the equally important thing is the capability of the instruments from which the quality characteristics are being measured, a comparison was made between the VMC touch probe readings and the measurements from a Mitutoyo coordinate measuring machine (CMM) on bore diameters. A machine mounted touch probe has gained a wide acceptance in recent years, as it is more suitable for the modern manufacturing environment. The data vindicated that the VMC touch probe has the capability that is suitable for the production environment. The test results can be incorporated in the process plan to help maintain the machining quality in the subsequent runs.

Key Words
Machining quality; Coordinate measuring machine (CCM); Design of experiment (DOE); Vertical machining center (VMC); Dimensional accuracy; Surface roughness

Orthogonal projection of points in CAD/CAM applications: an overview,
sequencing algorithm, an orientating algorithm, and a loading algorithm. These algorithms concern the respective aspects: the packing order, orientation decisions of parts, collision checking among parts and processing, position decisions of parts, efficiency verification, and loading and unloading simulation. Storage optimization and examination of the ease of loading and unloading are possible, and various kinds of engineering analysis, such as work performance analysis, are facilitated through the intelligent 3D packing method developed in this paper, by using the results of the 3D model.

Key Words
Packing, 3D CAD model, Grouping algorithm, Container engineering

Volume 1, No. 3

• An alternative method for smartphone input using AR markers,
  Yuna Kang and Soonhung Han, pages 153-160, DOI: 10.12989/cde.2014.1.3.015

Abstract
As smartphones came into wide use recently, it has become increasingly popular not only among young people, but among middleaged people as well. Most smartphones adopt capacitive full touch screen, so touch commands are made by fingers unlike the PDAs in the past that use touch pens. In this case, a significant portion of the smartphone’s screen is blocked by the finger so it is impossible to see the screens around the finger touching the screen; this causes difficulties in making precise inputs. To solve this problem, this research proposes a method of using simple AR markers to improve the interface of smartphones. A marker is placed in front of the smartphone camera. Then, the camera image of the marker is analyzed to determine the position of the marker as the position of the mouse cursor. This method can enable click, double-click, drag-and-drop used in PCs as well as touch, slide, long-touch-input in smartphones. Through this research, smartphone inputs can be made more precise and simple, and show the possibility of the application of a new concept of smartphone interface.

Key Words
Smartphone; Augmented reality (AR); Marker; Interface; Human-computer interaction (HCI)

• A comparison of three design tree based search algorithms for the detection of engineering parts constructed with CATIA V5 in large databases,
  Robin Roj, pages 161-172. DOI: 10.7315/JCDE.2014.016

Abstract
This paper presents three different search engines for the detection of CAD-parts in large databases. The analysis of the contained information is performed by the export of the data that is stored in the structure trees of the CAD-models. A preparation program generates one XML-file for every model, which in addition to including the data of the structure tree, also owns certain physical properties of each part. The first search engine specializes in the discovery of standard parts, like screws or washers. The second program uses certain user input as search parameters, and therefore has the ability to perform personalized queries. The third one compares one given reference part with all parts in the database, and locates files that are identical, or similar to, the reference part. All approaches run automatically, and have the analysis of the structure tree in common. Files constructed with CATIA V5, and search engines written with Python have been used for the implementation. The paper also includes a short comparison of the advantages and disadvantages of each program, as well as a performance test.

Key Words
CAD; CATIA V5; Classification; Database; Dat mining; Design tree; Feature recognition; Knowledge Discovery; Python; Search engine

• Development of a simulation method for the subsea production system,
  Jong Hun Woo, Jong Ho Nam and Kwang Hee Ko, pages 173-186. DOI: 10.7315/JCDE.2014.017

Abstract
The failure of a subsea production plant could induce fatal hazards and enormous loss to human lives, environments, and properties. Thus, for securing integrated design safety, core source technologies include subsea system integration that has high safety and reliability and a technique for the subsea flow assurance of subsea production plant and subsea pipeline network fluids. The evaluation of subsea flow assurance needs to be performed considering the performance of a subsea production plant, reservoir production characteristics, and the flow characteristics of multiphase fluids. A subsea production plant is installed in the deep sea, and thus is exposed to a highpressure/low-temperature environment. Accordingly, hydrates could be formed inside a subsea production plant or within a subsea pipeline network. These hydrates could induce serious damages by blocking the flow of subsea fluids. In this study, a simulation technology, which can visualize the system configuration of subsea production processes and can simulate stable flow of fluids, was introduced. Most existing subsea simulations have performed the analysis of dynamic behaviors for the installation of subsea facilities or the flow analysis of multiphase flow within pipes. The above studies occupy extensive research areas of the subsea field. In this study, with the goal of simulating the configuration of an entire deep sea production system compared to existing studies, a DES-based simulation technology, which can logically simulate oil production processes in the deep sea, was analyzed, and an implementation example of a simplified case was introduced.
Abstract

One of the hottest challenges in automotive industry is related to weight reduction in sheet metal forming processes, in order to produce a high quality metal part with minimal material cost. Stamping is the most widely used sheet metal forming process; but its implementation comes with several fabrication flaws such as springback and failure. A global and simple approach to circumvent these unwanted process drawbacks consists in optimizing the initial blank shape with innovative methods. The aim of this paper is to introduce an efficient methodology to deal with complex, computationally expensive multicriteria optimization problems. Our approach is based on the combination of methods to capture the Pareto Front, approximate criteria (to save computational costs) and global optimizers. To illustrate the efficiency, we consider the stamping of an industrial workpiece as test-case. Our approach is applied to the springback and failure criteria. To optimize these two criteria, a global optimization algorithm was chosen. It is the Simulated Annealing algorithm hybridized with the Simultaneous Perturbation Stochastic Approximation in order to gain in time and in precision. The multicriteria problems amounts to the capture of the Pareto Front associated to the two criteria. Normal Boundary Intersection and Normalized Normal Constraint Method are considered for generating a set of Pareto-optimal solutions with the characteristic of uniform distribution of front points. The computational results are compared to those obtained with the well-known Non-dominated Sorting Genetic Algorithm II. The results show that our proposed approach is efficient to deal with the multicriteria shape optimization of highly non-linear mechanical systems.

Key Words
Sheet metal forming; Initial blank shape; Springback; Failure; Multi-objective optimization

Efficient point cloud data processing in shipbuilding: Reformative component extraction method and registration method.

Abstract

To survive in the current shipbuilding industry, it is of vital importance for shipyards to have the ship components’ accuracy evaluated efficiently during most of the manufacturing steps. Evaluating components’ accuracy by comparing each component’s point cloud data scanned by laser scanners and the ship’s design data formatted in CAD cannot be processed efficiently when (1) extract components from point cloud data include irregular obstacles endogenously, or when (2) registration of the two data sets have no clear direction setting. This paper presents reformative point cloud data processing methods to solve these problems. K-d tree construction of the point cloud data fastens a neighbor searching of each point. Region growing method performed on the neighbor points of the seed point extracts the continuous part of the component, while curved surface fitting and B-spline curved line fitting at the edge of the continuous part recognize the neighbor domains of the same component divided by obstacles’ shadows. The ICP (Iterative Closest Point) algorithm conducts a registration of the two sets of data after the proper registration’s direction is decided by principal component analysis. By experiments conducted at the shipyard, 200 curved shell plates are extracted from the scanned point cloud data, and registrations are conducted between them and the designed CAD data using the proposed methods for an accuracy evaluation. Results show that the methods proposed in this paper support the accuracy evaluation targeted point cloud data processing efficiently in...
• Survey on the virtual commissioning of manufacturing systems,
  Chi G. Lee and Sang C. Park, pages 213-222. DOI: 10.7315/JCDE.2014.021
  **Abstract**
  This paper reviews and identifies issues in the application of virtual commissioning technology for automated manufacturing systems. While the real commissioning of a manufacturing system involves a real plant system and a real controller, the virtual commissioning deals with a virtual plant model and a real controller. The expected benefits of virtual commissioning are the reduction of debugging and correction efforts during the subsequent real commissioning stage. However, it requires a virtual plant model and hence still requires significant amount time and efforts. Two main issues are identified, the physical model construction of a virtual device, and the logical model construction of a virtual device. This paper reviews the current literature related to the two issues and proposes future research directions to achieve the full utilization of virtual commissioning technology.
  **Key Words**
  Virtual commissioning; Virtual plant model; Virtual device model; DEVS; PLC simulation

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• Hue-assisted automatic registration of color point clouds,
  Hao Men and Kishore Pochiraju, pages 223-232. DOI: 10.7315/JCDE.2014.022
  **Abstract**
  This paper describes a variant of the extended Gaussian image-based registration algorithm for point clouds with surface color information. The method correlates the distributions of surface normals for rotational alignment and grid occupancy for translational alignment with hue filters applied during the construction of surface normal histograms and occupancy grids. In this method, the size of the point cloud is reduced with a hue-based down sampling that is independent of the point sample density or local geometry. Experimental results show that use of the hue filters increases the registration speed and improves the registration accuracy. Coarse rigid transformations determined in this step enable fine alignment with dense, unfiltered point clouds or using Iterative Common Point (ICP) alignment techniques.
  **Key Words**
  Computational geometry; Mesh processing; Reverse engineering; Building information modeling (BIM); Computer graphics

• Discrete event simulation of Maglev transport considering traffic waves,
  Moo Hyun Cha and Duhwan Mun, pages 233-242. DOI: 10.7315/JCDE.2014.023
  **Abstract**
  A magnetically levitated vehicle (Maglev) system is under commercialization as a new transportation system in Korea. The Maglev is operated by an unmanned automatic control system. Therefore, the plan of train operation should be carefully established and validated in advance. In general, when making a train operation plan, statistically predicted traffic data is used. However, a traffic wave often occurs in real train service, and demand-driven simulation technology is required to review a train operation plan and service quality considering traffic waves. We propose a method and model to simulate Maglev operation considering continuous demand changes. For this purpose, we employed a discrete event model that is suitable for modeling the behavior of railway passenger transportation. We modeled the system hierarchically using discrete event system specification (DEVS) formalism. In addition, through implementation and an experiment using the DEVSim++ simulation environment, we tested the feasibility of the proposed model. Our experimental results also verified that our demand-driven simulation technology can be used for a priori review of train operation plans and strategies.
  **Key Words**
  Discrete event simulation; Train operation simulation; Traffic wave; Discrete event system specification

• Design of controller for mobile robot in welding process of shipbuilding engineering,
  Namkug Ku, Sol Ha2 and Myung-Il Roh, pages 243-255. DOI: 10.7315/JCDE.2014.024
  **Abstract**
  The present study describes the development of control hardware and software for a mobile welding robot. This robot is able to move and perform welding tasks in a double hull structure. The control hardware consists of a main controller and a welding machine controller. Control software consists of four layers. Each layer consists of modules. Suitable combinations of modules enable the control software to perform the required tasks. Control software is developed using C programming under QNX operating system. For the modularization architecture of control software, we designed control software with four layers: Task Manager, Task Planner, Actions for Task, and Task Executer. The embedded controller and control software was applied to the mobile welding robot for successful execution of the required tasks. For evaluate this imbedded controller and control software, the field tests are conducted, it is confirmed that the developed imbedded controller of mobile welding robot for shipyard is well designed and implemented.
  **Key Words**
  Mobile welding robot; Modularized control architecture; Embedded controller; Industrial automation
**Optimization of injection molding process for car fender in consideration of energy efficiency and product quality,**
Hong Seok Park* and Trung Thanh Nguyen, pages 256-265. DOI: 10.7315/JCDE.2014.025

**Abstract**
Energy efficiency is an essential consideration in sustainable manufacturing. This study presents the car fender-based injection molding process optimization that aims to resolve the trade-off between energy consumption and product quality at the same time in which process parameters are optimized variables. The process is specially optimized by applying response surface methodology and using non-dominated sorting genetic algorithm II (NSGA II) in order to resolve multi-object optimization problems. To reduce computational cost and time in the problem-solving procedure, the combination of CAE-integration tools is employed. Based on the Pareto diagram, an appropriate solution is derived out to obtain optimal parameters. The optimization results show that the proposed approach can help effectively engineers in identifying optimal process parameters and achieving competitive advantages of energy consumption and product quality. In addition, the engineering analysis that can be employed to conduct holistic optimization of the injection molding process in order to increase energy efficiency and product quality was also mentioned in this paper.

**Key Words**
Multi-objective optimization; Injection molding process; Energy efficiency; Plastic car fender

**Naval ship’s susceptibility assessment by the probabilistic density function,**
Kwang Sik Kim, Se Yun Hwang and Jang Hyun Lee, pages 266-271. DOI: 10.7315/JCDE.2014.026

**Abstract**
The survivability of the naval ship is the capability of a warship to avoid or withstand a hostile environment. The survivability of the naval ship assessed by three categories (susceptibility, vulnerability and recoverability). The magnitude of survivability of a warship encountering with threat is dependent upon the attributes of detection equipment and weapon system. In this paper, as a part of a naval ship’s survivability analysis, an assessment process model for the ship’s susceptibility analysis technique is developed. Naval ship’s survivability emphasizing the susceptibility is assessed by the probability of detection, and the probability of hit. Considering the radar cross section (RCS), the assessment procedure for the susceptibility is described. It’s emphasizing the simplified calculation model based on the probability density function for probability of hit. Assuming the probability of hit given a both single-hit and multiple-hit, the susceptibility is assessed for a RCS and the hit probability for a rectangular target is applied for a given threat.

**Key Words**
Survivability; Vulnerability; RCS (Radar Cross Section); Probability of hit; Probability of detection

**Interactive prostate shape reconstruction from 3D TRUS images,**
Tomotake Furuhata, Inho Song, Hong Zhang, Yoed Rabin and Kenji Shimada, pages 272-288. DOI:10.7315/JCDE.2014.027

**Abstract**
This paper presents a two-step, semi-automated method for reconstructing a three-dimensional (3D) shape of the prostate from a 3D transrectal ultrasound (TRUS) image. While the method has been developed for prostate ultrasound imaging, it can potentially be applicable to any other organ of the body and other imaging modalities. The proposed method takes as input a 3D TRUS image and generates a watertight 3D surface model of the prostate. In the first step, the system lets the user visualize and navigate through the input volumetric image by displaying cross sectional views oriented in arbitrary directions. The user then draws partial/full contours on selected cross sectional views. In the second step, the method automatically generates a watertight 3D surface of the prostate by fitting a deformable spherical template to the set of user-specified contours. Since the method allows the user to select the best cross-sectional directions and draw only clearly recognizable partial or full contours, the user can avoid time-consuming and inaccurate guesswork on where prostate contours are located. By avoiding the usage of noisy, incomprehensible portions of the TRUS image, the proposed method yields more accurate prostate shapes than conventional methods that demand complete cross-sectional contours selected manually, or automatically using an image processing tool. Our experiments confirmed that a 3D watertight surface of the prostate can be generated within five minutes even from a volumetric image with a high level of speckles and shadow noises.

**Key Words**
Shape reconstruction; Prostate; TRUS; Ultrasound; Image processing

**Tangible AR interaction based on fingertip touch using small-sized non-square markers,**

**Abstract**
Although big-sized markers are good for accurate marker recognition and tracking, they are easily occluded by other objects and deteriorate natural visualization and level of immersion during user interaction in AR environments. In this paper, we propose an approach to exploiting the use of rectangular markers to support tangible AR interaction based on fingertip touch using small-sized markers. It basically adjusts the length, width, and interior area of rectangular markers to make them more suitably fit to longish objects like fingers. It also utilizes convex polygons to resolve the partial occlusion of a marker and property enlarges the pattern area of a marker while adjusting its size without deteriorating the quality of marker detection. We obtained encouraging results from users that the approach can provide better natural visualization and higher level of immersion, and be accurate and tangible enough to support a pseudo feeling of touching virtual products with human hands or fingertips during design evaluation of digital handheld products.

**Key Words**
Augmented reality; Tangible interaction; Fingertip touch; Small-sized markers; Rectangular markers
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• **Adaptive B-spline volume representation of measured BRDF data for photorealistic rendering**
  Hyunjun Park* and Joo-Haeng Lee, pages 1-15. DOI: http://dx.doi.org/10.1016/j.jcde.2014.11.001

  **Abstract**
  Measured bidirectional reflectance distribution function (BRDF) data have been used to represent complex interaction between lights and surface materials for photorealistic rendering. However, their massive size makes it hard to adopt them in practical rendering applications. In this paper, we propose an adaptive method for B-spline volume representation of measured BRDF data. It basically performs approximate B-spline volume lofting, which decomposes the problem into three sub-problems of multiple B-spline curve fitting along u-, v-, and w-parametric directions. Especially, it makes the efficient use of knots in the multiple B-spline curve fitting and thereby accomplishes adaptive knot placement along each parametric direction of a resulting B-spline volume. The proposed method is quite useful to realize efficient data reduction while smoothing out the noises and keeping the overall features of BRDF data well. By applying the B-spline volume models of real materials for rendering, we show that the B-spline volume models are effective in preserving the features of material appearance and are suitable for representing BRDF data.

  **Key Words**
  B-spline volume; Measured BRDF; Approximate volume lofting; Adaptive knot placement; Data reduction

• **Open BIM-based quantity take-off system for schematic estimation of building frame in early design stage**

  **Abstract**
  Since construction projects are large and complex, it is especially important to provide concurrent construction process to BIM models with construction automation. In particular, the schematic Quantity Take-Off (QTO) estimation on the BIM models is a strategy, which can be used to assist decision making in just minutes, because 70–80% of construction costs are determined by designers' decisions in the early design stage [1]. This paper suggests a QTO process and a QTO prototype system within the building frame of Open BIM to improve the low reliability of estimation in the early design stage. The research consists of the following four steps: (1) analyzing Level of Detail (LoD) at the early design stage to apply to the QTO process and system, (2) BIM modeling for Open BIM based QTO, (3) checking the quality of the BIM model based on the checklist for applying to QTO and improving constructability, and (4) developing and verifying a QTO prototype system. The proposed QTO system is useful for improving the reliability of schematic estimation through decreasing risk factors and shortening time required.

  **Key Words**
  Industry Foundation Classes (IFC); Level of Detail (LoD); Open BIM (Building Information Modeling); Schematic estimation; Quantity Take-off (QTO)

• **A method for image-based shadow interaction with virtual objects**
  Hyunwoo Ha and Kwanghee Ko*, pages 26-37. DOI: http://dx.doi.org/10.1016/j.jcde.2014.11.003

  **Abstract**
  A lot of researchers have been investigating interactive portable projection systems such as a mini-projector. In addition, in exhibition halls and museums, there is a trend toward using interactive projection systems to make viewing more exciting and impressive. They can also be applied in the field of art, for example, in creating shadow plays. The key idea of the interactive portable projection systems is to recognize the user's gesture in real-time. In this paper, a vision-based shadow gesture recognition method is proposed for interactive projection systems. The gesture recognition method is based on the screen image obtained by a single web camera. The method separates only the shadow area by combining the binary image with an input image using a learning algorithm that isolates the background from the input image. The region of interest is recognized with labeling the shadow of separated regions, and then hand shadows are isolated using the defect, convex hull, and moment of each region. To distinguish hand gestures, Hu's invariant moment method is used. An optical flow algorithm is used for tracking the fingertip. Using this method, a few interactive applications are developed, which are presented in this paper.

  **Key Words**
  Shadow interaction; Hu moment; Gesture recognition; Interactive UI; Image processing

• **Spatial augmented reality for product appearance design evaluation**
  DOI: http://dx.doi.org/10.1016/j.jcde.2014.11.004

  **Abstract**
  Augmented reality based on projection, called “Spatial Augmented Reality (SAR),” is a new technology that can produce immersive contents by overlapping virtuality and real-world environment. It has been paid attention as the next generation digital contents in media art and human-computer interaction (HCI). In this paper, we present a new methodology to evaluate the product appearance design more intuitively by means of SAR technique. The proposed method first projects the high-quality rendered image considering the optical property of materials onto the mockup of a product. We also conduct a projector-camera calibration to compensate a color distortion according to a projector, a projection surface and
environment lighting. The design evaluation methodology we propose offers more flexible and intuitive evaluation environment to a designer and user (evaluator) than previous methods that are performed via a digital display. At the end of this research, we have conducted a case study for designing and evaluating appearance design of an automobile.

Key Words
Computer-aided appearance design; Methodology on design evaluation; Projection mapping; Spatial augmented reality; Realistic material modeling

**• AR based ornament design system for 3D printing**
Hiroshi Aoki, Jun Mitani* and Yoshihiro Kanamori and Yukio Fukui, pages 47-54. DOI: http://dx.doi.org/10.1016/j.jcde.2014.11.005

Abstract
In recent years, 3D printers have become popular as a means of outputting geometries designed on CAD or 3D graphics systems. However, the complex user interfaces of standard 3D software can make it difficult for ordinary consumers to design their own objects. Furthermore, models designed on 3D graphics software often have geometrical problems that make them impossible to output on a 3D printer. We propose a novel AR (augmented reality) 3D modeling system with an air-spray like interface. We also propose a new data structure (octet voxel) for representing designed models in such a way that the model is guaranteed to be a complete solid. The target shape is based on a regular polyhedron, and the octet voxel representation is suitable for designing geometrical objects having the same symmetries as the base regular polyhedron. Finally, we conducted a user test and confirmed that users can intuitively design their own ornaments in a short time with a simple user interface.

Key Words
3DCG; Modeling; Augmented reality; 3D printing; Voxel; Octet truss

**• Visualizing sphere-contacting areas on automobile parts for ECE inspection**
Masatomo Inui, Nobuyuki Umezu* and Yuuki Kitamura, pages 55-66. DOI: http://dx.doi.org/10.1016/j.jcde.2014.11.006

Abstract
To satisfy safety regulations of Economic Commission for Europe (ECE), the surface regions of automobile parts must have a sufficient degree of roundness if there is any chance that they could contact a sphere of 50.0 mm radius (exterior parts) or 82.5 mm radius (interior parts). In this paper, a new offset-based method is developed to automatically detect the possible sphere-contacting shape of such parts. A polyhedral model that precisely approximates the part shape is given as input, and the offset shape of the model is obtained as the Boolean union of the expanded shapes of all surface triangles. We adopt a triple-dexel representation of the 3D model to enable stable and precise Boolean union computations. To accelerate the dextel operations in these Boolean computations, a new parallel processing method with a pseudo-list structure and axis-aligned bounding box is developed. The possible sphere-contacting shape of the part surface is then extracted from the offset shape as a set of points or a set of polygons.

Key Words
ECE safety inspection; Automobile part design; Collision detection; Offsetting; GPU

**• An algorithm for estimating surface normal from its boundary curves**
Jisoon Park*, Taewon Kim, Seung-Yeob Baek and Kunwoo Lee, pages 67-72. DOI:http://dx.doi.org/10.1016/j.jcde.2014.11.007

Abstract
Recently, along with the improvements of geometry modeling methods using sketch-based interface, there have been a lot of developments in research about generating surface model from 3D curves. However, surfacing a 3D curve network remains an ambiguous problem due to the lack of geometric information. In this paper, we propose a new algorithm for estimating the normal vectors of the 3D curves which accord closely with user intent. Bending energy is defined by utilizing RMF (Rotation-Minimizing Frame) of 3D curve, and we estimated this minimal energy frame as the one that accords design intent. The proposed algorithm is demonstrated with surface model creation of various curve networks. The algorithm of estimating geometric information in 3D curves which is proposed in this paper can be utilized to extract new information in the sketch-based modeling process. Also, a new framework of 3D modeling can be expected through the fusion between curve network and surface creating algorithm.

Key Words
Computer-aided design; Curve network; Surface modeling; Surface normal estimation
**Interactive lens through smartphones for supporting level-of-detailed views in a public display**

Minseok Kim and Jae Yeol Lee*, pages 73-78. DOI: http://dx.doi.org/10.1016/j.jcde.2014.12.001

**Abstract**

In this paper, we propose a new approach to providing interactive and collaborative lens among multi-users for supporting level-of-detailed views using smartphone. In order to provide smartphone-based lens capability, the locations of smartphones are effectively detected and tracked using Kinect, which provides RGB data and depth data (RGB-D). In particular, human skeleton information is extracted from the Kinect 3D depth data to calculate the smartphone location more efficiently and correctly with respect to the public display and to support head tracking for easy target selection and adaptive view generation. The suggested interactive and collaborative lens using smartphones not only can explore local spaces of the shared display but also can provide various kinds of activities such as LOD viewing and collaborative interaction. Implementation results are given to show the advantage and effectiveness of the proposed approach.

**Key Words**

Smartphone interaction; Kinect; Interactive lens; Head tracking; Shared display; Level-of-detail view generation

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**Robust surface segmentation and edge feature lines extraction from fractured fragments of relics**


**Abstract**

Surface segmentation and edge feature lines extraction from fractured fragments of relics are essential steps for computer assisted restoration of fragmented relics. As these fragments were heavily eroded, it is a challenging work to segment surface and extract edge feature lines. This paper presents a novel method to segment surface and extract edge feature lines from triangular meshes of irregular fractured fragments. Firstly, a rough surface segmentation is accomplished by using a clustering algorithm based on the vertex normal vector. Secondly, in order to differentiate between original and fracture faces, a novel integral invariant is introduced to compute the surface roughness. Thirdly, an accurate surface segmentation is implemented by merging faces based on face normal vector and roughness. Finally, edge feature lines are extracted based on the surface segmentation. Some experiments are made and analyzed, and the results show that our method can achieve surface segmentation and edge extraction effectively.

**Key Words**

Surface segmentation; Edge lines extraction; Fractured fragments; Relics

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**Flattening simulations of 3D thick sheets made of fiber composite materials**


**Abstract**

Recently, fiber composite materials have been attracting attention from industry because of their remarkable material characteristics, including light weight and high stiffness. However, the costs of products composed of fiber materials remain high because of the lack of effective manufacturing and designing technologies. To improve the relevant design technology, this paper proposes a novel simulation method for deforming fiber materials. Specifically, given a 3D model with constant thickness and known fiber orientation, the proposed method simulates the deformation of a model made of thick fiber-material. The method separates a 3D sheet model into two surfaces and then flattens these surfaces into two dimensional planes by a parameterization method with involves cross vector fields. The cross vector fields are generated by propagating the given fiber orientations specified at several important points on the 3D model. Integration of the cross vector fields gives parameterization with low-stretch and low-distortion.

**Key Words**

Fiber composite material; Parameterization; Cross vector field

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**3D scanning based mold correction for planar and cylindrical parts in aluminum die casting**

Takashi Seno*, Yutaka Ohtake, Yuji Kikuchi, Noriaki Saito, Hiromasa Suzuki, Yukie Nagai, pages 96-104. DOI: http://dx.doi.org/10.1016/j.jcde.2014.12.004

**Abstract**

Aluminum die casting is an important manufacturing process for mechanical components. Die casting is known to be more accurate than other types of casting; however, post-machining is usually necessary to achieve the required accuracy. The goal of this investigation is to develop machining-free aluminum die casting. Improvement of the accuracy of planar and cylindrical parts is expected by correcting metal molds. In the proposed method, the shape of cast aluminum made with the initial metal molds is measured by 3D scanning. The 3D scan data includes information about deformations that occur during casting. Therefore, it is possible to estimate the deformation and correction amounts by comparing 3D scan data with product computer-aided design (CAD) data. We corrected planar and cylindrical parts of the CAD data for the mold. In addition, we corrected the planar part of the metal mold using the corrected mold data. The effectiveness of the proposed method is demonstrated by evaluating the accuracy improvement of the cast aluminum made with the corrected mold.

**Key Words**

Geometric modeling; Aluminum die casting; Mold correction; 3D scanning; Mesh deformation
A comprehensive approach for managing feasible solutions in production planning by an interacting network of Zero-Suppressed Binary Decision Diagrams
Keita Takahashi*, Masahiko Onosato, Fumiki Tanaka, pages 105-112. DOI: http://dx.doi.org/10.1016/j.jcde.2014.12.005

Abstract
Product Lifecycle Management (PLM) ranges from design concepts of products to disposal. In this paper, we focus on the production planning phase in PLM, which is related to process planning and production scheduling and so on. In this study, key decisions for the creation of production plans are defined as production-planning attributes. Production-planning attributes correlate complexly in production-planning problems. Traditionally, the production-planning problem splits sub-problems based on experiences, because of the complexity. In addition, the orders in which to solve each sub-problem are determined by priorities between sub-problems. However, such approaches make solution space over-restricted and make it difficult to find a better solution. We have proposed a representation of combinations of alternatives in production planning attributes by using Zero-Suppressed Binary Decision Diagrams. The ZDD represents only feasible combinations of alternatives that satisfy constraints in the production planning. Moreover, we have developed a solution search method that solves production-planning problems with ZDDs. In this paper, we propose an approach for managing solution candidates by ZDDs’ network for addressing larger production-planning problems. The network can be created by linkages of ZDDs that express constraints in individual sub-problems and between sub-problems. The benefit of this approach is that it represents solution space, satisfying whole constraints in the production planning. This case study shows that the validity of the proposed approach.

Key Words
Production planning; Production-planning attributes; ZDD

An adaptive nonlocal filtering for low-dose CT in both image and projection domains
Yingmei Wang, Shujun Fu*, Wanlong Li, Caiming Zhang, pages 113-118. DOI: http://dx.doi.org/10.1016/j.jcde.2014.12.006

Abstract
An important problem in low-dose CT is the image quality degradation caused by photon starvation. There are a lot of algorithms in sonogram domain or image domain to solve this problem. In view of strong self-similarity contained in the special sinusoid-like strip data in the sonogram space, we propose a novel non-local filtering, whose average weights are related to both the image FBP (filtered backprojection) reconstructed from restored sinogram data and the image directly FBP reconstructed from noisy sinogram data. In the process of sinogram restoration, we apply a non-local method with smoothness parameters adjusted adaptively to the variance of noisy sinogram data, which makes the method much effective for noise reduction in sinogram domain. Simulation experiments show that our proposed method by filtering in both image and projection domains has a better performance in noise reduction and details preservation in reconstructed images.

Key Words
Low-dose CT; Noise reduction; Sinogram restoration; Non-local filtering; Weighted average

On condition based maintenance policy
Jong-Ho Shin, Hong-Bae Jun*, pages 119-127. DOI: http://dx.doi.org/10.1016/j.jcde.2014.12.007

Abstract
In the case of a high-valuable asset, the Operation and Maintenance (O&M) phase requires heavy charges and more efforts than the installation (construction) phase, because it has long usage life and any accident of an asset during this period causes catastrophic damage to an industry. Recently, with the advent of emerging Information Communication Technologies (ICTs), we can get the visibility of asset status information during its usage period. It gives us new challenging issues for improving the efficiency of asset operations. One issue is to implement the Condition-Based Maintenance (CBM) approach that makes a diagnosis of the asset status based on wire or wireless monitored data, predicts the assets abnormality, and executes suitable maintenance actions such as repair and replacement before serious problems happen. In this study, we have addressed several aspects of CBM approach: definition, related international standards, procedure, and techniques with the introduction of some relevant case studies that we have carried out.

Key Words
Condition-based maintenance; Predictive maintenance; Prognostic and health management
• Variational surface design under normal field guidance
Weidong Wu, Xunnian Yang*, pages 129-136. DOI: http://dx.doi.org/10.1016/j.jcde.2015.03.001
Abstract
This paper proposes a novel method for shape design of a Bézier surface with given boundary curves. The surface is defined as the minimizer of an extended membrane functional or an extended thin plate functional under the guidance of a specified normal field together with an initial prescribed surface. For given boundary curves and the guiding normal field, the free coefficients of a Bézier surface are obtained by solving a linear system. Unlike previous PDE based surface modeling techniques which construct surfaces just from boundaries, our proposed method can also be used to generate smooth and fair surfaces that even follow a specified normal field. Several interesting examples are given to demonstrate the applications of the proposed method in geometric modeling.
Key Words
Membrane energy functional; Thin plate energy functional; Normal vector field; Geometric modeling

• Hybrid Type II fuzzy system & data mining approach for surface finish
Tzu-Liang (Bill) Tseng, Fuhua Jiangb, Yongjin (James) Kwon*, pages 137-147. DOI: http://dx.doi.org/10.1016/j.jcde.2015.03.002
Abstract
In this study, a new methodology in predicting a system output has been investigated by applying a data mining technique and a hybrid type II fuzzy system in CNC turning operations. The purpose was to generate a supplemental control function under the dynamic machining environment, where unforeseeable changes may occur frequently. Two different types of membership functions were developed for the fuzzy logic systems and also by combining the two types, a hybrid system was generated. Genetic algorithm was used for fuzzy adaptation in the control system. Fuzzy rules are automatically modified in the process of genetic algorithm training. The computational results showed that the hybrid system with a genetic adaptation generated a far better accuracy. The hybrid fuzzy system with genetic algorithm training demonstrated more effective prediction capability and a strong potential for the implementation into existing control functions.
Key Words
Data mining; Fuzzy set theory; Surface roughness; Metal cutting; Machining quality characteristics

• A web-based collaborative framework for facilitating decision making on a 3D design developing process
Purevdorj Nyamsuren, Soo-Hong Lee*, Hyun-Tae Hwang, Tae-Joo Kim, pages 148-156. DOI: http://dx.doi.org/10.1016/j.jcde.2015.02.001
Abstract
Increased competitive challenges are forcing companies to find better ways to bring their applications to market faster. Distributed development environments can help companies improve their time-to-market by enabling parallel activities. Although, such environments still have their limitations in real-time communication and real-time collaboration during the product development process. This paper describes a web-based collaborative framework which has been developed to support the decision making on a 3D design developing process. The paper describes 3D design file for the discussion that contains all relevant annotations on its surface and their visualization on the user interface for design changing. The framework includes a native CAD data converting module, 3D data based real-time communication module, revision control module for 3D data and some sub-modules such as data storage and data management. We also discuss some raised issues in the project and the steps underway to address them.
Key Words
Decision making; Distributed environment; 3D data visualization; Revision control; WebGL

• Fundamental framework toward optimal design of product platform for industrial three-axis linear-type robots
Kana Sawai*, Yutaka Nomaguchi, Kikuo Fujita, pages 157-164. DOI: http://dx.doi.org/10.1016/j.jcde.2015.03.002
Abstract
This paper discusses an optimization-based approach for the design of a product platform for industrial three-axis linear-type robots, which are widely used for handling objects in manufacturing lines. Since the operational specifications of these robots, such as operation speed, working distance and orientation, weight and shape of loads, etc., will vary for different applications, robotic system vendors must provide various types of robots efficiently and effectively to meet a range of market needs. A promising step toward this goal is the concept of a product platform, in which several key elements are commonly used across a series of products, which can then be customized for individual requirements. However the design of a product platform is more complicated than that of each product, due to the need to optimize the design across many products. This paper proposes an optimization-based fundamental framework toward the design of a product platform for industrial three-axis linear-type robots; this framework allows the solution of a complicated design problem and builds an optimal design method of fundamental features of robot frames that are commonly used for a wide range of robots. In this formulation, some key performance metrics of the robot are estimated by an reduced order model which is configured with beam theory. A multi-objective optimization problem is formulated to represent the trade-offs among key design parameters using a weighted-sum form for a single product. This formulation is integrated into a mini–max type optimization problem across a series of robots as an optimal design formulation for the product platform. Some case studies of optimal platform design for industrial three-axis linear-type robots are presented to demonstrate the applications of a genetic algorithm to such mathematical models.
Key Words
Product family; Product platform; Optimal design; Reduced-order model; Multi-objective optimization; Industrial robot
Multicriteria shape design of an aerosol can
Benki Aalae*, Habbal Abderrahmane, Mathis Gael, Beigneux Olivier, pages 165-175. DOI: http://dx.doi.org/10.1016/j.jcde.2015.03.003

Abstract
One of the current challenges in the domain of the multicriteria shape optimization is to reduce the calculation time required by conventional methods. The high computational cost is due to the high number of simulation or function calls required by these methods. Recently, several studies have been led to overcome this problem by integrating a metamodel in the overall optimization loop. In this paper, we perform a coupling between the Normal Boundary Intersection – NBI – algorithm with Radial Basis Function – RBF – metamodel in order to have a simple tool with a reasonable calculation time to solve multicriteria optimization problems. First, we apply our approach to academic test cases. Then, we validate our method against an industrial case, namely, shape optimization of the bottom of an aerosol can undergoing nonlinear elasto-plastic deformation. Then, in order to select solutions among the Pareto efficient ones, we use the same surrogate approach to implement a method to compute Nash and Kalai–Smorodinsky equilibria.

Key Words
Multicriteria optimization problem; Normal boundary intersection; Radial basis function metamodel; Nash equilibria; Kalai-Smorodinsky equilibria

Shape memory alloy (SMA)-based head and neck immobilizer for radiotherapy
Hyun-Taek Lee, Sung-In Kim, Jong Min Park, Ho-Jin Kim, Dae-Seob Song, Hyung-II Kim, Hong-Gyun Wu, Sung-Hoon Ahn*, pages 176-182. DOI: http://dx.doi.org/10.1016/j.jcde.2015.03.004

Abstract
Head-and-neck cancer is often treated with intensive irradiation focused on the tumor, while delivering the minimum amount of irradiation to normal cells. Since a course of radiotherapy can take 5–6 weeks or more, the repeatability of the patient posture and the fastening method during treatment are important determinants of the success of radiotherapy. Many devices have been developed to minimize positional discrepancies, but all of the commercial devices used in clinical practice are operated manually and require customized fixtures for each patient. This is inefficient and the performance of the fixture device depends on the operator's skill. Therefore, this study developed an automated head-and-neck immobilizer that can be used during radiotherapy and evaluated the positioning reproducibility in a phantom experiment. To eliminate interference caused by the magnetic field from computed tomography hardware, Ni_Ti shape-memory alloy wires were used as the actuating elements of the fixtures. The resulting positional discrepancy was less than 5 mm for all positions, which is acceptable for radiotherapy.

Key Words
Radiotherapy; Shape memory alloy; Immobilizer; Head and neck cancer; Prototype

Thickness and clearance visualization based on distance field of 3D objects
Masatomo Inui, Nobuyuki Umezu*, Kazuma Wakasaki, Shunsuke Sato, pages 183-194. DOI: http://dx.doi.org/10.1016/j.jcde.2015.04.001

Abstract
This paper proposes a novel method for visualizing the thickness and clearance of 3D objects in a polyhedral representation. The proposed method uses the distance field of the objects in the visualization. A parallel algorithm is developed for constructing the distance field of polyhedral objects using the GPU. The distance between a voxel and the surface polygons of the model is computed many times in the distance field construction. Similar sets of polygons are usually selected as close polygons for close voxels. By using this spatial coherence, a parallel algorithm is designed to compute the distances between a cluster of close voxels and the polygons selected by the culling operation so that the fast shared memory mechanism of the GPU can be fully utilized. The thickness/clearance of the objects is visualized by distributing points on the visible surfaces of the objects and painting them with a unique color corresponding to the thickness/clearance values at those points. A modified ray casting method is developed for computing the thickness/clearance using the distance field of the objects. A system based on these algorithms can compute the distance field of complex objects within a few minutes for most cases. After the distance field construction, thickness/clearance visualization at a near interactive rate is achieved.

Key Words
Inscribed spheres; Spatial coherence; Parallel computation; Axis-aligned bounding box (AABB); Modified ray casting; GPU
**Abstract**

In this paper, the cutting force calculation of ball-end mill processing was modeled mathematically. The developed mathematical model of cutting forces, the relationship of average cutting force and feed per flute was characterized as a linear function. The cutting force coefficient model was formulated by a function of average cutting force and other parameters such as cutter geometry, cutting conditions, and so on. An experimental method was proposed based on the stable milling condition to estimate the cutting force coefficients for ball-end mill. This method could be applied for each pair of tool and workpiece.

**Key Words**

CNC machining; G-code; B-Spline fitting; Progressive iterative approximation; Energy minimization
The developed cutting force model has been successfully verified experimentally with very promising results.

**Key Words**
Ball-end mill; Cutting force coefficients; Cutting force simulation

• **An approach for machining allowance optimization of complex parts with integrated structure**
Ying Zhang*, Dinghua Zhang, Baohai Wu, pages 248-252. DOI: http://dx.doi.org/10.1016/j.jcde.2015.06.007

**Abstract**
Currently composite manufacturing process, such as linear friction welding plus NC machining, is the main method for the manufacturing and repairing of complex parts with integrated structure. Due to different datum position and inevitable distortion from different processes, it is important to ensure sufficient machining allowance for complex parts during the NC machining process. In this paper, a workpiece localization approach for machining allowance optimization of complex parts based on CMM inspection is developed. This technique concerns an alignment process to ensure sufficient stock allowance for the single parts as well as the whole integrated parts. The mathematical model of the constrained alignment is firstly established, and then the symmetric block solution strategy is proposed to solve the optimization model. Experiment result shows that the approach is appropriate and feasible to distribute the machining allowance for the single and whole parts for adaptive machining of complex parts.

**Key Words**
Adaptive machining; CMM; Complex parts; Machining allowance optimization; Workpiece localization

• **An automatic 3D CAD model errors detection method of aircraft structural part for NC machining**
Bo Huang, Changhong Xu, Rui Huang*, Shusheng Zhang, pages 253-260. DOI: http://dx.doi.org/10.1016/j.jcde.2015.06.008

**Abstract**
Feature-based NC machining, which requires high quality of 3D CAD model, is widely used in machining aircraft structural part. However, there has been little research on how to automatically detect the CAD model errors. As a result, the user has to manually check the errors with great effort before NC programming. This paper proposes an automatic CAD model errors detection approach for aircraft structural part. First, the base faces are identified based on the reference directions corresponding to machining coordinate systems. Then, the CAD models are partitioned into multiple local regions based on the base faces. Finally, the CAD model error types are evaluated based on the heuristic rules. A prototype system based on CATIA has been developed to verify the effectiveness of the proposed approach.

**Key Words**
Heuristic rule; CAD model errors; Aircraft structural part; Feature-based NC machining

• **Adaptive location of repaired blade for multi-axis milling**
Baohai Wu*, Jian Wang, Ying Zhang, Ming Luo, pages 261-267. DOI: http://dx.doi.org/10.1016/j.jcde.2015.06.009

**Abstract**
Free-form blades are widely used in different industries, such as aero-engine and steam turbine. Blades that are damaged during service or have production deficiencies are usually replaced with new ones. This leads to the waste of expensive material and is not sustainable. However, material and costs can be saved by repairing of locally damaged blades or blades with localized production deficiencies. The blade needs to be further machined after welding process to reach the aerodynamic performance requirements. This paper outlines an adaptive location approach of repaired blade for model reconstruction and NC machining. Firstly, a mathematical model is established to describe the localization problem under constraints. Secondly, by solving the mathematical model, localization of repaired blade for NC machining can be obtained. Furthermore, a more flexible method based on the proposed mathematical model and the continuity of the deformation process is developed to realize a better localization. Thirdly, by rebuilding the model of the repaired blade and extracting repair error, optimized tool paths for NC machining is generated adaptively for each individual part. Finally, three examples are given to validate the proposed method.

**Key Words**
NC Machining; Repaired Blade; Adaptive Localization; Model Reconstruction

• **A complete S-shape feed rate scheduling approach for NURBS interpolator**
Xu Du, Jie Huang, Li-Min Zhu*, pages 268-275. DOI: http://dx.doi.org/10.1016/j.jcde.2015.06.013

**Abstract**
Blisk is an essential component in aero engines. To maintain good aero-dynamic performance, one critical machining requirement for blades on blisk is that the generated five-axis tool path should be boundary-conformed. For a blade discretely modeled as a point cloud or mesh, most existing popular tool path generation methods are unable to meet this requirement. To address this issue, a novel five-axis tool path generation method for a discretized blade on blisk is presented in this paper. An idea called Linear Morphing Cone (LMC) is first proposed, which sets the boundary of the blade as the constraint. Based on this LMC, a CC curve generation and expansion method is then proposed with the specified machining accuracy upheld. Using the proposed tool path generation method, experiments on discretized blades are carried out, whose results show that the generated tool paths are both uniform and boundary-conformed.

**Key Words**
Five-axis tool path; Mesh; Blisk machining; Boundary-conformed; Linear morphing cone
Computational design of mould sprue for injection moulding thermoplastics
Muralidhar Lakkanna*, G.C. Mohan Kumar, Ravikiran Kadoli, pages 37-52. DOI: http://dx.doi.org/10.1016/j.jcde.2015.06.006

Abstract
To injection mould polymers, designing mould is a key task involving several critical decisions with direct implications to yield quality, productivity and frugality. One prominent decision among them is specifying sprue-bush conduit expansion as it significantly influences overall injection moulding; abstruseness anguish in its design criteria deceives direct determination. Intuitively designers decide it wisely and then exasperate by optimising or manipulating processing parameters. To overwhelm that anomaly this research aims at proposing an ideal design criteria holistically for all polymeric materials also overwhelm that anomaly this research aims at proposing an ideal design criteria holistically for all polymeric materials also

Key Words
Design of experiments; Fuzzy logic; Surface roughness; End milling; Process control

Volume 3, No. 1

A novel approach to predict surface roughness in machining operations using fuzzy set theory

Abstract
The increase of consumer needs for quality metal cutting related products with more precise tolerances and better product surface roughness has driven the metal cutting industry to continuously improve quality control of metal cutting processes. In this paper, two different approaches are discussed. First, design of experiments (DOE) is used to determine the significant factors and then fuzzy logic approach is presented for the prediction of surface roughness. The data used for the training and checking the fuzzy logic performance is derived from the experiments conducted on a CNC milling machine. In order to obtain better surface roughness, the proper sets of cutting parameters are determined before the process takes place. The factors considered for DOE in the experiment were the depth of cut, feed rate per tooth, cutting speed, tool nose radius, the use of cutting fluid and the three components of the cutting force. Finally the significant factors were used as input factors for fuzzy logic mechanism and surface roughness is predicted with empirical formula developed. Test results show good agreement between the actual process output and the predicted surface roughness

Key Words
Design of experiments; Fuzzy logic; Surface roughness; End milling; Process control

A graph-based method for fitting planar B-spline curves with intersections
Pengbo Bo*, Gongning Luo, Kuanquan Wang, pages 14-23. DOI: http://dx.doi.org/10.1016/j.jcde.2015.05.001

Abstract
The problem of fitting B-spline curves to planar point clouds is studied in this paper. A novel method is proposed to deal with the most challenging case where multiple intersecting curves or curves with self-intersection are necessary for shape representation. A method based on Delauney Triangulation of data points is developed to identify connected components which is also capable of removing outliers. A skeleton representation is utilized to represent the topological structure which is further used to create a weighted graph for deciding the merging of curve segments. Different to existing approaches which utilize local shape information near intersections, our method considers shape characteristics of curve segments in a larger scope and is thus capable of giving more satisfactory results. By fitting each group of data points with a B-spline curve, we solve the problems of curve structure reconstruction from point clouds, as well as the vectorization of simple line drawing images by drawing lines reconstruction.

Key Words
Curve fitting; Curve reconstruction; B-spline; Point cloud

Lion Optimization Algorithm (LOA): A nature-inspired metaheuristic algorithm
Maziar Yazdani, Fariborz Jolai, pages 24-36. DOI: http://dx.doi.org/10.1016/j.jcde.2015.06.003

Abstract
During the past decade, solving complex optimization problems with metaheuristic algorithms has received considerable attention among practitioners and researchers. Hence, many metaheuristic algorithms have been developed over the last years. Many of these algorithms are inspired by various phenomena of nature. In this paper, a new population based algorithm, the Lion Optimization Algorithm (LOA), is introduced. Special lifestyle of lions and their cooperation characteristics has been the basic motivation for development of this optimization algorithm. Some benchmark problems are selected from the literature, and the solution of the proposed algorithm has been compared with those of some well-known and newest meta-heuristics for these problems. The obtained results confirm the high performance of the proposed algorithm in comparison to the other algorithms used in this paper.

Key Words
Lion Optimization Algorithm (LOA); Global optimization; Metaheuristic
scope and altitude for each polymeric character. In which congruent ranges of apparent viscosity and shear thinning index were conceived to characteristically sort most thermoplastics. Thereon results accorded aggressive conduit expansion widening for viscous incrust, while a very aggressive narrowing for shear thinning encrust; among them apparent viscosity had relative dominance. This important rationale would certainly form a priori design basis as well diagnose filling issues causing several defects. Like this the proposed generic design criteria, being simple would immensely benefit mould designers besides serve as an inexpensive preventive cliché to moulders. Its adaption ease to practice manifests a hope of injection moulding extremely alluring polymers. Therefore, we concluded that appreciating injectant's polymeric character to design exclusive sprue bush offers a definite a priori advantage.

**Key Words**
Injection moulding; Sprue bush; Apparent viscosity; Shear thinning index

- **Programming of adaptive repair process chains using repair features and function blocks**
  Gunter Spöcker*, Thorsten Schreiner, Tobias Huwer, Kristian Arntz, pages 63-70. DOI: http://dx.doi.org/10.1016/j.jcde.2015.06.001

**Abstract**
The current trends of product customization and repair of high value parts with individual defects demand automation and a high degree of flexibility of the involved manufacturing process chains. To determine the corresponding requirements this paper gives an overview of manufacturing process chains by distinguishing between horizontal and vertical process chains. The established way of modeling and programming processes with CAX systems and existing approaches is shown. Furthermore, the different types of possible adaptions of a manufacturing process chain are shown and considered as a cascaded control loop. Following this it is discussed which key requirements of repair process chains are unresolved by existing approaches. To overcome the deficits this paper introduces repair features which comprise the idea of geometric features and defines analytical auxiliary geometries based on the measurement input data. This meets challenges normally caused by working directly on reconstructed geometries in the form of triangulated surfaces which are prone to artifacts. Embedded into function blocks, this allows the use of traditional approaches for manufacturing process chains to be applied to adaptive repair process chains.

**Key Words**
CAX; Flexible process chain; Adaptive; Function blocks; Manufacturing; Turbomachinery; Repair

- **Prediction and optimization of thinning in automotive sealing cover using Genetic Algorithm**
  Ganesh M. Kakandikar*, Vlas M. Nandedkar, pages 63-70. DOI: http://dx.doi.org/10.1016/j.jcde.2015.06.001

**Abstract**
Deep drawing is a forming process in which a blank of sheet metal is radially drawn into a forming die by the mechanical action of a punch and converted to required shape. Deep drawing involves complex material flow conditions and force distributions. Radial drawing stresses and tangential compressive stresses are induced in flange region due to the material retention property. These compressive stresses result in wrinkling phenomenon in flange region. Normally blank holder is applied for restricting wrinkles. Tensile stresses in radial direction initiate thinning in the wall region of cup. The thinning results into cracking or fracture. The finite element method is widely applied worldwide to simulate the deep drawing process. For real-life simulations of deep drawing process an accurate numerical model, as well as an accurate description of material behavior and contact conditions, is necessary. The finite element method is a powerful tool to predict material thinning deformations before prototypes are made. The proposed innovative methodology combines two techniques for prediction and optimization of thinning in automotive sealing cover. Taguchi design of experiments and analysis of variance has been applied to analyze the influencing process parameters on thinning. Mathematical relations have been developed to correlate input process parameters and Thinning. Optimization problem has been formulated for thinning and Genetic Algorithm has been applied for optimization. Experimental validation of results proves the applicability of newly proposed approach. The optimized component when manufactured is observed to be safe, no thinning or fracture is observed.

**Key Words**
Thinning; Prediction; DOE; Regression

- **Steel nitriding optimization through multi-objective and FEM analysis**
  Pasquale Cavaliere, Angelo Perrone, Alessio Silvello, pages 71-90. DOI: http://dx.doi.org/10.1016/j.jcde.2015.06.002

**Abstract**
Steel nitriding is a thermo-chemical process leading to surface hardening and improvement in fatigue properties. The process is strongly influenced by many different variables such as steel composition, nitrogen potential, temperature, time, and quenching media. In the present study, the influence of such parameters affecting physic-chemical and mechanical properties of nitride steels was evaluated. The aim was to streamline the process by numerical–experimental analysis allowing defining the optimal conditions for the success of the process. Input parameters–output results correlations were calculated through the employment of a multi-objective optimization software, modeFRONTIER (Esteco). The mechanical and microstructural results belonging to the nitriding process, performed with different processing conditions for various steels, are presented. The data were employed to obtain the analytical equations describing nitriding behavior as a function of nitriding parameters and steel composition. The obtained model was validated, through control designs, and optimized by taking into account physical and processing conditions.

**Key Words**
Nitriding; Mechanical properties; Optimization
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• E-quality control: A support vector machines approach
Tzu-Liang (Bill) Tsenga, Kalyan Reddy Aletia, Zhonghua Hua, Yongjin (James) Kwonb,*, pages 91-101. DOI: http://dx.doi.org/10.1016/j.jcde.2015.06.010
Abstract
The automated part quality inspection poses many challenges to the engineers, especially when the part features to be inspected become complicated. A large quantity of part inspection at a faster rate should be relied upon computerized, automated inspection methods, which requires advanced quality control approaches. In this context, this work uses innovative methods in remote part tracking and quality control with the aid of the modern equipment and application of support vector machine (SVM) learning approach to predict the outcome of the quality control process. The classifier equations are built on the data obtained from the experiments and analyzed with different kernel functions. From the analysis, detailed outcome is presented for six different cases. The results indicate the robustness of support vector classification for the experimental data with two output classes.
Key Words
Support vector machines; Part classifications; Remote inspection; Networked robotic station; e-quality

• Feature curve extraction from point clouds via developable strip intersection
Kai Wah Leea, Pengbo Bob,*, pages 102-111. DOI: http://dx.doi.org/10.1016/j.jcde.2015.07.001
Abstract
In this paper, we study the problem of computing smooth feature curves from CAD type point clouds models. The proposed method reconstructs feature curves from the intersections of developable strip pairs which approximate the regions along both sides of the features. The generation of developable surfaces is based on a linear approximation of the given point cloud through a variational shape approximation approach. A line segment sequencing algorithm is proposed for collecting feature line segments into different feature sequences as well as sequential groups of data points. A developable surface approximation procedure is employed to refine incident approximation planes of data points into developable strips. Some experimental results are included to demonstrate the performance of the proposed method.
Key Words
Feature extraction; Point cloud; Developable surface; Reverse engineering

• Development of a novel set of criteria to select methodology for designing product service systems
Tuananh Tran, Joon Young Park*, pages 112-120. DOI: http://dx.doi.org/10.1016/j.jcde.2015.10.001
Abstract
This paper proposes eight groups of twenty nine scoring criteria that can help designers and practitioners to compare and select an appropriate methodology for a certain problem in designing product service system (PSS). PSS has been researched for more than a decade and is now becoming more and more popular in academia as well as industry. Despite that fact, the adoption of PSS is still limited for its potential. One of the main reasons is that designing PSS itself is a challenge. Designers and developers face difficulties in choosing appropriate PSS design methodologies for their projects so that they can design effective PSS offerings. By proposing eight groups of twenty nine scoring criteria, this paper enables a “step by step” process to identify the most appropriate design methodology for a company's PSS problem. An example is also introduced to illustrate the use of the proposed scoring criteria and provide a clear picture of how different design methodologies can be utilized at their best in terms of application.
Key Words
Product service system; PSS; PSS application; PSS design methodology selection

• A hybrid approach for character modeling using geometric primitives and shape-from-shading algorithm
Abstract
Organic modeling of 3D characters is a challenging task when it comes to correctly modeling the anatomy of the human body. Most sketch based modeling tools available today for modeling organic models (humans, animals, creatures etc) are focused towards modeling base mesh models only and provide little or no support to add details to the base mesh. We propose a hybrid approach which combines geometrical primitives such as generalized cylinders and cube with Shape-from-Shading (SFS) algorithms to create plausible human character models from sketches. The results show that an artist can quickly create detailed character models from sketches by using this hybrid approach.
Key Words
Sketch based modeling; Character; Modeling; Shape-from-shading; Sketch
• **Minimum time path planning of robotic manipulator in drilling/spot welding tasks**
  Qiang Zhang, Ming-Yong Zhao, pages 132-139. DOI: http://dx.doi.org/10.1016/j.jcde.2015.10.004

**Abstract**
In this paper, a minimum time path planning strategy is proposed for multi points manufacturing problems in drilling/spot welding tasks. By optimizing the travelling schedule of the set points and the detailed transfer path between points, the minimum time manufacturing task is realized under fully utilizing the dynamic performance of robotic manipulator. According to the start-stop movement in drilling/welding task, the path planning problem can be converted into a traveling salesman problem (TSP) and a series of point to point minimum time transfer path planning problems. A new TSP with minimum time index is constructed by using point-point transfer time as the TSP parameter. The classical genetic algorithm (GA) is applied to obtain the optimal travelling schedule. Several minimum time drilling tasks of a 3- DOF robotic manipulator are used as examples to demonstrate the effectiveness of the proposed approach.

**Key Words**
Minimum time; Mixed integer; Path planning; Point to point motion; Drilling/spot welding task

• **Design optimization of precision casting for residual stress reduction**
  Appasaheb Adappa Keste, Shravan Haribhau Gawande*, Chandrani Sarkar, pages 140-150. DOI: http://dx.doi.org/10.1016/j.jcde.2015.10.003

**Abstract**
Normally all manufacturing and fabrication processes introduce residual stresses in a component. These stresses exist even after all service or external loads have been removed. Residual stresses have been studied elaborately in the past and even in depth research have been done to determine their magnitude and distribution during different manufacturing processes. But very few works have dealt with the study of residual stresses formation during the casting process. Even though these stresses are less in magnitude, they still result in crack formation and subsequent failure in later phases of the component usage. In this work, the residual stresses developed in a shifter during casting process are first determined by finite element analysis using ANSYSs. Mechanical APDL. Release 12.0 software. Initially the analysis was done on a simple block to determine the optimum element size and boundary conditions. With these values, the actual shifter component was analyzed. All these simulations are done in an uncoupled thermal and structural environment. The results showed the areas of maximum residual stress. This was followed by the geometrical optimization of the cast part for minimum residual stresses. The resulting shape gave lesser and more evenly distributed residual stresses. Crack compliance method was used to experimentally determine the residual stresses in the modified cast part. The results obtained from the measurements are verified by finite element analysis findings.

**Key Words**
Casting; Finite element analysis (FEA); Optimization; Residual stresses; Crack compliance method

• **Cutter-workpiece engagement determination for general milling using triangle mesh modeling**
  Xun Gong, Hsi-Yung Feng*, pages 151-160. DOI: http://dx.doi.org/10.1016/j.jcde.2015.12.001

**Abstract**
Cutten-workpiece engagement (CWE) is the instantaneous contact geometry between the cutter and the in-process workpiece during machining. It plays an important role in machining process simulation and directly affects the calculation of the predicted cutting forces and torques. The difficulty and challenge of CWE determination come from the complexity due to the changing geometry of in-process workpiece and the curved tool path of cutter movement, especially for multi-axis milling. This paper presents a new method to determine the CWE for general milling processes. To fulfill the requirement of generality, which means for any cutter type, any in-process workpiece shape, and any tool path even with self-intersections, all the associated geometries are to be modeled as triangle meshes. The involved triangle-to-triangle intersection calculations are carried out by an effective method in order to realize the multiple subtraction Boolean operations between the tool and the workpiece mesh models and to determine the CWE. The presented method has been validated by a series of case studies of increasing machining complexity to demonstrate its applicability to general milling processes.

**Key Words**
Cutter-workpiece engagement; Machining simulation; General milling; Cutting force; Triangle mesh

• **Implementation of persistent identification of topological entities based on macro-parametrics approach**
  Shahjadi Hisan Farjana*, Soonhun Han*, Duhwan Mun*, pages 161-177. DOI: http://dx.doi.org/10.1016/j.jcde.2016.01.001

**Abstract**
In history based parametric CAD modeling systems, persistent identification of the topological entities after design modification is mandatory to keep the design intent by recording model creation history and modification history. Persistent identification of geometric and topological entities is necessary in the product design phase as well as in the re-evaluation stage. For the identification, entities should be named first according to the methodology which will be applicable for all the entities unconditionally. After successive feature operations on a part body, topology based persistent identification mechanism generates ambiguity problem that usually stems from topology splitting and topology merging. Solving the ambiguity problem needs a complex method which is a combination of topology and geometry. Topology is used to assign the basic name to the entities. And geometry is used for the ambiguity solving between the entities. In the macro parametrics approach of ICAD lab of KAIST a topology based persistent identification mechanism is applied which will solve the ambiguity problem arising from topology splitting and also in case of topology merging. Here, a method is proposed where no geometry comparison is necessary for topology merging. The present research is focused on the enhancement of the persistent
identification schema for the support of ambiguity problem especially of topology splitting problem and topology merging problem. It also focused on basic naming of pattern features.

Key Words
Feature based CAD; Macro-parametrics approach; Persistent identification; TransCAD; Topological element