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CAD Tools for Products

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Report

on the Dagstuhl Seminar on

CAD Tools for Products

04.09.1995 - 08.09.1995

Organized by:

Pere Brunet, Universitat Politecnica de Catalunga, Barcelona, Spain
Dieter Roller, Universität Stuttgart, Institut für Informatik, Germany
Jarek Rossignac, IBM, Yorktown Hights, USA

The objective of this seminar on CAD Tools for Products was to bring leading experts in the field of CAD-technology together and discuss research results and experience on advanced tools and methods that have the potential as a foundation for future CAD Systems.

The 36 participants of this seminar came from universities, research institutes an industrial companies of nine different countries.

Workshops and presentations throughout the week covered the following major CAD topics:

- Algorithmic aspects
- Product data and development process
- CAD Architecture
- Feature-based modeling
- Automatic feature recognition
- Surface design
- System implementation

In this report, abstracts of the presented papers are included to provide an overview of the discussed solutions, methods and approaches for nex generation systems.

The lively discussions between the university researchers and the experts from companies have proven the importance of research exchange in this field between academic and industrial partners.

Multiresolution Approximation of Polyhedral Solids

P. Brunet, D. Ayala, R. Juan-Arinyo, I. Navazo
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Multiresolution models with different levels of detail is a based tool for handling very large and complex systems in CAD - ship design, for instance -.We focus on automatic simplification algorithms for the generation of a multiresolution family $s_1 \ldots s_1$ of solid models from a BRep of an initial polyhedral solid S. Output BRep solids s_k must represent valid polyhedra such that dist(surf(S), surf(s_k)) <= ε_k with increasing $\varepsilon_k, \varepsilon_k = \varepsilon * 2^k$. On the other hand, coarser representations must be geometrically simpler, $nf_k < nf_{k-1} \forall k, nf_k$ being the number of faces of s_k. We have investigated algorithms based on an intermediate octree representation. An algorithm has been developed for the class of orthogonal polyhedra; an example involving the multiresolution simplification of a building model is presented and discussed. A second algorithm for general polyhedra, based on face octrees, is also presented and discussed.

Algorithm for Approximate NURBS Skinning

Les Piegl
University of South Florida, Department of Computer Science
Tampa, FL, USA
and
Wayne Tiller
GeomWare, Inc.Tyler, Texas, USA

An algorithm for approximate skinning through cross-sectional NURBS curves is presented. The method eliminates the problem of dealing with huge amounts of control points obtained during the curve compatibility process. It also allows the designer to specify large numbers of cross-sections and approximately fit a smooth surface to these curves to any given tolerance. Depending on the tolerance used, up to 99% of the control points can be eliminated.

An Adaptive Algorithm to Compute the Medial Axis Transform of 2-D Polygonal Domains

R. Juan-Arinyo, L. Perez-Vidal, E. Gargallo-Moullan
Department LiSI; Universitat Politecnica de Catalunga
Barcelona, Catalonia, Spain

An adaptive algorithm to compute the medial axis transform of 2D polygonal domains is presented. The algorithm is based on the refinement of a coarse medial axis transform by

subdividing the domain adaptively. The algorithm provides the medial axis represented by a set of triangles of a predefined size and the closest boundary element. Examples of results are presented to illustrate the method.

Surface Reconstruction and Variable Offset

Siegfried Heinz
TransCAT GmbH, Karlsruhe, Germany

Surface reconstruction is currently a main research topic in several application areas. In this paper we present a method for surface reconstruction based upon a variational design principle. The construction algorithm combines a weighted least-square fitting with an automatic smoothing process. This algorithm for calculating technical smooth surfaces directly from scattered point data can be used for many other applications. We illustrate the method by applying it to generate a variable offset surface. For the definition of the variable offset we use a law surface.

Direct Construction of a Surface Model from a Dense Range Image through Region Growing

Nickolas S. Sapidis
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Department of Naval Architecture and Marine Engineering,
Ship-Design LAB,
Atehns, Greece

Today's range image sensors can measure (x,y,z) points on a physical object with high accuracy and at rates up to several millions of points per minute. To make effective use of dense range images (DRIs) in a CAD/CAM system, one needs a method for transforming them into a surface model. Existing techniques are based on either curve fitting or edge detection and rely on the user for determining the number of polynomial segments in the surface. We propose a new technique for surface fitting based on the concept of "region growing" (RG).

RG maximises the amount of data represented by a single polynomial segment and uses the "surface information" existing in a DRI. Also, the new technique guarantees a priori that the distance point-to-surface is smaller than a given tolerance, and it automatically identifies and rejects erroneous points. Experimental results are presented showing that RG produces surfaces with smooth curvature plots for a variety of data sets.

Large Construction of the Construction Delaunay- Triangulation of a Polygonal Domain

Reinhard Klein
Universität Tübingen, WSI-GRIS, Germany

A fast and easy to implement divide-and-conquer algorithm is presented for the construction of the Constrained Delaunay Triangulation of a polygonal domain. The algorithm avoids the merging step inherent to divide-and-conquer algorithms for the computation of triangulations.

Furthermore, no triangles are computed outside the valid region of the domain. A grid structure accelerates the computation of the visibility among vertices with respects to the boundary polygons as well as the computation of Constrained Delaunay triangles.

Extracting Reusable Product Data

Martti Mäntylä
Helsinki University of Technology, Finland

The objective of the talk is to discuss the future challenges of product and process modelling from the viewpoint of industrial expectations and problems. The competitive environment of industrial companies in all industrialised nations has changed dramatically during the last decade due to decreasing product life cycles, increasing product complexity, rapid lead time requirements, and other similar pressures. To respond to these pressures, companies must re-examine their product development and customer order satisfaction processes so as to eliminate unnecessary and unproductive steps; improve the communication between different functions both inside the company and with its customers, suppliers, and partners; and ensure effective reuse of all types of engineering data on all levels so as to stabilise and standardise effective work processes and provide a basis for their continuous improvement.

From product modelling viewpoint, this poses several challenges not effectively met by past and present research. These include adequate life-cycle support, including early stages of design; process support for different types of engineering processes (e.g. standard vs. non-standard products); and integration of different perspectives to product information (functional, structural, and manufacturing views).

Simulation of Multibody Systems in Mechanical Engineering

Alejandro Garcia-Alonso
CEIT, San Sebastian, Spain

A broad range of kinematic and dynamic problems in multibody systems can be simulated in real time with a realistic feedback, that is, simultaneously computing the motion of the parts

and displaying them by means of 3D images. This fact leads to consider two new areas of research interest within the field of interactive analysis of mechanism and vehicles: taking advantage of computer networks and solving geometric problems related with the motion of parts.

Networks have been used both to establish a Computer Supported Co-operative Work environment for engineers and to test a Distributed Simulation prototype. These two network research activities are based in different environments. The CSCW is based on the use of X window system within a LAN, and the distributed simulation prototype links several simulators connected to the European pilot ATM network. Data sent by means of the ATM network include: synchronisation messages, analysis data shared by the simulators and compressed video images that show the unique scene where all the simulators work.

On the other hand, interactive interrogation about the geometric relations among sets of moving parts includes both interference detection and minimum distance (clearance) evaluation. Although different approaches were used to solve these problems, both are based on spacial sorting techniques that make a volume subdivision in the local reference system of each individual moving part. Both time and space coherence help to solve the problems.

Virtual Prototyping - An Open System Environment to Support the Integrated Product Development Process

Joachim Rix
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Based on the idea of an integrated product development environment the CoConut system (Computer support for Concurrent design using STEP) for the application in the design and prototyping phase was presented. Using product data technology as developed in the ISO standard STEP (ISO 10303), the data integration will be realised via the SDAI interface to a distributed object-oriented database. Different application modules for management, design, analysis, presentation, and co-operation can be integrated, linked by the communication system. From the application scenario major tasks were identified as open issues in the data preparation process from CAD to the Virtual Prototype presented in Virtual Reality. Those issues are data correction, reduction, level of detail, area of interest, and enrichment of data for sophisticated visualisation and co-operation needs.

Co-operative Product Development via Broadband Communication Techniques

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Due to current demands for the improvement of "time to market", companies are forced to follow new strategies organising and performing their product development processes in terms of distributed single subtasks.

In consequence the increasing distribution of product development tasks onto different locations requires a fast and comfortable co-operation between designers involved for adjusting their development activities. Today's CAD systems do not support simultaneous engineering work sufficiently, since they have not been made for that purpose. Broadband communication networks (B-ISDN/ATM) allow interactive co-operation without delay. They also support dynamical processes with very high data transmission rates, such as exchange of video data on simulation processes.

The paper introduces a proposal for a multimedia based working environment which has been developed within the research project SEBID (Simultaneous Engineering Broadband Integrated Development), sponsored by DeTeBerkom GmbH. The concept developed in SEBID covers manyfold facilities of broadband communication technology, delivering new and powerful capabilities of information processing for the product development process. Video conferencing, distributed co-operative modelling and hypermedia techniques are novel tools for the designer enabling him to understand his product development task as a group task which can be simultaneously performed in terms of distributed subtasks. Different aspects of the proposed working environment are discussed. The paper concludes with an outlook on further development tasks within the project SEBID2 which is also sponsored by DeTeBerkom GmbH and currently running in Berlin. Maintask of this project is the integration of commercial CAD systems CADDS5, CATIA V4 and ProEngineer with distributed product data management and hypermedia systems into a common system environment for distributed co-operative work.

"CAD-Reference Model"- An Architectural Approach to Future CAD Systems

Olaf Abeln
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The long time experience of German industry and low penetration of using CAD-systems along the running course of a business order forced a new CAD-generation. The future CAD-systems have to be based on a new concept, which is easily structured, can be configurated and is able to support the whole design process, dealing with the special claims of a company and its products. The individual demands of a design engineer or a design group and the easy handling of the systems have to be supported.

This paper presents the results of the joint project supported by the German Minister for Research an Development.

CAx - System Architecture of the Future

C. Werner Dankwort
Universität Kaiserslautern, Germany

In the last years a lot of companies started severe changes and re-organisations in the development- and manufacturing processes. As a consequence many new requirements were set up by the user-departments of these companies concerning information technology and CAx-techniques. Independent from all these changes in industry a revolutional process in this technical field takes place. Old CAD/CAM-hardware used over years in the companies has to be replaced - giving the chance to renew the CAD/CAM-software as well. Therefore the German car manufactures formed a working group to develop a CAx-strategy as a base for long range decisions in the CAD/CAM-field. One result from this activity is a concept for an open CAx-System architecture which will impact both the CAD/CAM-applications within the automobile industry and the products of the CAD/CAM-system vendors. Possibilities for co-operations and projects between these groups of enterprises - with long term benefits for all - are pointed out.

Djinn - A Geometric Interface for Solid Modelling

John Woodwark
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Solid modelling functionality can be made available for integration with applications by packaging it under an API. Kernel modellers already exists, but their API procedures are cast in terms of their underlying modelling paradigms. The aim of the Djinn project is to develop an innovative API for solid modelling research which is cast in terms of geometric operations on point-sets, not manipulations of model data-structures.

Ground rules for the API have been formulated. Its style relies heavily on hiding model data-structures and providing methods to interrogate them. Procedures to instantiate common geometric entities are to be provided explicitly in the API. The geometric scope of the API is to be non-manifold, stationary, three-dimensional point-sets. A bottom interface will be defined to allow more complex data-types, such as free form surfaces, to be accessed indirectly. Ways are being explored to support useful but poorly defined modelling operations, such as 'tweaking', in the language of point-sets.

A Generalised Segment Concept

Manfred Rosendahl
Universität Koblenz, Germany

In normal CAD-Systems collections of elements, called group, block or segment are either programmed or the parameters of an instance can only be insertion point, angle, size. In the RelCAD-System a segment is a collection of objects that not only logically belong together, but also have geometric/numerical relationships among each other. They can even have relationships to objects outside the segment and are thereby dependent on them. Any object of a segment definition can be treated as a parameter, not only dimensions or points but also other items and even segments.

When creation a segment instance for the formal parameters of the segment definition actual parameters are assigned and by inserting the actual parameters the segment instance can be computed. A segment instance is treated in RelCAD as a normal geometric object and can therefore also be an element of an other segment definition, though nested segments can easily be defined. In a CAD-model you also need access from outside to the local elements of a segment instance. But in the RelCAD-System the segment definition is only stored once. To make this never the less possible a replace-element is introduced, which hold the information to access a local element of a segment instance.

New ECAD System Technology

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and
Dieter Roller
Universität Stuttgart, Germany

Electrotechnical CAD (ECAD) has some major differences compared to mechanical CAD (MCAD): the major task is to describe the functional design of an electrotechnical control or distribution by schematic drawings including logic. On these schematics, the components (like relais) might be represented by symbols on different sheets of the design, with cross references to the other parts of the component. From the schematics, there is a need to derive different production documents, e.g. parts lists, terminal lists, connection lists (wiring lists) etc. Another kind of drawings relate to control cabinet design. It shows how the components are to be placed into the cabinet, and is done to scale using a geometric view of the components. Support of 3D-Graphics, automatic routing of cables, interference checking and design rules would be very useful in this area.

Besides these, there are some highly sophisticated market requirements for ECAD systems to be foreseen. Examples will be given. When knowing that nowadays ECAD systems were founded on packages who have been designed to draw the schematics, it is understandable that they are no valid basis for the fulfilment of these requirements. For that reason, TCS, who is in the ECAD business for more than 14 years, decided to start the development of a new

ECAD system. The architectural basis for this new package will be the CAD Reference Model developed by Prof. Olaf Abeln and others. We will show how this reference model is planned to be used for this system, and some ideas of implementation will be given. The paper will close with some consideration on variational design within the ECAD applications.

Model Transmutation Product Modelling for DFM and DFA

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National Institute of Standards & Technology, USA

The first release of the international standard STEP (ISO 10303) was made in 1994. The intention of STEP is to permit the exchange of product life-cycle data between different computer-aided design (CAD) systems, or between CAD systems and applications downstream of design. Its development started in 1984, and for a number of reasons the first release of STEP does not reflect all the developments in CAD technology which have occurred since that time. In particular, modern CAD systems provide the means for parametric, variational and feature-based design, while STEP makes no provision for the capture and transmission of the information associated with those activities.

A project has recently started within the STEP development community (ISO TC184/SC4) to seek methods of handling these new kinds of data. Such methods should preferably be compatible with the infrastructure underlying the standard, particularly the information modelling language EXPRESS which provides means for the formal definition of the data structure and schemes used by STEP. The extension is not proving easy. Some proposals stretch the representational capability of EXPRESS to its limits while others require changes to the language. These proposals are being evaluated to determine the best direction to take.

The talk described the current situation, the problems encountered, and the setting up of liaisons between ISO and various external projects and CAD vendor companies. The intention is to picture several threads in parallel, and to channel all the results into the ISO effort in the interests of rapid movement towards enhancement of STEP for compatibility with current CAD technology.

Product Modelling for DFM and DFA

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Cranfield University, UK

DFM and DFA are now established as important tools in industrial implementation of concurrent engineering. Initially the methodologies were delivered through paper based systems, latterly many of them have been encapsulated in software. Integration of such design evaluation tools into the CAD environment has been desirable for several reasons. However ,

there are difficulties in getting accurate information from the designer concerning what are essentially manufacturing issues. This paper reports some of the results of a project which aimed to explore an alternative scenario in which data required by a DFM and DFA methodology could be automatically extracted from a geometric / CAD / product model. This work was carried out in a joint investigation by the author and another leading DFM/DFA expert: Prof. K.G. Swift of Hull University, UK. The paper outlines the requirements of DFM and DFA, gives an assessment of the capabilities of 'state of the art CAD systems', and describes the need for development of new techniques and algorithms. Some details of the research response so far are given along with indications of necessary future research directions.

Stability Features for Free Form Surfaces

Hans Hagen
Universität Kaiserslautern, Germany

In CAD/CAM technologies the design of free form surfaces is the beginning of a chain of operations that ends with the numerically controlled NC-production of the designed object. An important part of this chain is shape control. A new aspect of shape control is the stability of a surface. In this contribution stability conditions based on the concept of infinitesimal bendings are presented.

Towards Parametric, Variational and Feature Approach Unification

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Currently, the „Variational" and „Feature" techniques are only considering 2.5D problems. Complex free form design is never taken into account. Based on a „control process" technique applied to the parametric model (history graph), a method that could unify parametric, variational and feature approaches is presented. The unification could have as one result the handling of complex free form design. Assumptions to be proven and problems to be solved are discussed, as well as the different global implementation steps.

Feature Conversion

Willem F. Bronsvoort and Klaas Jan de Kraker
Delft University of Technology, The Netherlands

A new approach to feature modelling is presented that supports multiple feature views of a product, each with its own feature model. Feature models are specified declaratively, and

model validity in each view is maintained. Consistency between the views is maintained by feature conversion.

A feature model is represented at two levels: feature and evaluated geometry. At the feature level, a shape type and validation constraints are combined in a generic feature definition, specified in an object-oriented language. Each view has its own extendible sets of generic features and feature instances. At the evaluated geometry level, a central cellular model is maintained, that stores all feature intersections. The cellular model is used to link the views. A feature model is validated by maintaining all constraints specified in the view.

The product model, which contains each view's feature model, is initially specified from one view: generic features are instantiated by specification of parameter values. When another view is opened, feature conversion is performed using the central cellular model and view-specific information. Modifications can be made in all views by changing feature parameters, and by adding or deleting feature instances. The constraints in all views are maintained simultaneously by the modelling system. Feature conversion thus propagates changes between views, maintaining consistency between all views.

Feature Recognition from CSG

John Woodwark
Information Geometers Ltd., Winchester, UK

Spatial division techniques are an efficient way to process CSG models, without losing the robustness of the set-theoretic representation. Both graphics and geometric properties can be obtained in this way, without ever computing a boundary structure.

The recursive division paradigm can be enhanced by extending the division process to involve variables in addition to the spatial dimensions. For instance, variables representing:

- Translations
- Rotations
- Parameterizations

By searching the resulting multi-dimensional spaces, and using appropriate new criteria to terminate the division process, several significant problems can be attacked:

Feature recognition can be performed as a purely spatial matching process. This approach is particularly appropriate for problems like gripper placement, where FR methods based on recognising sub-graphs in a boundary structure are totally inappropriate.

Parameterized features can also be matched, offering solutions to problems like: „What is the biggest cylinder (e.g. hydraulic reservoir) that can be fitted into this existing assembly; where will it go and what should its dimensions be?"

Packing problems can be attacked, although the combinatorial aspects of packing is not addressed.

Minkowski sums can be computed, including offset volumes and some sweeps.

Configuration diagrams can be obtained for moving objects. By searching these, allowable states of mechanisms can be found, within which paths can be traced.

All these applications have been demonstrated using a multi-dimensional version of the svLis kernel modeller.

Multi-dimensional division is potentially expensive but, even using a naive approach, small but non-trivial three-dimensional examples can be computed within a matter of minutes on a workstation. New methods of focusing the division process are being implemented. They promise to allow further problems involving higher dimensional spaces to be addressed, and offer the potential of interactive performance on CAD tasks such as checking hand-tool access, which are difficult to perform by any existing methods.

Integration of Design by Features and Feature Recognition Approaches in an Open CAD Framework

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A research project in the field of feature-based modeling is currently carried out at the Instituto per la Matematica Applicata del C.N.R. in Genova, Italy, in collaboration with the Fraunhofer Institut für Graphische Datenverarbeitung in Darmstadt.

The aim of this project is the realisation of a system which integrates two different approaches for feature-based modelling, called design-by-features and feature recognition. In such a system the user will have the possibility to generate the feature-based product description by using both features and geometric primitives and to map feature-based description between different application contexts through a feature conversion mechanism.

A new generation of more intelligent CAD systems exploits the potential of features, considered as communication link between the application and the geometry worlds since they associate a functional meaning to geometric and topological information within a product description.

A feature based model can be created by following two different approaches: design-by-features and feature recognition. Using the first strategy the user creates the object model directly with features, while in recognition feature information are extracted from the geometric model of the part.

The main limits of these two methods are that, on one hand, design features can be different from the features of interest for a given application, on the other hand, no feature recognition algorithm can capture the designer's intent. As a consequence, the solution to efficient feature-based modelling seems to be a combination of the both strategies.

In this project the integration has been realised through the definition of an intermediate representation which is shared by the recognition and the design systems and from which a feature conversion mechanism, based on recognition techniques, can derive different application dependent representations.

A feature recognition system which has been developed at IMA in the past has been partly re-designed and extended in order to be integrated in the global system. Thus, the intermediate model has been defined taking into account the requirements from the design, the recognition and the conversion mechanisms viewpoints. The defined model is a hierarchical graph which stores features entities relations which express the feature semantics as well as topological relations in order to perform geometric reasoning. From the application viewpoint, manipulations on the model are performed by the feature converter, which maps the intermediate model into different contexts dependent feature based models.

The realisation of the system is currently under development, it is implemented in C++ on top of the commercial solid modeller ACIS which supports non manifold geometry.

Consistency Management Feature-Based Parametric Design

Ana Vieira and Gino Brunetti
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Current research and development in Computer-Aided Design (CAD) is concentrated on advanced product modelling methods and tools for providing systems with facilities to capture the *engineer's design intent* and to support the *generation of model variations*. One of these methodologies is *Feature-based Design*. Features have been identified in the engineering community as meaningful abstractions with which humans can reason about products and processes. From the designer's point of view, features are seen as functional design primitives, which complete the traditional representation of a product with more semantic information. The use of these design primitives helps to improve not only the design quality, but also to reduce the product design costs and the product time-to-market. It also allows to link different phases of the product life cycle, such as process planning and manufacturing.

Feature-based design can be seen as one of the phases of a concurrent product development process. In this context, two kinds of a data transfer must be taken into consideration: an horizontal data transfer (during the design stage, between designers and engineers) and a vertical data transfer (from design to downstream phases). Both must preserve continually the semantics of the model expressed by features. This necessity leads to the development of a *consistency mechanism* able to check the *semantic correctness* of feature-based models. This mechanism is one of the main challenges to be solved in the design-by features approach.

Design features are defined by two main components: engineering semantics and form. Engineering semantics describe the meaning and behaviour of a feature in a certain environment. The form describes the geometry of the feature. The parameterised form is then evaluated to the shape of the design feature. A potential approach to express and preserve both semantic and form is the association of different kinds of constraints within the design feature definitions. A first analysis of these constraints classifies them as semantic and geometric

constraints. *Semantic constraints* are used to express and preserve the engineering meaning and behaviour of a feature. *Geometric constraints* are used to define the form of a feature.

Shapes are represented by entities of a solid modeller. The dynamic integration of the feature-based model and the solid model is done by relational model based on algebraic geometry. Within this model, feature forms are represented by algebraically described feature entities. The parametric dependencies within the form of a feature and between features are described by geometric constraints which are expressed as spacial relations between feature entities. The relational model and the interactive manipulation of semantic and geometric constraints are essential for the development of a consistency mechanism to preserve the semantic correctness of the whole feature-based model. They also support the interactive definition of the design features during the design process.

Semantic and geometric constraints work on the basis of a parametric description of features. Parameters are also required for an additional purpose. In fact, the design of a product typically needs a lot of changes before all the requirements imposed by engineers and clients are matched. In many cases, the formulation of different product model configurations is based on pure variations of some model parameters. This leads to a demand for efficient methods to support the generation of model variations in feature-based design systems. The integration of the feature-based design and the parametric design methodologies is the basis for the development of a system where the already mentioned requirements can be satisfied: (1) capture of the engineer's design intent using design features, (2) guarantee of semantic correctness of feature-based models, and (3) generation of model variations. We call this integration *Feature-based Parametric Design (FbPD).*

EREP Project Overview

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EREP - Editable representation, addresses the need to derive a neutral CAD representation that can form the basis of interoperability. After reviewing the basic rationale and objectives of the project, some of the technical issues are explained, including multiplicity of solutions in constraint solving orientation difficulties for reference constructs, persistent naming, and the semantics of feature attachment. Solutions to these problems are explained. Then we preview future developments to derive a systematic concept of features that embodies non geometric and validation information and constraints. We explain some ways in which these notations can be neutrally realised.

Development and Implementation of a Feature-Based Design System for an Industrial Application

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A great number of companies own CAD and CAM software, and these are not usually integrated. In other words, the activity of Process Planning, which is vital for linking CAD to CAM, is carried out manually in these companies. This problem motivated the GRUCON group to develop a CAD/CAPP/CAM system. This software referred to as „Manufacturing Support System for Process Planing (MSSPP) is being developed in co-operation with „Schneider Logemann Cia."(SLC), a company that manufactures machines for agricultural harvesting and planting. This paper aims at presenting the CAD module of MSSPP, which is based on features. This CAD module is used for modelling the company's parts in the computer. Also, a description of the methodology applied to the development of the CAD system is given. Moreover, the graphical interface for part design is shown. Finally, the communication between the CAD and CAPP modules is presented.

Context independent Classification of Protrusions and Depressions for Flexible Feature Recognition

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The importance of feature-based modelling for the realisation of CAD systems able to support the product design in all its different phases has been widely recognised. The main approaches for feature based modelling are: design-by-feature, feature recognition from traditional CAD models, and some combinations of them. Systems based on the first approach allow the user to model the part directly with features. Design-by-feature approach is efficient but has the disadvantage that the product feature-based representation depends on the set of features which are provided by the system. With feature recognition features are identified from the object solid model. This process is based on geometric and topological analysis of the parts and can be easily adapted to different application contexts. Limits of this approach are that, in general, it is not possible to recognise the designer's intent and that the domain of recognisable features is limited, for example interacting features are difficult to be recognised. Systems which combine the two approaches try to take advantage from both while overcoming their disadvantages. In such a system, the role of feature recognition is to maintain consistent the feature-based description of the object when the solid modeller is used and to provide different context dependent feature-based models of the product.

In this paper, a method for context independent classification of generic protrusions and depressions is presented. This classification is the result of shape analysis based on geometric and topological reasoning and can be performed on any face set of the object B-rep which has

been previously recognised as local concave or convex area, respectively depression and protrusion. This classification has been introduced with the aim of supporting application dependent feature recognition, within an integrated feature-based modelling system which is under development at the Instituto per la Matematica Applicata del CNR, Genova, in co-operation with Fraunhofer Institut für Graphische Datenverarbeitung, Darmstadt.

The proposed classification, which has no limited domain, allows the recognition of classes as well as specific instances of feature which can be performed at different levels of details according to the application context and the user's requirements.

A Constrain Solver for a Conceptual Design System

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The constraint problem, here, is expressed by geometric objects (the variables) and geometric relations (constraints) between them. The objects and relations are expressed as the nodes and arcs of a constraint graph.

We developed a graph-based algorithm to find an embedding of the constraint graph, which is expressed symbolically as a sequence of geometric construction operations.

The approach is very suitable for conceptual geometric design, since it allows users to define shapes by combining constraint definitions and geometric construction operations in arbitrary order.

Transfinite B-Spline Interpolation with Derivatives

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Cross-sections are very often used to define complex shapes. We present a method which analysis a given grid of B-spline curves to determine cross-boundary derivatives, such that G1 (or G2) continuous surfaces interpolating the given curve grid can be calculated. The transfinite (curve-interpolation) Problem is converted to an equivalent point interpolation problem, with well known solution algorithms.

Handling Very Complex Environments using a Discrete Visibility Graph

Isabel Navazo and Sebastia Vila
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The visual navigation and interaction is a real problem when we are handling scenes with a large number of elements (polygons). An algorithm which allows to compute a week visibility graph of a large scene based on its discretization by means of a regular grid is described. The algorithm computes the visibility graph for the discrete scene using a new approach for the cell to cell visibility test and an auxiliary quadtree for the hierarchical computation of the graph.

The simulation shows that the use of the graph speeds up the visibility of the discrete scene by 75 % in grids with a density of block nodes up to 30%.

Blending Between two Parametric Surfaces - A Case Study

Xiaolin Zhou and Dieter Roller
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Construction of blending surfaces plays an important role in computer aided geometric design. There have been already some mathematically well-defined blending algorithms in use, such as the rolling ball method. But most of them are very time consuming and therefore not suitable for the cases where stringent speed requirements must be meet like for a fast preview.

In this paper we introduce a method to generate a blending surface between two parametric surfaces. We focus on the flexibility, ease of implementation as well as speed, not on the mathematical precision. This method consists of two phases. In the first phase, the linkage curves which bound the blending surface are defined. Here, we use the intersection of the parametric surfaces as a reference to determine the linkage curves. In the second phase, the blending surface between the linkage curves are generated. Thereby a certain condition of continuity is fulfilled. This method is independent of the form of the underlying surfaces and can be easily implemented using the programming interfaces provided by the most geometric modellers.

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