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METODOLÓGIA VÝVOJA APLIKÁCIÍ STEP/EXPRESS PRE OBLASŤ NAVRHOVANIA TECHNOLOGICKÝCH POSTUPOV

METHODOLOGY FOR THE DEVELOPMENT OF STEP/EXPRESS APPLICATIONS IN THE AREA OF PROCESS PLANNING

Článok sa zaoberá výskumom týkajúcim sa vývoja generickej metodológie, ktorá umožňuje interakciu modelov založených na STEP/EXPRESS a nástrojov na špecifické aplikácie navrhovania technologických postupov.

The paper deals with the research related to the development of a generic methodology which enables the interaction of STEP/EXPRESS based models, and tools for specific applications in the area of process planning.

1. Introduction

In order to develop a CAPP application, the main problem is to develop a system for extracting CAD information that can be used by the process planning application. At present, the current CAD systems are AutoCad, PRO//Engineer, and CATIA that run on different hardware systems such as PC and graphical workstations. There are many widely used methods for extracting information from solid models. Two of the most commonly used techniques are Constructive Solid Geometry (CSG) and Boundary Representation (B-Rep) modelling. These representations are complete and unambiguous, and represent an object in 3D space. However, solid modellers do not link low level geometric and topological entities with the technological information necessary to CAPP systems. Some of the currently available CAPP systems that use solid modelling techniques require extra information to be added manually.

Research has been focused on the aspects of feature modelling, feature extraction and feature refinement, using solid modelling as a basis to create/extract the feature data and knowledge.

Since the creation of the STandard for the Exchange of Product Model Data (STEP, ISO 10303), a new methodology for the development of CAPP systems could be approached. ISO 10303 is an international standard to provide an unambiguous representation and exchange mechanism of computer-interpretable product information throughout the life cycle of a product [1]. The standard aims at being generic and it is a framework for representing information, and knowledge, and exchanging/sharing this information. Also, it is an *Open Data Standard* that gives

the user back the control of his data. The first released version of STEP has been operational since 1994.

2. Overview of STEP and EXPRESS

STEP can be defined as a neutral product model data exchange mechanism that is capable of representing product, and it is intended to be informationally complete for all engineering applications. STEP is organized by three layers: application, logical and physical [1].

The *application layer* develops some models specific to applications.

The *logical layer* uses *EXPRESS*, *EXPRESS-G* (the graphical subset of the *EXPRESS*) and *EXPRESS-X*, which are data descriptive languages developed in order to define entities and their relationships and to describe the models physically implemented by a schema.

The *physical layer* provides data structures to meet data sharing and communication needs.

2.1. STEP - Fundamental Concepts

- Application protocols:

The specification of an application context and the data constructs that are required for product data exchange. Therefore, an application protocol is the specification of the product-

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related data constructs, which are supported according to the implementation methods.

- **Integrated resources:**
The application-context-independent data constructs which constitute the minimal set of entities that are used by all application protocols.
- **Description methods:**
Common mechanism for the specification of data constructs of ISO 10303.
- **Implementation methods:**
Standard implementation techniques for the information structures defined in the application protocols.

Step Components

Table 1.

Part 1	Overview and fundamental principles
Part 11	Description methods: EXPRESS language
Part 21	Implementation methods: clear text encoding of the exchange structure
Part 31	Conformance testing: general concept
Part 41	Integrated generic resources: fundamentals of product structure configuration
Part 42	Integrated generic resources: geometric and topological representation
Part 43	Integrated generic resources: representation structure
Part 44	Integrated generic resources: product structure configuration
Part 46	Integrated generic resources: visual presentation
Part 101	Integrated application resources: draughting
Part 201	Application protocol: explicit draughting
Part 203	Application protocol: configuration controlled design

- **Abstract test suites:**
Provide data used to test the conformance of a given implementation of ISO 10303.

2.2. STEP - General Organization and generic product models

According to the fundamental concepts, the current version of the standard is formed by the components presented within table 1.

Based on the fundamental concepts the generic product model has been developed as it is described in detail within reference [1]. The model has been designed and implemented using the integrated resources of STEP.

It consists of generic entities which are well defined by the EXPRESS language in STEP [1]. Generally, a product model called also a generic product model (GPM) can be adapted for

any applications. Furthermore, GPM provides a complete product description according to STEP. The product models can be used to integrate different software systems.

2.3. Some Aspects regarding EXPRESS Language

The development of STEP required a method of modelling the information relationships that should facilitate the task of data transfer and storage. The EXPRESS information modelling language has been developed and it is used throughout the STEP standard.

EXPRESS is a complex language when taken as a whole. However, a lot of it is quite simple and once the fundamentals have been mastered, the difficult parts fall into place. The fundamentals are as follows:

- **SCHEMA** represents a wrapper for collections of related information;
- **ENTITY** is the logical definition of an object which represents a real world object;
- **ATTRIBUTE** defines the property of an object;
- **TYPE** is the representation of value domains;
- **RULE** defines handling of full and partial constraints.

Other aspects of EXPRESS include:

CONSTANT FUNCTION
PROCEDURE executable
STATEMENT

Programming in EXPRESS language is based on the definition of SCHEMA and all the declarations must occur within a schema. EXPRESS-G allows a graphical representation of schema.

EXPRESS-X specifies the conversion of information from one structure to another. The conversion is defined as mapping.

The EXPRESS language can be used outside the STEP standard.

3. Development of STEP/EXPRESS Applications

The research regarding the definition of a unified methodology for the development of applications in the area of process planning is directed to investigate the following aspects:

- Complex structures defined within the EXPRESS environment are very difficult to understand unless deep knowledge of the structure has been achieved. Application programming using STEP/EXPRESS tools is, therefore, a specialized task. The problems are: *how to extract, manipulate and use the information included in the physical files used to transfer the product information.*
- The main direction could be the creating of specific programs to interact with the information using probably one of the many EXPRESS tools available on the market (National Institute of Standards and Technology and/or PDES/STEP Tools Inc.'s) Using these tools, the EXPRESS schema for the Application

model is converted into an appropriate language which should be used to manipulate the Physical File information.

- EXPRESS language is a relatively Object-oriented language, and the schemas could be translated into C++, CLOS, Smalltalk. Depending on the toolkit the information is either stored interactively within the computer or uses an object-oriented language.
- In some situations the software developer should need to know what information structures and entities are defined within the EXPRESS schema. This problem is then doubled if a further schema is also required to be accessed within the application. It is envisaged that some form of generic tool should be required to query the physical files allowing non-EXPRESS users to develop applications that utilize the physical file information. This tool would be built upon one of the available EXPRESS toolkits employing an Object-Oriented programming language and using an X-based graphics toolkit for extra data input/output. The tool would be graphically and icon driven using a pseudo EXPRESS-G structure to allow non-EXPRESS users to visualize and access various physical file information constructs. Also, the tool would allow mathematical manipulation of information, checking of the physical files to make sure that required entities for the application are present, development of windows for input and output of relevant data, the creation of new physical files for use in other applications and allow for queries of more than one physical file at any time.
- Due to the way the NIST toolkit has been written, it is essential to know which schemas will be required within a certain application. Once the schema libraries have been written, the compilation of the EXPRESS-G Query Program can go ahead. This will allow the access to the schema structures as required as well as access to the physical files of the schemas.
- The application program itself should be a combination of C++ standard functions with the NIST toolkit functions.
- The STEP standard only defines the data required for Product Data. Several applications such as Process Planning require Manufacturing Data. A provision has been made within the STEP standard but it is limited to passing the title of the operation as well as a text description of the process. The Manufacturing data that is required is purely based on the resources available within most factories: for example machines, both computer controlled and manual, robots, flexible manufacturing cells, assembly processes, for example welding, gluing etc, as well as people. Each of these resources has various limitations. In the case of machines, some of the limitations are: size of raw material, component that can be machined safely, surface finish capability (related for both tool type and the speeds and feeds of machining) and machining tolerances (for example parallelism, cylindricity, perpendicularity, etc.) It is, therefore, envisaged that the EXPRESS-data modelling language to be used in order to develop a manufacturing resource model for including costs, possible tolerance limitations, features which can be manufactured, etc., which would enhance the functionality of the STEP environment.
- Assuming some forms of STEP data in the required form is available, how to use the Application program created in conjunction with the CAD system to allow an integrated CAD/CAPP/CAM system to be developed. Using a CAD system that uses features as a basis for developing solid models initially, it will be necessary to convert the data stored into STEP data conforming to the required parts of the standard.
- Some form of STEP data in the required form is available. Application program created in conjunction with the CAD system allows developing an integrated CAD/CAPP/CAM system. Using a CAD system that uses features as a basis for developing solid models initially, it will be necessary to convert the data stored into STEP data conforming to the required parts of the standard.
- Exchange product knowledge between different hardware/software systems in order to create a distributed process planning system which could use the Internet environment to communicate.
- Within the STEP standard the dynamic data exchange could be defined. However, a real progress in dynamic data exchange and communication has been made by VRML (Virtual Reality Modelling Language) that creates the background for the development of collaborative engineering systems

4. Conclusions

Several STEP/EXPRESS applications are still under research, and in the development phase.

Some projects supervised by the National Institute of Standards and Technology are presented at <http://www.mel.nist.gov/div826/msid/sima/projectmap.html>.

Other useful Internet addresses are as follows:

<http://ts.nist.gov/ts/htdocs/210/216/216.htm>

<http://www.prostep.darmstadt.gmd.de>

<http://www.steptools.com>

<http://www.epmtech.jotne.com/learn/index.html>

<http://bbbsr1.bau.tu-dresden.de/sphinx/anonymous/card/STEP>

<http://wwwcib.bau.tu-dresden.de/~rainer>

Based on the development and research directions presented in the paper it is possible to use STEP/EXPRESS within a practical framework such as a process planning application. However, a unified and generic methodology for STEP/EXPRESS applications is still under research and there are a lot of tools commercially available in order to build applications. Further research will approach in detail the development and the implementation of STEP/EXPRESS process planning applications based on the methodology outlined in this paper.

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5. References:

- [1] GU, P., NORRIE, D.H.: Intelligent Manufacturing Planning, Chapman & Hall, UK, 1995.
- [2] KURIC, I., DUDA, J., NEAGA, I.: Integration of CAD, CAD/CAM, and CAPP systems by means of Step for`mat. NOVÉ SMERY VO VÝROBNÝCH TECHNOLOGIÁCH, IV.INTERNATIONAL CONFERENCE, 17 - 18. 6. 99, Presov, Slovakia, pp. 359-361.
- [3] NEDERBRAGT, W., ALLEN, R., FENG, S. and col.: The NIST Design/Process Planning Integration Project. Proceedings Artificial Intelligence and Manufacturing Research Planning Workshop, State of the Art & State of the Practice, Albuquerque, USA, 1998, pp. 135-139.
- [4] PRATT, M. J.: Extensions of the Standard ISO 10303 (STEP) for the Exchange of Parametric and Variational CAD models. Proceedings of the 10th International IFIP WG5.2/5.3 Conference PROLOMAT'98, at <http://www.mel.nist.gov/publications>.