



BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
FACULTY OF MECHANICAL ENGINEERING

**ADAPTATION OF THE “REVERSE ENGINEERING”
METHODS IN NC TECHNOLOGY PLANNING**

Theses of Ph.D. Dissertation

ATTILA FRIEDRICH

Supervisor: Dr. Gyula Mátyási

New academic results

1.

I examined the literature for the procedures and models regarding the reverse engineering processions. Confronting the models to my requirements from the special point of view of the reconstruction of simple mechanical parts, I examined the validity, the applicability and the efficiency of these classical models. I found out that the structural set-up of the examined models could not allow for the duplex information flow between the sub-processes, furthermore, the set-up of the formulated geometrical model is not appropriate regarding to the set of criteria defined before. Because of the above mentioned facts, the quick and simple applicability of the features is limited.

1. Thesis. I worked out a procession model for the quick and severe technology-based reconstruction of the simple mechanical parts. Contrasted to the known models from the literacy, my model could take into consideration the application-specific characteristics, and generates a structural geometrical model by integrating the sub-processes into a complex set-up based on the reconstruction of the machining features. My worked out procession model is as follows:

- 1.1. by the novel pre-processing course, my model is collecting information about the unknown object based on digital images, making the clear and definite input and output parameters of the further sub-processes; using this, I made each and all of the sub-processes designable, which is heavily supported by the feedback inside the procession;*
- 1.2. by the iteration of the process I made the self-organisation of the sub-processes and the processing based model-level intervention possible;*
- 1.3. I defined the sub-processes of the measurement process for general cases of the direct reconstruction of the MRSEV (Material Remove Shape Element Volumes) feature classes, and I defined the exact geometrical and measurement algorithm for the reconstruction of the measuring trajectory; and additionally*
- 1.4. I formulated on the output model those important characteristics, which provide sufficient information for the planning of the NC technology on the defined level (operation planning, operation-element planning)*

My first thesis based on chapters 2-4 of my dissertation and on the publications number [3], [6], [7], [9], [11] and [15].

2.

I found out that the geometrical model generated by the classical reconstruction method doesn't carry any additional information for the efficient realisation of the total reconstruction. The output model doesn't support the posterior model-level editing, and additionally the parameterisation is very difficult. Because of this, during the last phase of the reconstruction it is practical to perform an additional examination on the output model from the predefined aspects.

2. Thesis. *I defined a structured, parametrical, feature-based integrated geometrical-technological model, which provides sufficient information for the modern CAD systems, matching with their hard requirements. My model consists of exactly defined machining features. The structure of the reconstructed model consists of the stock, and the models of each machining feature. Resulting from this I provided that all of the posterior editing should be performed only on the model of the features, which is available in parametric form. Because of this in most of the cases it is not necessary to handle the whole complex model in a CAD system.*

- 2.1. *During the reconstruction, I did not define a general geometrical model, but I focused on a reconstruction of a set of features, which directly supports the planning of the NC technology. When I reconstructed the total machining features instead of the reconstruction of simple surface representations, beyond the simple geometrical parameters I could get additional important technological information. Making the hierarchical relations between the different features, I could directly calculate the maximal measurement and the trajectory of the machining tools, which are necessary to cutting out the shape of the machining features.*
- 2.2. *I defined the machining features as delta volumes, which were determining the manufacturing technology, determining the requirement for the machining machine, and furthermore providing additional important information for the planning of the operation and for the planning of the operation-elements. By exactly defining the hierarchical relations between the features and defining their precedence conditions I got some additional important technological information like the permitted tool overrunning zone and starting positions.*
- 2.3. *Working out a frame system I certified that the structure of the reconstructed model has an effect on the planning of the manufacturing process (time, cost). Because there is a significant difference when the planning of the manufacturing is based on a complex model or based on a set of machining features. The geometry of my reconstructed machining features is representing a part of a space, which should be skimmed internally for the technologically correct manufacturing of the object (tool overrun, islands, etc.).*

My second thesis based on chapter 5 of my dissertation and on the publications number [4], [8], [9], [10], [13] and [14].

3.

I examined the possibilities provided by the classical method for the managing of the degenerations of the model and I found out, that the elimination of the degenerations using the mathematical-programming model is very difficult and complex in cases of simple objects so far. Using simple feature primitives it is far clearer and transparent, if we are looking for the solution based on discreet relations which are determined from predefined point of views.

3. Thesis. *Using a set of conditions built on discreet rules I adapted the simple relation-managing and – detecting algorithms for efficient managing of the degenerations in cases of complex mechanical parts which consist of simple feature primitives. Based on technological consideration I confirmed that the output models (geometrical-technological) generated using the performed examinations based on the above mentioned discreet rules has a beneficial effect on the discretion of the manufacturing technology, respectively on the planning of the whole NC technology. In the course of using these discreet rules I defined an alternate approach, in which I defined the programming process by tolerance-technical and technological aspects.*

- 3.1. For solving the problem of the degeneration management I worked out a two-step corrective algorithm, which is in the first step only analysing the reconstructed machining features (local degeneration management). Since I stored the features in parametric form, the modifications could be performed on the parameters themselves, known as variables. In the second step of the degeneration management I examined the set of features in global level.*
- 3.2. Defining tolerance-technical attributes (perpendicular, parallelism, etc.) the technology, the set-up of conditions for the machining machine and the cutting tools could be chosen more exactly.*
- 3.3. Finally I defined a structure of a dynamic graph as a result, which uses the machining features supplemented tolerance attributes, and storing the constraints between them.*

My third thesis based on chapter 6 of my dissertation and on the publications number [10], [12] and [15].

4.

4. Thesis. *Using the method described in the above mentioned 3 thesis, I created a prototype application for the presentation of the applicability of my model. The input of the system was the set of digital images of an unknown object, and on the one part the output was the geometrical-technical model of the reconstructed machining features, and on the other part the set of important technological information. For the storing of the geometrical representation of the model I did not choose the IGES or VDAFS interface formats, because they were not able to store information about the features. Instead of them I chose the native format using OLE (COM) interface channel (e.g.: STEP interface format). The main characteristics of my software:*

- *based on digital image information, my program automatically generates the set of measuring points of bottom surfaces and the trajectories of the probe, and generate the raw skeleton of the features. Based on this information my software could calculate the set of measuring points of the characteristic curves and necessary trajectories of the probe.*
- *based on the above defined information it could generate the set of correct machining features and the local and global relations between them by managing the degenerations*
- *based on the hierarchy of the features and the precedence conditions my software calculates automatically the maximal size of the tool, and correcting it based on the connected tool database, and after that it could determine the cutting tool trajectories*
- *my software assures the automatic checking of the eligibility of the final model*
- *supporting the further analysis (e.g.: FEM) it defines not only the machining feature based final model of the object, but also defines the B-rep format of it.*

My fourth thesis based on chapter 7 of my dissertation and on the publications number [9] and [11].

Publications by the author

- [1] Dr. Zatykó Sándorné, Friedrich Attila, Krikler Róbert: **Szabadformájú felületek rekonstrukciója, ellenőrzése**, *microCAD '99 International Computer Science Conference*
- [2] Dr. Mátyási Gyula, Friedrich Attila: **Újlevű mérési és megmunkálási stratégiák a „Reverse Engineering” alkalmazásakor**, *microCAD '2000 International Computer Science Conference*
- [3] Dipl.Ing A. Friedrich: **Reverse engineering mit Anwendung des symbolischen Modells**, *Forschungsergebnisbericht TU-Dresden, 2001. pp. 11-17*
- [4] Dr. Mátyási Gyula, Friedrich Attila: **Felületszegmentálás módszere modell-rekonstrukció esetén**, *GTE Gépgyártástechnológia A Gépipari Tudományos Egyesület műszaki folyóirata (2001. október)*
- [5] Dr.Ing. Schöne, Dipl.Ing. Friedrich: **Anwendung der Flächensegmentierung bei der Modellrekonstruktion**, *Werkstatstechnik online Springer, 2002. Március*
- [6] Dr. Mátyási Gyula, Friedrich Attila: **Pontsorozattal definiált 2D-s kontúrok approximációjának vizsgálata**, *GTE Gépgyártástechnológia A Gépipari Tudományos Egyesület műszaki folyóirata (2002)*
- [7] A. Friedrich, Gy. Mátyási: **Interactive reconstruction of geometric models based on a set of discrete measured points**, *Third Conference on Mechanical Engineering 30-31 May, 2002 Volume 2 pp 530-534*
- [8] A. Friedrich, Gy. Mátyási: **Problems of the full-reconstruction of simple geometrical elements**, *microCAD '2003 International Computer Science Conference 6-7 March 2003, Section M: Production Engineering, Manufacturing Systems pp.167-172.*
- [9] A. Friedrich, Gy. Mátyási: **Pre-defined geometrical model of reverse engineering in case of simple mechanical parts**, *7th IFAC Workshop on Intelligent Manufacturing Systems 6-8 April, 2003 pp. 67-72*
- [10] A. Friedrich, Gy. Mátyási: **Post-processor generator for creating parametric cad models by using reverse engineering method**, *4th International Conference of PHD Students 11-17 August, 2003, Section: Engineering Sciences II pp 165-170*
- [11] A. Friedrich, Gy. Mátyási: **Creating parametric structured model by using reverse engineering method**, *Fourth Conference on Mechanical Engineering 27-28 May, 2004 Volume 2 pp 638-642*
- [12] A. Friedrich, Gy. Mátyási: **Controlling of model-degeneration on local and global levels in reverse engineering concept**, *5th International Conference of PHD Students 14-20 August, 2005, Section: Engineering Sciences I pp 55-60*
- [13] A. Friedrich, Gy. Mátyási: **Manufacturing Feature Extraction for Reverse Engineering**, *Budapest, Periodica Polytechnica Mechanical Engineering Series, (elfogadva: 2006. március)*
- [14] A. Friedrich, Gy. Mátyási: **Non-classical Reverse Engineering Concept Based On Machining Feature Recognition**, *Budapest, Periodica Polytechnica Mechanical Engineering Series, (elfogadva: 2006. január)*
- [15] A. Friedrich, Gy. Mátyási: **Integrated feedback measuring sequence for machining feature reconstruction**, *Fifth Conference on Mechanical Engineering May, 2006, (elfogadva: 2006. január)*