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APPROACHES FOR GENERATING 3D SOLID MODELS IN AUTOCAD AND SOLID WORKS

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ABSTRACT:
3D modeling is a superior method of communicating many of the design intents and it is useful in the transmission of knowledge.
Methods for 3D modeling – solid modeling and feature parametric modeling are discussed and are applied for generating real body models. Different variants for translation modeling with CAD systems AutoCAD® and Solid Works® are proposed. The total coefficients of change for solid modeling with both systems are calculated. They do not differ significantly for various variants of both systems. The comparison of both systems showed, that when translation modeling with Solid Works® the total coefficients of change are smaller than these of AutoCAD®. Results can be applied in teaching to students majoring in Technical Documentation and Engineering Graphics.
KEYWORDS:
3D; solid; parametric; modeling; AutoCAD; Solid Works

1. INTRODUCTION

CAD technologies are the biggest engineering accomplishment in 20th century. The use of CAD has significantly increased the last decade in the sector of furniture - in the process of study, drawing and production of furniture [2].

In particular, 3D modeling CAD plays an important role in many newly manufacturing techniques and allows sharing the 3D database of the proposed product. Such, more people can be working simultaneously on various aspects of the design problem. The graphics nature of the database has convinced many that 3D modeling is a superior method of communicating many of the design intents and it is useful in the transmission of knowledge.

3D modeling consists of tool of presentation for many scientific fields. Respectively, in furniture design the presentation of our creation with different kinds of designing ways, in order to give our idea a shape. One of these designing ways is the use of three dimension modeling.

The 3D models are wireframe, surface and solid models [1, 4]. Optimal technique for description with universal character can not be recommended. Two considerations have to be envisaged in the choice of the constructed geometric model: first - planed constructive configuration of the object with a view to fulfillment of given functional, reliable and aesthetical requirements; second – technological methods for its development. The more complex solid shapes are easier for generation and reduction in comparison with wireframe and surface models that is way solid modeling has been imposed in modern CAD systems.

2. METHODS FOR 3D SOLID MODELING

The construction of 3D models can be realized by two schemes: different kind of gauges - Sweeping scheme /S-scheme/; and schemes, based on the volume geometry - Constructive Solid Geometry /CSG - schemes or C – schemes/. The principle of modeling with S-scheme is connected with translation of one 2D or 3D body gauges by trajectory in the space. The solid body is fully defined by the gauges and trajectory. Basic S-schemes for modeling are the translation and rotation modeling. C – schemes are based on solid geometry and represent tree-like structures of three-dimensional bodies. The three-dimensional body is constructed as a combination of primitives by Boolean operations.

2.1. Solid modeling

The solid modeling operates with simple volume primitives /bodies with simple shape and simple mathematical dependence – pyramids, polyhedron, cylinders, cones, spheres, ellipsoids, surfaces and others/, from which the complex bodies are generated by the Boolean operations Union, Subtract and Intersect [4]. 3D transformations also are applied for finally forming of the model. A tree-like structure is received, which “branches” are 3D primitives and ramifications – Boolean operations and/or 3D transformations. The principle of aggregation is used in CAD systems for 3D geometric modeling that use volume primitives, that is the construction of the body realizes by consecutive union or intersection of primitives.

Disadvantage of the Solid modeling method is that after applying of Boolean operations, primitives lose their individuality and difficulties at model reduction occur – in more cases almost impossible.

2.2. Feature parametric solid modeling

The feature parametric solid modeling is a method based on the feature technology, at which the separate elements of the designing product have individual characteristics [1]. The designing process can be represented as a correct sequence of design operations, by which a constructive element with its parameters is constructed. The first object from which the model construction starts is “Base Feature” and it includes 2D sketch with necessary constraints and dimensions. All objects, created after that are “Additional Feature” and different Boolean operations and 3D transformations can be applied to them to finish the construction of the body.

The operation of the systems with parametrical modeling is different from this of the systems with solid modeling. It is required accurate representation of the objects through coordinates. The necessary primitives are sketched in different planes, after which they settled by means of dimensioning and the necessary constraints. The geometric constrains, which can be imposed on, are horizontal or vertical line, identity of geometric figures of the same type, tangency between line and arc or between arcs, coincidence of points of geometric elements, parallelism or perpendicularity of lines, concentricity of arcs and etc. The availability of parametric connections and constraints in the model, of course, is reflected to the principles of its reduction. In every moment it is possible to change parameters of every object (sketch, operation, connections) of the model. After specification of new values of parameters, the model is rearranged in conformity with them. Moreover, all occurred connections in the model are kept. After reduction of the element, a repetition of the sequence for construction of subordinate elements and its parameters is not required. All information for this is remembered in the model and it is not destroyed at reduction of its parts.

3. GENERATING SOLID 3D MODELS IN AutoCAD® AND SOLID WORKS®

AutoCAD® and Solid Works® are used for construction of the real body solid models (Fig.1). CAD system AutoCAD® is an example for using solid modeling method. Except of method described in 2.1, it is possible to create solids with AutoCAD® by extruding 2D primitives (Extruded Solid) or combination of them. Solid Works® is one of leading CAD systems for 3D feature parametrical modeling.

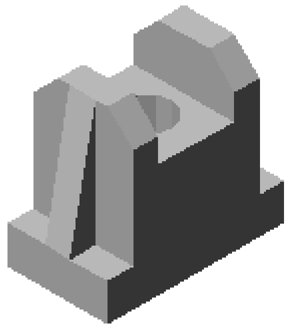

Figure1. Body

For comparison of possibilities of both systems for solid modeling one and the same body is modeled- Fig.1. The consequence of generating a solid model of the body from Fig.1 with AutoCAD® is presented on Fig.2, and for Solid Works® - on Fig.3. The possibilities of both systems allow realizing of three variants of modeling.

For variant 1 of AutoCAD® (Fig.2) the model is generated as a complex body(Composite Solid), which is created from the basic body parallelepiped (Solid Box), cylinder and wedge by the Boolean operations Union and Subtract. In this case, Constructive Solid Geometry (CSG) is applied for generation of the body - the full set of Boolean operations is used and representation is intended for designer, the efforts of which are directed to ensure of characteristics of construction product [4]. For variant 2 and 3 on Fig.2 and variant 1, 2 and 3 on Fig.3 for both systems one of the basic S-scheme for 3D modeling is applied – translation modeling. The principle of modeling is connected with translation (Extrude for AutoCAD® or Extrude Boss for Solid Works®) of predefined 2D primitive – two dimensional contour (Feature in Solid Works®) by a trajectory in the space. For variants 2 of both systems 2D transformation Mirror is used, because the 2D primitive from which the solid modeling starts is symmetrical. Such, intermediate solids are received, on which the equal Boolean operations and 3D reforms are applied – Chamfer, subtract of a cylinder, creation of a wedge, that is all variants are combined in one variant after determined number of actions.

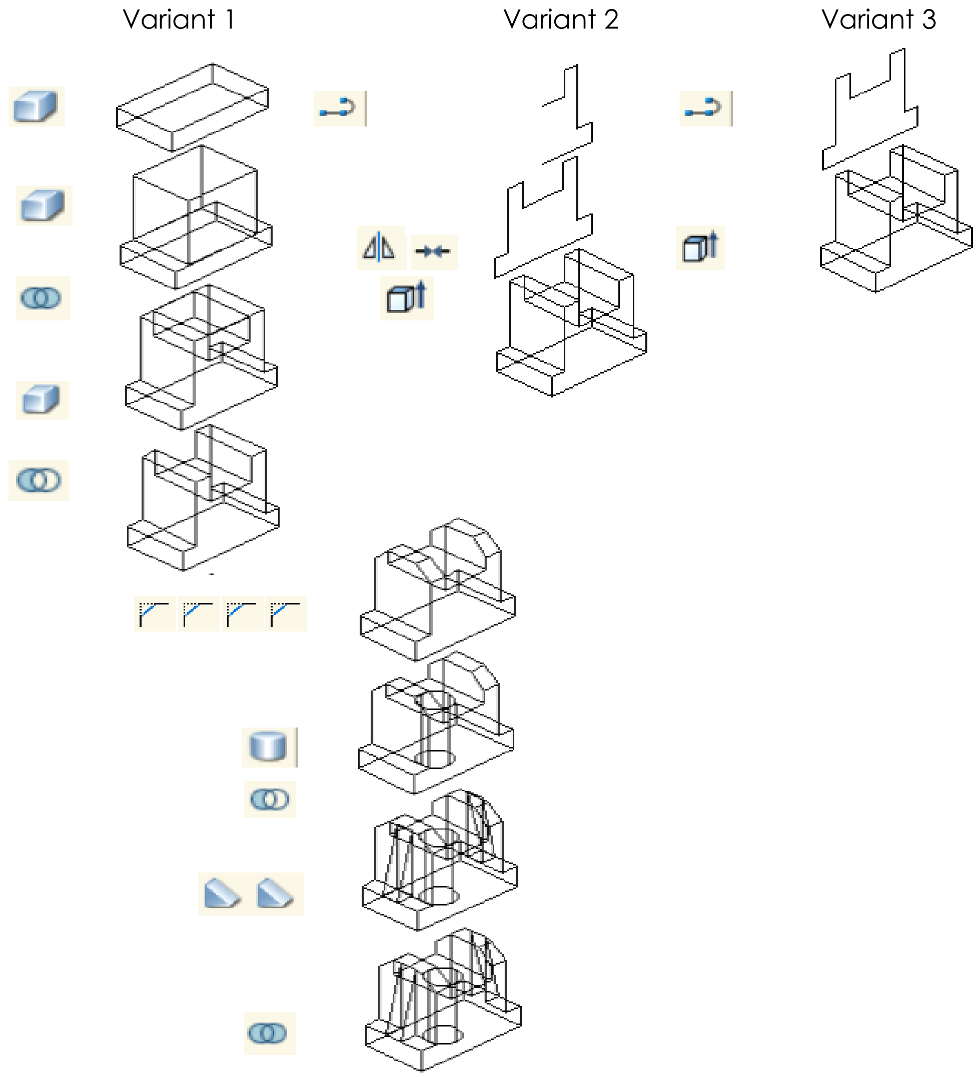

Figure 2. Modeling with autocad

The coefficients of change K_P for every operation of model creation are calculated by the methods of Penev and others [3]. They are shown in Table 1 for AutoCAD® and in Table 2 for Solid Works® for all variants. The coefficient of change is a numerical expression of the possible changes, with which the operator can influence on given primitive or transformation [3]. The sum of the coefficients of change of used primitives or transformations for every variant represents the total coefficient of change - K_P^o. The total coefficients of change K_P^o are calculated and are shown in Table 1 for AutoCAD® and in Table 2 for Solid Works® for all variants.

The total coefficients of change K_P^o for the three variants of AutoCAD® are approximately equal – for variant 1 – 45, for variant 2 – 47 and for variant 3- 45 (Table 1). Only apparently, the variant 3 seems with less numbers of actions.

The total coefficients of change K_P^o for the three variants of Solid Works® are almost equal - for variant 1 – 40, for variant 2 – 42 and for variant 3- 40 (Table 2). The three variants differ only in the consequence of the separated stages – Fig.3.

It is obviously that when modeling with Solid Works® the total coefficients of change are smaller than these of AutoCAD® for all variants (Table 1 and Table 2).

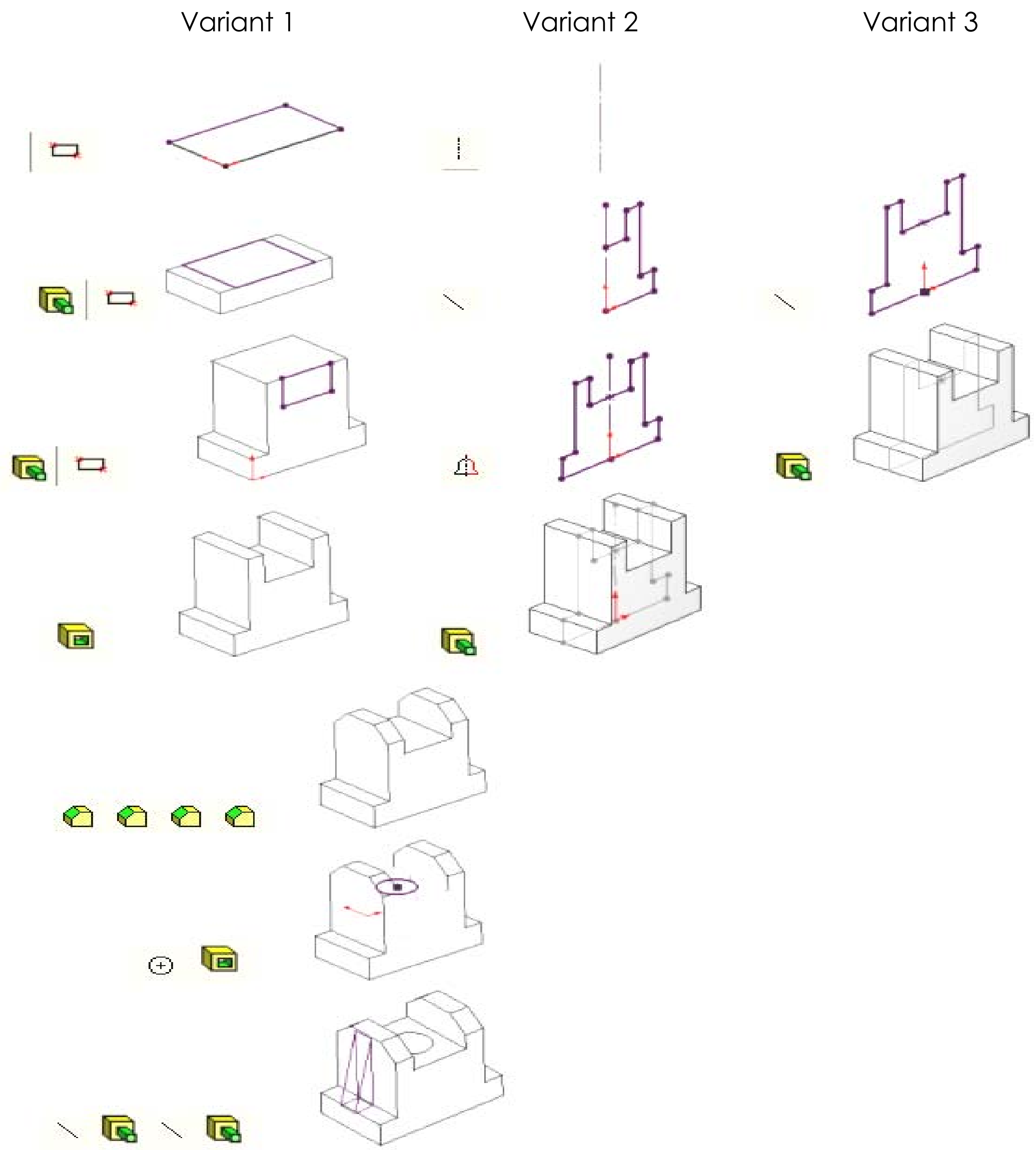

Figure 3. Modeling with Solid Works®

Table1. Determination of K_p^o for Autocad®

Variant 1			Variant 2			Variant 3		
operation	number	Kp	operation	number	Kp	operation	number	Kp
	1	3		7	8		11	12
	1	3		1	3		1	4
	1	3		1	3		4	12
	1	3		1	4		1	4
	1	4		4	12		1	4
	4	12		1	4		2	6
	1	4		1	4		1	3
	1	4		2	6	-	-	-
	2	6		1	3	-	-	-
	1	3	-	-	-	-	-	-
K_p^o		45	K_p^o		47	K_p^o		45

Table 2. Determination of K_p^o for Solid Works®

Variant 1			Variant 2			Variant 3		
Operation	number	Kp	operation	number	Kp	operation	number	Kp
	1	2		1	2		11	12
	1	2		7	8		1	2
	1	2		1	2		4	12
	1	2		1	2		1	2
	1	2		4	12		1	2
	1	2		1	2		2	8
	4	12		1	2		2	4
	1	2		2	8	-	-	-
	1	2		2	4	-	-	-
	2	8	-	-	-	-	-	-
	2	4	-	-	-	-	-	-
K_p^o		40	K_p^o		42	K_p^o		42

4. CONCLUSIONS

Methods for generating solid models of real body in different variants with CAD systems AutoCAD® and Solid Works® are proposed. The possibilities of both CAD systems allow generation of solid 3D models of equal variants.

The total coefficients of change K_p^o for solid modeling with AutoCAD® and Solid Works® are calculated. The total coefficients of change of various variants for both systems do not differ significantly.

The comparison of both systems showed, that when modeling with Solid Works® the total coefficients of change are smaller than that in AutoCAD® for translation modeling.

Results can be applied in teaching technical documentation and engineering graphics to students from majoring in Woodworking and Furniture Production" and Engineering Design in the University of Forestry, Sofia.

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