PERIODICA POLYTECHNICA SER. MECH. ENG. VOL. 36, NOS. 3-4, PP. 239-243 (1992)

THE RIGHT PLACE OF CAD-COURSES IN ENGINEERING EDUCATION[1]

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Received: November 16, 1992

Abstract

An educational conception of teaching CAD for beginners is presented based upon the geometric backgrounds of CAD. Teaching of geometric modelling is proposed as an extension of the fundamental geometry courses.

Keywords: CAD, geometric modelling, engineering education.

Introduction

The first step in a CAD/CAM process is the definition of the model as a geometric object. The actual method of description of the shape depends on the system: what kind of algorithms is implemented for generating the numerical data structure from the input data. The more variety of different shapes allowed, the more flexible is the system. The geometric definition of the same model requires different manipulations at different systems. For example for generating a prism several lines with different attributes have to be given on the screen or a sequence of symbols have to be chosen, or several commands have to be typed, or simply numerical input data are required, however, the geometric data (the base polygon and generating vector) are the same. Similarly, the manipulations required from the user are also different with different modeling systems at a given geometric operation. The used terminology also differs from system to system frequently not corresponding to the correct geometric phenomena. A well educated user who understands the geometric backgrounds of CAD thinks about the modeling process and not about the menu structures or key functions , consequently can use a system effectively.

[1]Supported by Hungarian Nat. Found. for Sci. Research (OTKA) No. 1615 (1991)

Geometric Backgrounds of CAD

The widespreading CAD courses concentrating upon engineering applications show the necessity of knowledge of geometric backgrounds obviously. Namely, working with a 3D modelling system requires the ability of spatial visualizing and fundamental knowledges of descriptive geometry. Moreover, the user of a CAD–system must know the fundamentals of many chapters of geometry. Therefore CAD–courses have to be built upon geometry education.

A basic aim of teaching the different chapters of geometry is to teach geometric constructions and methods for generating, recording and transferring geometric informations about spatial objects. Not only the theory of geometry must be taught, but also the tools of geometric constructions. Beyond technical drawing, that was the only tool for carrying geometric informations, computer graphic systems have a more important role in technical practice.

The other important aim of the geometry education is to enhance the ability of visualizing spatial objects and constructions. The need of this capacity becomes obvious also at the first encounter with a CAD system, when different projections of three dimensional objects appear on the screen. No other subject has overtaken this important task from geometry in engineering education.

The analysis of the construction of the model in *Fig. 1* shows that geometric modelling supposes the knowledge of the following subjects:

- coordinate systems,
- definition of surfaces and solids (primitives and generators),
- transformations (translation, rotation, scaling),
- construction of composed models by positioning the parts,
- projections (orthographic and axonometric views, perspective).

All these topics belong to a classical geometry course. The informations about the model representing data structures, the structure of CAD systems and data handling complete the study of geometric modelling. Therefore all traditional chapters of geometry are necessary for understanding the fundamental processes and functions of CAD.

Methods and Tools of Teaching CAD

Geometric modelling systems are the newest and most flexible tools for numerical solutions of 3D geometric constructions. The good professional CAD systems are problem oriented, contain special procedures and macros for industrial applications using the corresponding specific phenomena, are

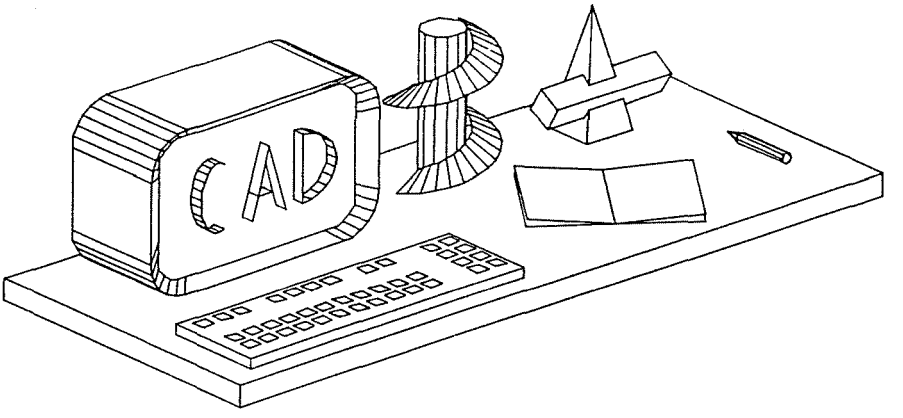

Fig. 1. Composite model described by polyhedral data structure

able to handle the biggest models probably occurring, consequently require long training time and are expensive. Those systems are not suitable for educational purposes for beginners.

An introductory CAD course has to give as general knowledges as possible based upon the geometric backgrounds of geometric modelling. The proposed chapters of a CAD course for beginners are the followings:

- model definition methods, primitiva, generators,
- model data structures, discrete (polyhedral) and analytic (spline surfaces) description,
- different types of data structures, wire frame, boundary representation, CSG trees,
- geometric transformations,
- Boole operations,
- projections,
- viewing algorithms, hidden line, ray tracing.

Parallel to the theoretical lectures practical training is also necessary, in order to make students familiar with the basic methods of CAD systems in geometric modelling. The proper tool for training is a teaching software that is available for all students, simple to use having a transparent structure, replying in a correct and understandable language, using few symbols, therefore it does not demand long training time studying thick manuals. The system has to give help at any time and show the inner model representation in order to make clear how it works. All these advantages of using teaching programs in introductory CAD courses are recognised by more and more studies dealing with engineering education.

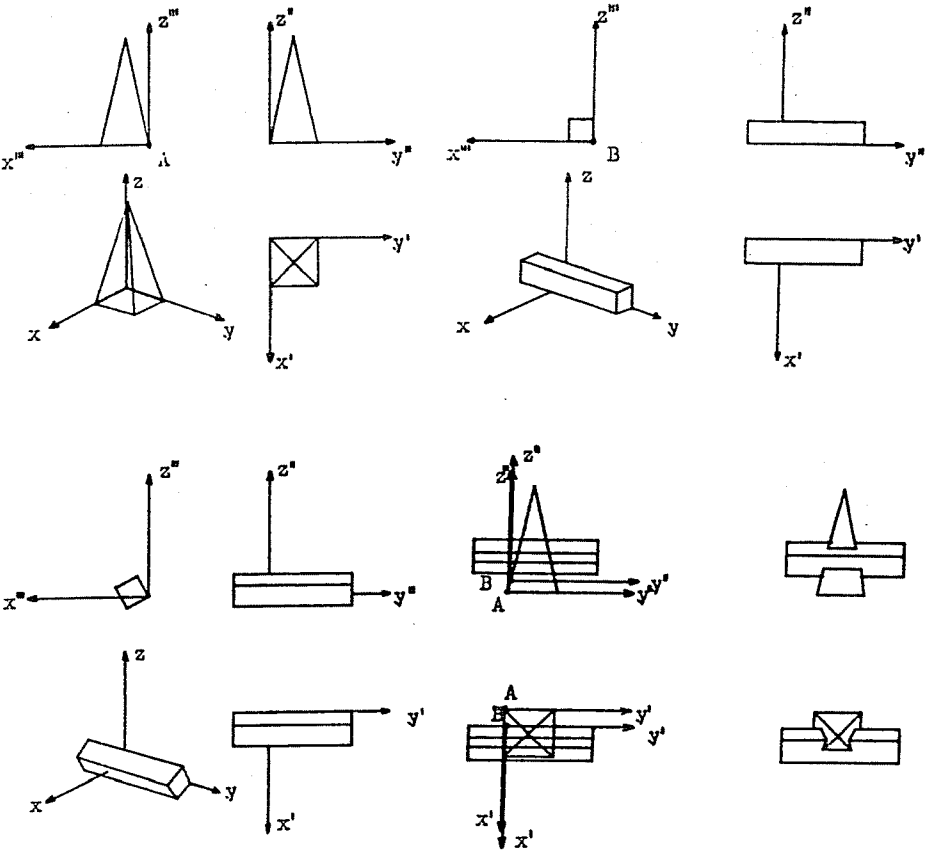

Fig. 2. Steps of the construction of intersecting prism and pyramide

Conclusion: Our Proposals for Teaching CAD

The traditional goals of the teaching of 3D geometry, i.e. to develop the capacity for visualizing objects and constructions in three dimensional space are further on essential in engineering education. Our experiences show that CAD courses concentrating upon engineering applications cannot substitute the teaching of geometry. Our suggestion is to integrate the teaching of geometric modelling into the first or second year curriculum built upon the fundamental geometry courses. The most effective tool in a CAD course is using a simple modelling system developed for teaching purposes that makes all the basic functions of a CAD system understandable.

In *Fig. 2* the steps of a short 3D construction are shown drawn by the author's modelling system implemented on an IBM PC/AT.

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