THE "CADME" APPROACH TO THE INTERFACE OF SOLID MODELLERS

Carlo Bizzozero, Umberto Cugini

Politecnico di Milano, Dipartimento di meccanica
Piazza Leonardo da Vinci 32
20133 Milano

ABSTRACT

This work stands as a contribution in the area of the man-machine communications. In the field of Computer Aided Design the solution of such a problem has led us to the definition and realization of an indipendent interface placed in front of solid modellers accepting C.S.G. definitions. This system is able to simulate the orthographic projections of the specified part without activating the solid modeller. The illustrated interface is a part of an integrated system called CADME.

RESUME'

Ce travail se situe comme contribution dans le domaine de la communication homme-machine. Dans le domaine de la C.A.O. la solution de ce problem nous a porte' a la definition d'une interface indipendante qui peut etre connectee a des systemes de modelisation volumique acceptan des definitions du genre C.S.G. Ce systeme peut simuler les projection ortogonales de la piece decrite sans utiliser le modelleur volumique. Le systeme illustree fait partie d'un systeme integre' pour C.F.A.O. nomme' CADME.

KEYWORDS: solid modelling, interaction, user interface

Introduction

To understand the logical process followed in the illustrated system and the software proposed tools we have to clarify the meaning we give, following Stafford Beer [1], to the words "capacity" and "ability". **Capacity** stands for a systemic concept: it gives a value of the theoretical performances of a system, without any consideration about the constraints imposed by the environment. On the other hand, **ability** represents what we can really get from the system, noticing that an informatic system becomes more and more only a component in more complex and integrated ones [2].

If a system is not able to express all its potential features there have to be some phenomena which are restricting its capacity; such bottlenecks may depend, and this is our case, on the big problem of man-machine interaction. Generally the use of a computer imposes new mechanisms of formal communication which are alien to the way of thinking of experts in other disciplines.

The problem

A typical example of systems which join high capacity and a usually low ability is that of the Solid Modellers [3],[4].
These systems have the main characteristic of being able to merge in an unique mathematical model all the informations necessary in the industrial process of manufacturing solid objects (typically mechanical parts). Solid modellers are able to maintain all the geometrical and topological features of the described object, logically connected and structured. Traditionally all these informations have to be deduced from a non connected set of geometrical and topological data represented in engineering drawings. Those data must be interpreted by an expert able to correlate them using representations, conventions and standards.
What dramatically reduces the ability of such systems resides in the interaction process: in fact modellers mainly use command languages which lead to the use of complex sentences and describing operations in a three dimensional space: an unfamiliar job to almost all the designers [5].

Towards a solution

This work suggests a step towards the solution of such problems, describing an interface system between Geometric Modellers and designers implemented into CADME system [15]: the interface system is able to simulate the work of a modeller, being at the same time a more natural tool for the usual user: a draftman.

This system has been designed in such a way to represent an interactive graphic generalized front-end to solid modellers. The adopted point of view was the "designer" point of view who, in a design process, uses the modeller mainly with the aim to create a unique representation of a complex solid. Thus the preliminary study has been devoted to an analysis of the designer's usual ways of working and of the problems arising because of the introduction of modelling systems.

We found that the existing modellers have some disadvantages:

- there is a low level of interaction, which is mainly based on the use of sentences in a specific command language
- the system is oriented towards the modellers' problems rather than those of the users'
- the designer is forced to produce preliminary sketches in order to obtain the geometrical and topological informations needed for the model definition
- it is necessary to evaluate the model to obtain the visual feed-back assuring the user of the correctness of the specified operations

As a matter of fact a mechanical designer does want to use the modeller in a correct and simple way, preserving methods which he is accustomed to, avoiding, as much as possible, other difficulties connected with the introduction of the computer in his work. In other words the use of a modelling system needs more interaction based on of procedures (as much as possible graphical ones) allowing the use of traditional drafting methods (bidimensional representations of solid objects by means of orthographic projections, sections etc.). It also needs an immediate visualization of the results of each action, operating on the graphical bidimensional representations.
The design of a system able to join capacity of the modellers with ability started from the identification of such needs. The resulting system, indipendent from a specific modeller, can be roughly divided in two main parts: the first one allows the user to describe the object via drafting procedures and performs the simulation of the resulting orthographic projections; the second one is really an interpreter, used as a code generator to arrange commands in the language of the modeller, starting from the generalized data structure defined during the designer work and stored by the first module.

This solution also permits to avoid the problems arising when a user, who has learned the command language of a specific modeller, tries to fit the shape of the part he is going to design on the features of the well known modeller; it should be better to use, among different modellers, the one which best performs the particular shape. Thus, the unification of the input modalities adds freedom to the use of different modelling systems.

A 2D drafting system as an emulator of the Solid Modeller

The tipical task of a system which models rigid solids is combining simple primitives in different ways to obtain complex shapes. On the other hand, it is possible to operate solid objects by means of a planar description, more simple and natural for a designer. In order to obtain these planar representations of complex solid objects it is possible to resort to a system which produces the orthographic projections by superimposing several planar figures. These ones, which represent sections of the solid, perpendicular to the point of view, can be obtained applying logical multivalued functions of union, intersection, difference, and finally superimposition, to planar operands which represent co-planar sections of the solids to be combined.
The problem is now that of being able to univocally represent complex shapes by means of a sequence of characteristic sections which are parallel one another. In simple cases (see fig. 1) it is easy to identify such sections; in these situations it's enough to apply the logical function (the set union, intersection, difference) to the co-planar sections of the objects, superimposing the results in a second time applying a procedure for hidden line removal.

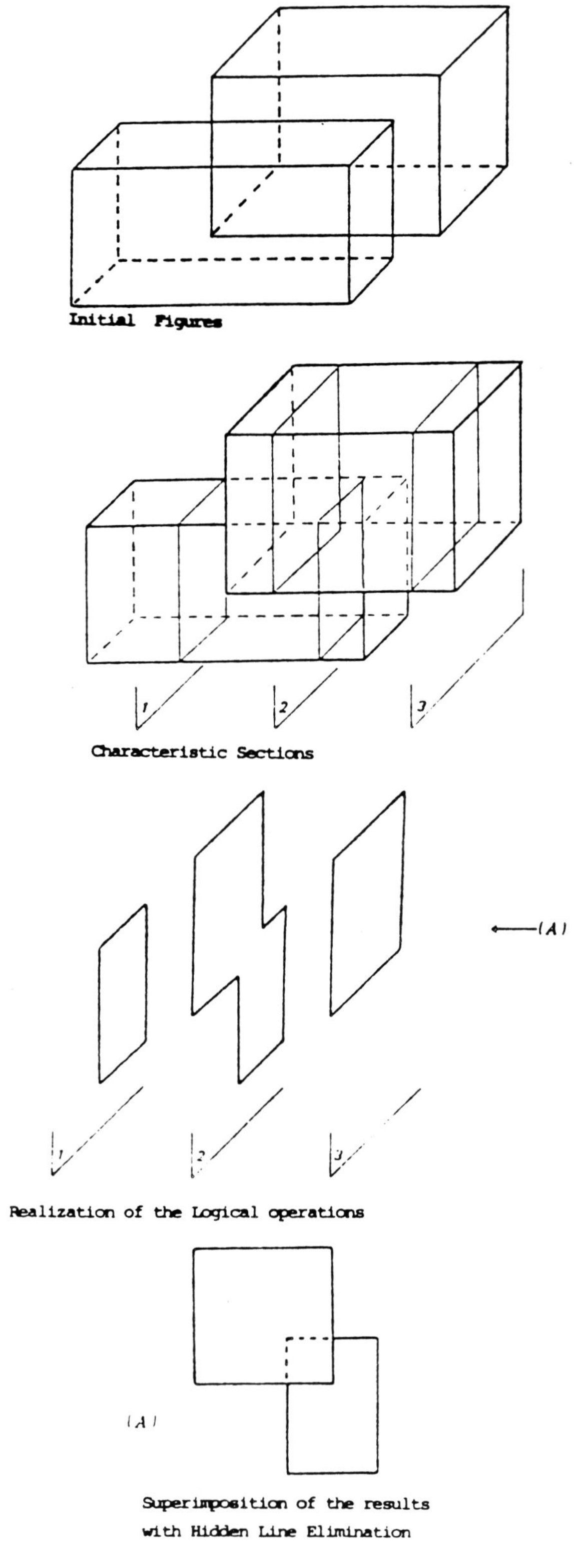

Figure 1

By means of the "constructive" approach [6], followed by the simulation process, it is easy to translate the graphic commands for the definition and operation of solids in the 3D space into an equivalent set of instructions for the definition of the 2D figures and their combinations.

Connections of the simulation system

The simulation system's dialog towards its environment is mainly kept by means of two modules (see fig. 2)

a) a user-interface system
b) an interface towards the modelling system

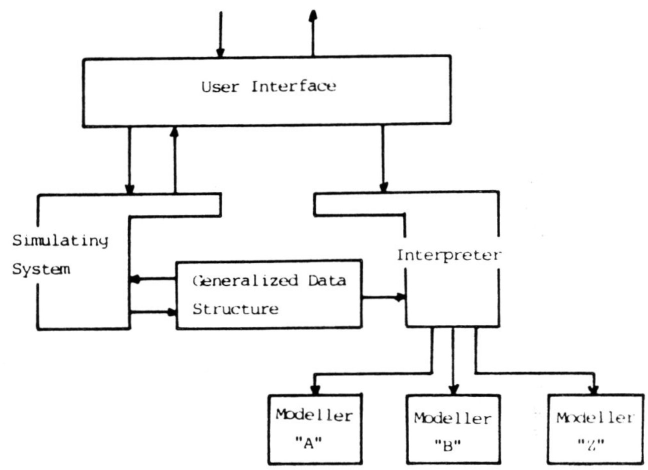

Figure 2

The first module is designed to acquire the geometric and topologic data for the definition of the solid primitives in terms of dimentions, absolute and relative positions, and the operations between them; it handles in an interactive way the dialog with the user. Using graphical input software tools which simulate the tipical tools of designers (a ruler, a protractor, a drawing board) and hardware allowing real time 2-D and 3-D transformations for high interaction, a flexible and dynamic user-interface has been implemented.

The interactive part of a design process coincides, in modellers, with a phase of definition of simple solid shapes (primitives). This is performed in our system describing primitives via their three orthogonal projections. These projections are defined by users with interactive procedures (graphic and alphanumeric); permits the use of graphical tools and modalities of interaction which can be chosen and activated via dynamic menus displayed on the screen.
It is possible to select a "direct", exclusively graphic, interaction (without any of the software tools mentioned: ruler, protractor and drawing-board) which is based on the use of a graphical device (a joystick) or an alphanumeric input (pairs of coordinates typed on a keyboard) or a pick device.
On the other hand, it is possible to select one of the three software tools which can be used in one of the three modalities: graphic, alphanumeric, pick.
The use of these tools make it possible to join the ease of use of the graphic interaction instruments with the precision, which is necessary in the definition of shapes via their coordinate values.

The second system, the interface between the simulation system and the modeller, called "interpreter", automatically translates the designer actions into a set of instructions, intelligible for a modeller [16]; this has been done in order to obtain the mathematical model of the defined object. In order to have a generalized channel between the system and the modeller we maintain a common basis for the different modellers: this basic element resides in the "constructive" approach for the input modalities of the different modelling systems.
The interface between the simulator and the modeller is a processor which, starting from a generalized data structure created during the phase of definition ofcomplex solids, is able to generate the shape (geometry and topology) of the designed object.
This modularity lets a possibility of using the user interface and the simulating system combined with different modellers.

Our applications deal with three different "translators", each of which related to a particular modeller. The first two modellers used are: PADL1, developed by the University of Rochester, N.Y. [7],[8],[9],[10],[11] and TIPS1, developed in Japan by a research group of the Hokkaido University [12],[13]. As a note we underline the substantial difference between the languages of this two modellers.
We have built up a third "translator", which is necessary for the system to support a modeller, based on a C.S.G. approach and a Ray Casting technique [14], developed in the CADME research group, Politecnico di Milano.

An example

In the design of a simple mechanical part are defined the geometrical and topological features of the part itself. In figure 3 is shown a moment of this phase. In the picture it is possible to note the four graphic windows: in one of the three bidimensional ones the user is interacting with the system via the simulation of a drawing board. The three-dimensional window maintains a wire frame echo of the object already created. The other parts of the screen are devoted to the menus (commands, instruments, swithes, figure's names) and to the alphanumeric interaction.
At the end of the interactive phase, which gives as a result the object representation via its orthogonal projections, the user may instance the chosen modelling system; this one creates the mathematical model of the solid object.

Figures 4, 5 and 6 show three results obtained submitting to three different modellers the results of the implemented interpreters; the pictures refer respectively to PADL1, TIPS1 and CADME.

Conclusions

The present implementation is able to deal with objects in "two and half" dimensions defined using two primitives: box and cylinder. The extwnsion for fully three dimensional objects is under development and testing.

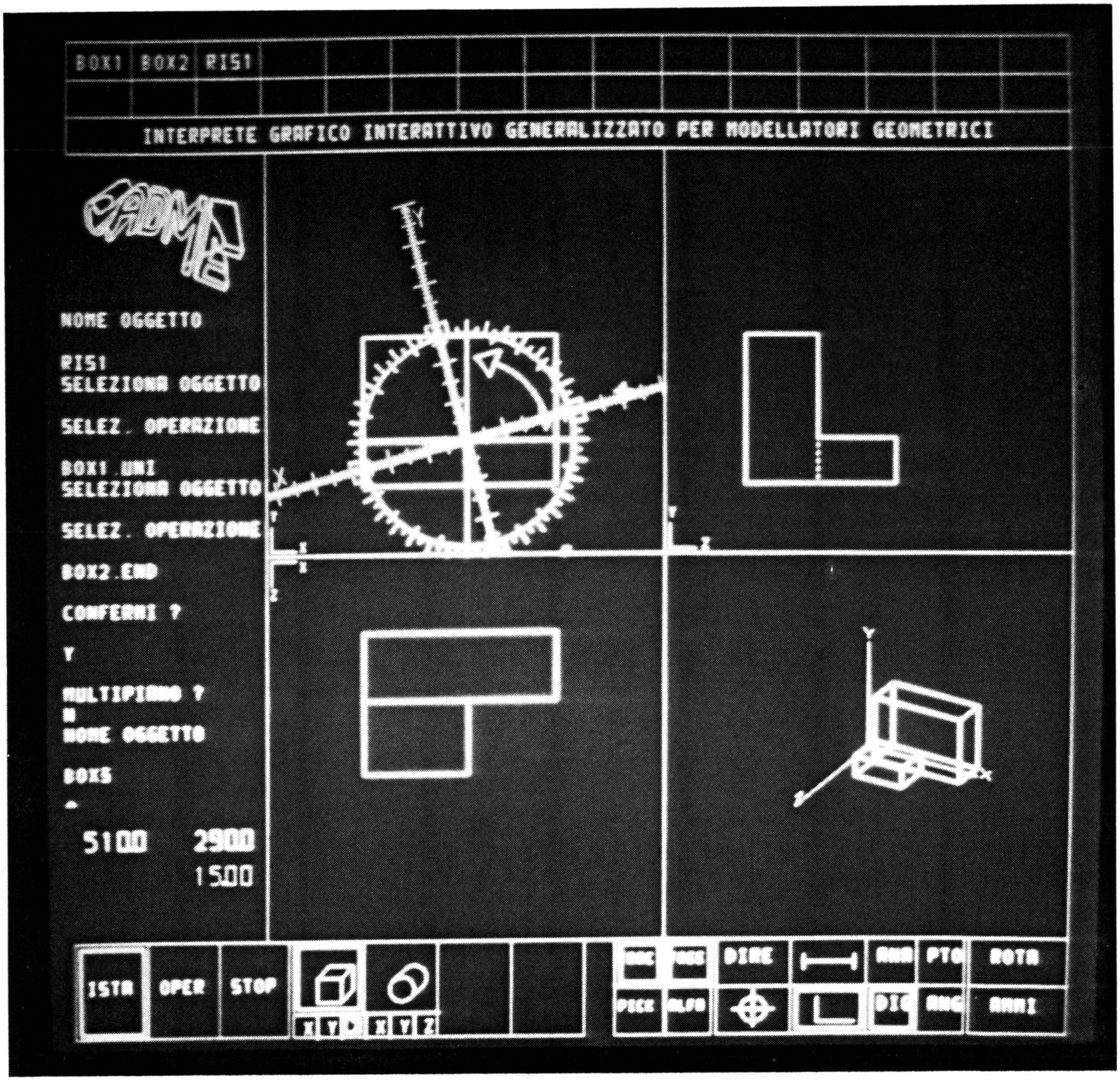
BOX1
BOX2
RIS1
INTERPRETE GRAFICO INTERATTIVO GENERALIZZATO PER MODELLATORI GEOMETRICI
NOME OGGETTO
RIS1
SELEZIONA OGGETTO
SELEZ. OPERAZIONE
BOX1.UNI
SELEZIONA OGGETTO
SELEZ. OPERAZIONE
BOX2.END
CONFERMI ?
Y
MULTIPIANO ?
N
NOME OGGETTO
BOX3
5100
2900
1500
ISTA
OPER
STOP
DIRE
PTO
ROTA
PICK
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Figure 3

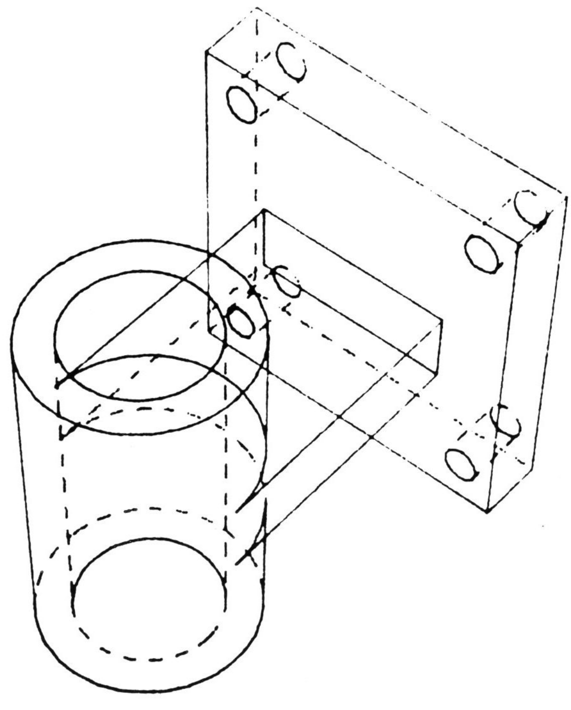

Figure 4

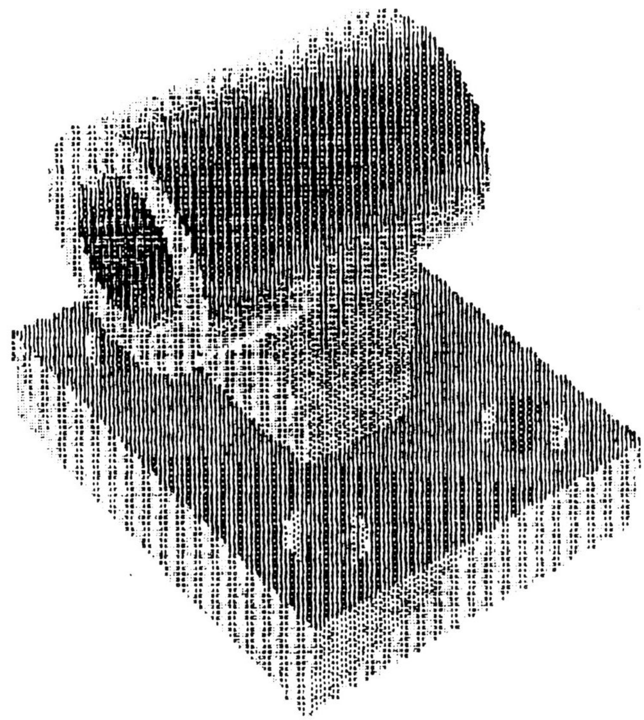

Figure 6

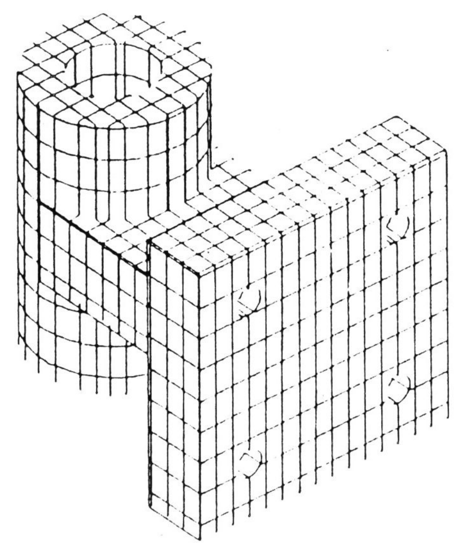

Figure 5

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