# DESIGNERS' INTENTION BASED CAD FOR CONCURRENT ENGINEERING

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## ABSTRACT

When manufacturing a product, both designers and production planners need to reciprocally exchange and transfer information related to the manufacturing process and product specifications. In actual manufacturing practices this has been done through the use of CAD/CAM systems.

In a cooperative design/production environment, fast decision making can be achieved by communicating the designer's intention. For this purpose we developed a system where the designer's intention is a class of the product model.

## BACKGROUND

In the field of concurrent engineering extensive research has been done in order to shorten the lead time from the conceptual design of the product to its release to the market. Also the use of CAD/CAM systems, as core information technology, allow the increase of efficiency in the production practices.

Particularly, in the field of machinery manufacturing, the propagation of the technical information is usually more advanced than that of the managerial information; this technical information is usually related to the model of the designed object and its geometrical shapes.

Non-geometrical information such as accuracy, tolerance and materials is highly required for the integration of CAD/CAM systems and for the automation of process control systems. This information is usually specified in later stages of the product design.

Some CAD/CAM systems can deal with non-geometrical information including production processes, by combining them with geometrical information.

In a cooperative design/production environment, an important characteristic is that in terms of real time, designers and production engineers reciprocally transfer information and make their decisions. Moreover, the reasons of the designer's decision making when already transferred, should not be affected by the designer's former ideas.

This paper makes a proposal of a modeling methodology of the design process, that describes the "design intentions", as a way to achieve a high cooperative manufacturing practice.

## ACQUIRING A FAST WAY TO TRANSFER AND EXCHANGE OF INFORMATION

In order to achieve a cooperative design/production environment, and also to be able to shorten the total manufacturing lead time, it is always necessary to establish an exchange of information and decision-making objectives, among the designers, planners and engineers, in real time terms.

But, sometimes in the global production environment, it is not possible for all designers, planners and engineers to communicate with each other at a given required time.

In actual CAD/CAM systems, the exchange of decision making information among the designers and production planners, is not realized as a function. In this case, there should be also other decision-making processes that the system should take into account, here the consideration of non-real time becomes necessary.

In the development of a design process, the specifications are usually described and decomposed but the reasons or intentions are not included, but by handling cooperative information this becomes a possibility. Including the case where the model is imperfect, if the process of how the answer was reached is integrated into the model of geometric shapes and non-geometrical information, even in the case of non-real time (unsynchronic), information transfer can be done as quick as in the case of real time (synchronic).

## DESIGN INTENTION MODELING

The design process of mechanical products can be thought as the process where the input is the function of demand for the product, and the geometric shape and non-geometrical information model which satisfies the demand, is the output.

There are detailed levels in the demand function, the expression of classes is also needed. On the other hand is also possible to use a class to give non-geometrical information about the geometric shape elements. So, the designer's intention can be defined as an expression of the demand function that combines the measurements of the geometric shape elements and the non-geometrical information.

The geometric model can specify, and make reference to the predicate description of the geometrical shape elements – faces, edges, vertices – combined together with the required function. Also it is important to specify parallelism, verticality, points of contact, specific parts and specific geometric shape elements.

The revised design will be able to recall the specified changes, revisions or eliminations to the shape elements. It is always necessary to make a correspondence among new shape elements and the old ones.

## DESIGN INTENTION

The design intention, should be able to understand the purpose logic (intention) of the designers to satisfy the given required function while being reciprocally transferred.

Figure 1 shows the geometric model and the intention (in the form of a network), appearing at the same time. At the top of the tree, we find the required function, then the function is decomposed in detail, with its geometric shape elements and the non-geometrical information related together. Each node of the network shows either of the required/decomposed functions, geometric element or non-geometrical information. Between two nodes in the network, the designer's intention flows in correspondence.

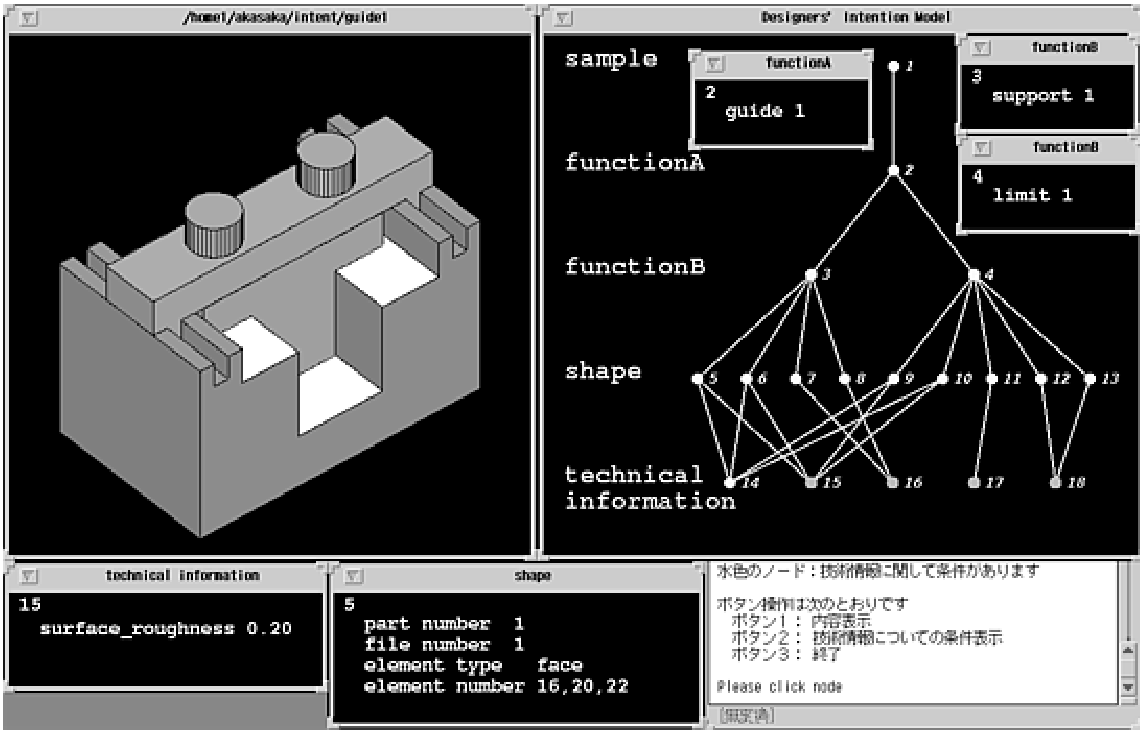


Fig.1 The display of the "design intentions" model in the CAD system

Two nodes of the network are strongly related to each other because of the designer's intention. For example, if the function of one node is changed, then the function of another node will also be affected.

As it can be observed in figure 1, due to the size of the screen, it is not possible to show all the contents of each node, for this purpose when clicking on each node, a new window appears with the information to describe the required/decomposed function, geometric shape element or non-geometrical information.

## CASE STUDY – A DESIGN MODIFICATION

When modeling the product design process it is possible to make reference to the designer's intention through the product's geometrical information (shapes). So, when revising a design of the product it is possible to make judgments on whether the designer's intention is satisfied and maintained with those changes or not.

For a correct realization of a design revision, in a multiple restrictions case, it is always important to refer to designer's intention. Usually when trying to revise (fix) one part, as mentioned before, other parts will become affected, but if the intention behind the design "logical thinking process" is followed, then one part can be fixed without affecting the others.

In figure 2, an example of the expressions used for the "design intentions", when guiding part 2 to part 1 are shown. Figure 3 shows (in flow), how to maintain the "guide" function by using the design intention, in the way it is used to modify the shape of face A (part 1) moving along the x axis (in parallel).In order to connect the required function and the geometric elements/non-geometrical information, connotational assignments are used to specify them to satisfy the function.

When Face A is moved by using local operation of the CAD system, connotational assignment #3 is not satisfied. The CAD detects this unsatisfaction and decides that the "guide" function is also not satisfied by this modification. Then, CAD moves Face B to contact with Face A, in order to maintain the designer's intention to satisfy the "guide" function. This connotational assignments are described as a part of designers' intention that is located on the branch between two nodes in the network.

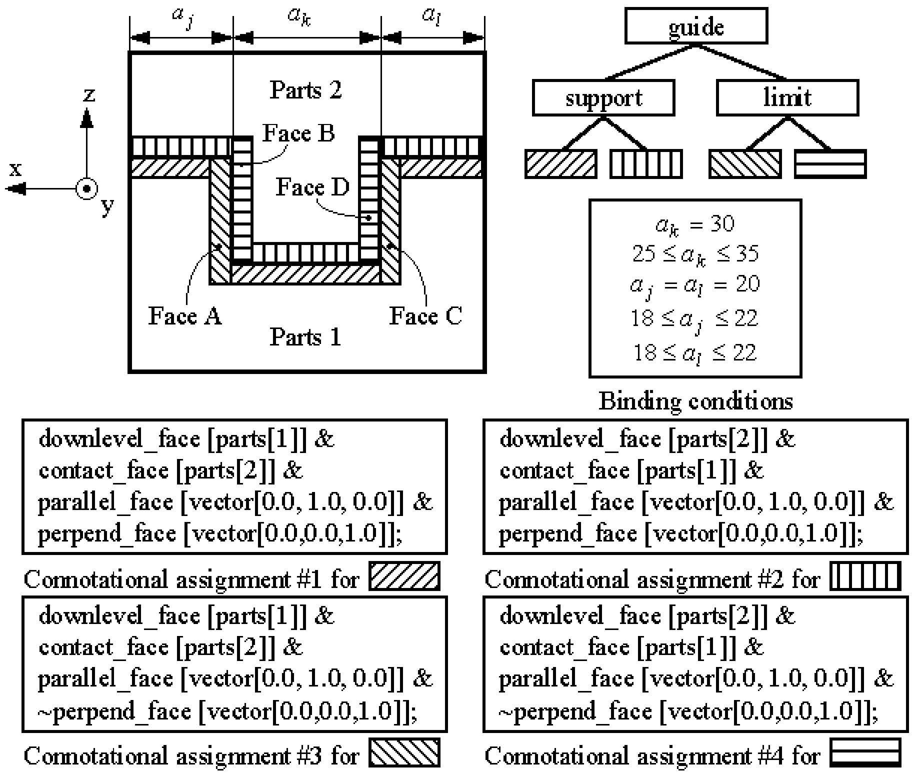


Fig.2 Example of the expressions for the designers' intention expressions

As soon as the design intention model becomes a class of the CAD system, it is not only possible to make reference to the designer's intention every time its needed, but also to obtain warnings when the designer's intention is contradicted, for example, when realizing a geometrical shape revision and it is found that the restriction conditions of the shape elements are not satisfied. As a result, it is possible to make an efficient revision of the design without being against the first intention of the designer.

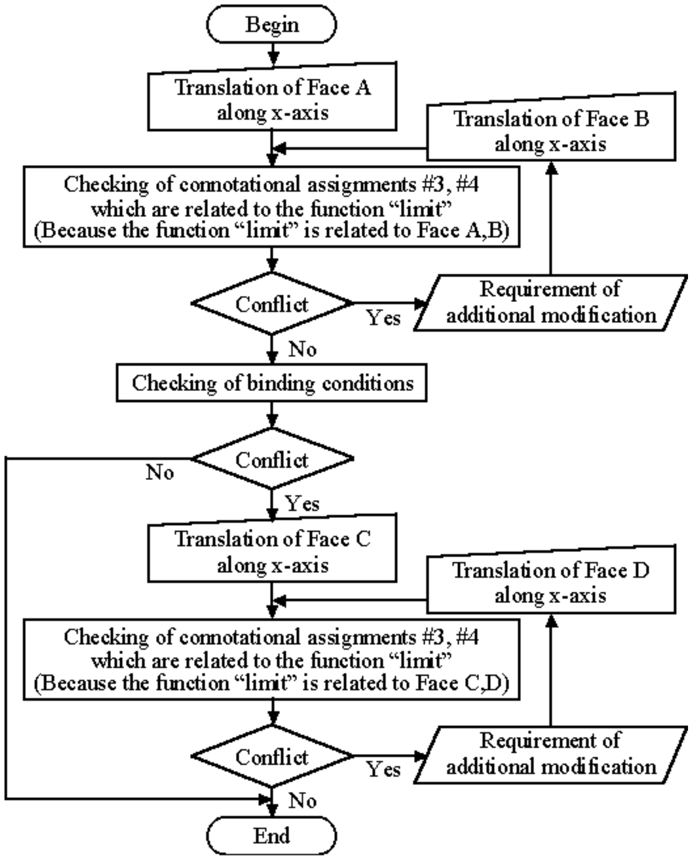

Fig.3 Design revision for the function maintenance

This kind of "design intention" model, promotes the good understanding of the purpose logic (intention), between the number of designers in the process, and it will also become an efficient tool in concurrent design. Besides, if the design intention is regarded as a fragment of knowledge of the designers, it will also be possible to obtain and systematize the design or the production knowledge.

## CONCLUSIONS

In order to enhance the importance of cooperative activities and smooth communication through the manufacturing practices, a modeling technique, which combines the product model and the design intention model using CAD, was proposed in this paper.

This modeling technique takes into account the characteristics of cooperative activities, the transfer of information among designers, planners and engineers, and overall puts emphasis in the consideration of the designer's intention.

A case study of the modification design of a product is included, illustrating the usage of the developed modeling techniques for the design intention and validating the effectiveness of the present work.

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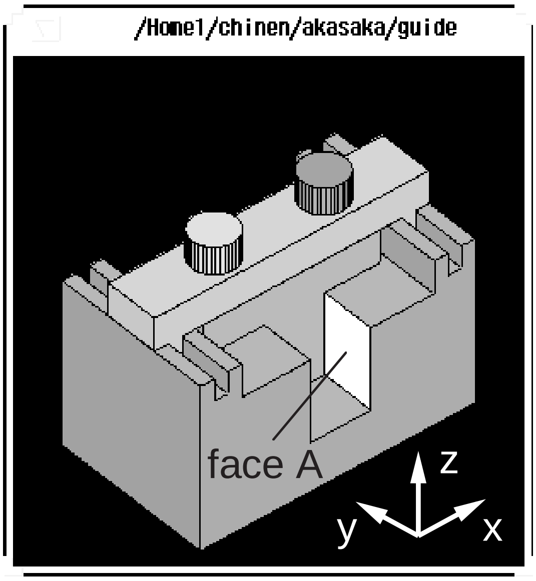
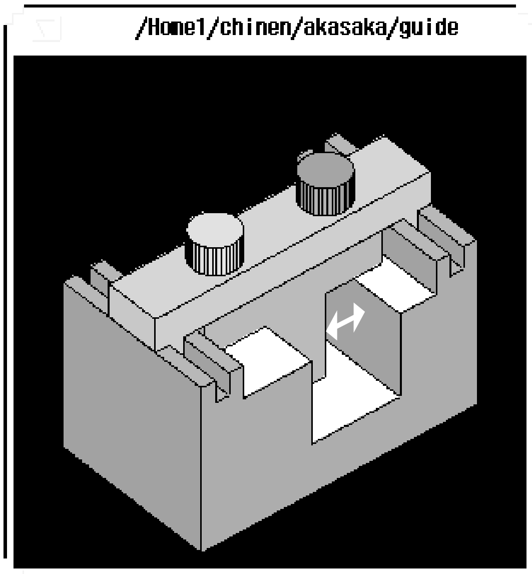
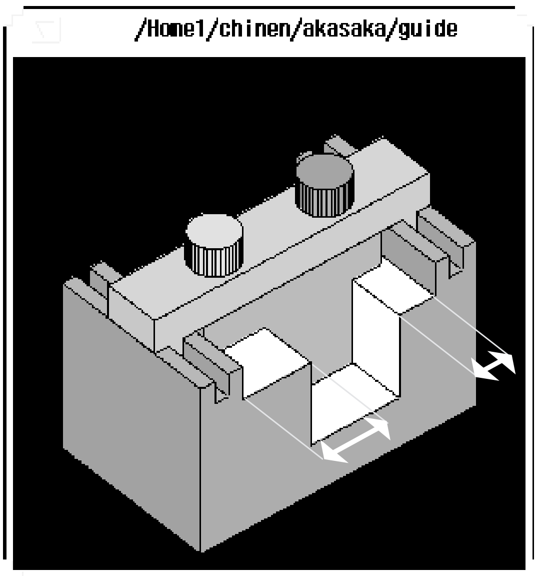


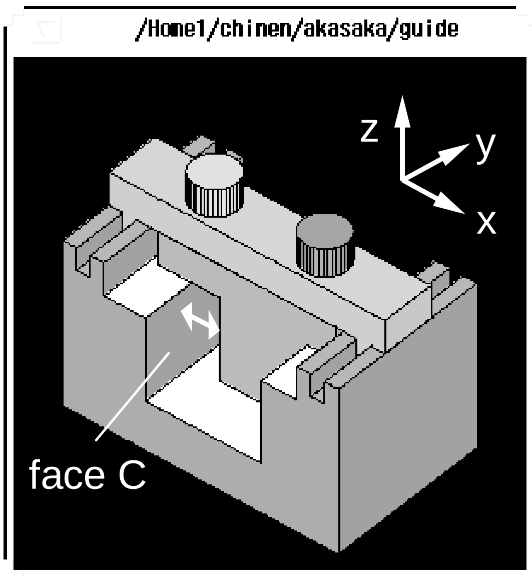

(a) Start modification – move face A along $x$-axis



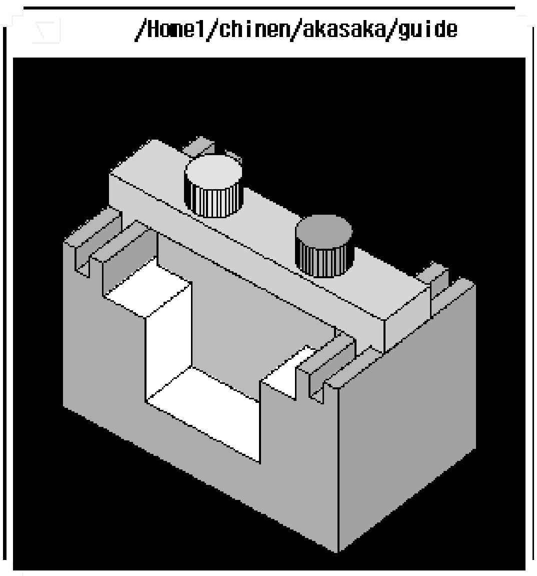

(b) Not satisfy the contact – move face B along $x$-axis




(c) Satisfy the contact but not satisfy the symmetry – move face C along $x$-axis




(d) Satisfy the symmetry but not satisfy the contact – move face D along $x$-axis




(e) Satisfy all conditions – finish modification

Fig.4 An example of modification design to maintain the function with use of intention