UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

VI ITALIAN - SPANISH SEMINAR

DESIGN FOR ASSEMBLING AND TOLERANCING

NAPLES, JUNE 4TH, 2007

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Tools for easing the Human-Computer Interaction during Virtual Assembly Process, by way of Sketch-Based Interfaces

Pedro Company

REGEO

Summary

I shall introduce my presentation by reading the title in reverse order, as I am going to introduce

1 *Sketch-based interfaces*

Which is our current research goal!

2 *Their potential role during virtual assembly process…*

3 *… and the advantages this could add to the human-computer interaction along a computer-aided design-for-assembly process*

Some antecedents of the group

REGEO

REGEO was born in 1994

Our work began to be fruitful since 2000

Current situation can be know visiting:
www.regeo.uji.es

CAI

To sum up our research, we can state that…

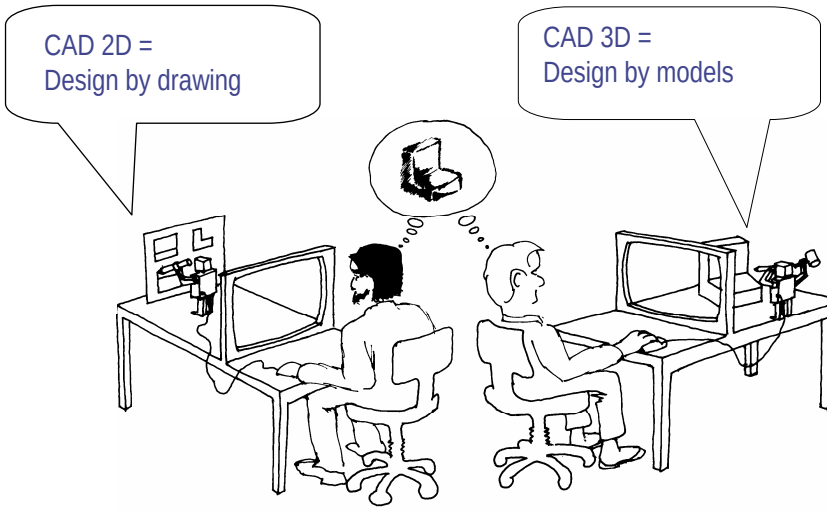
…computers are still unpractical
during conceptual steps
of industrial products design...

...because CAD applications
are unable to work with
confuse,
poorly structured and
incomplete ideas.

CAI

The designer is asked to provide actions to be executed by CAD application

well defined and sequential tasks!



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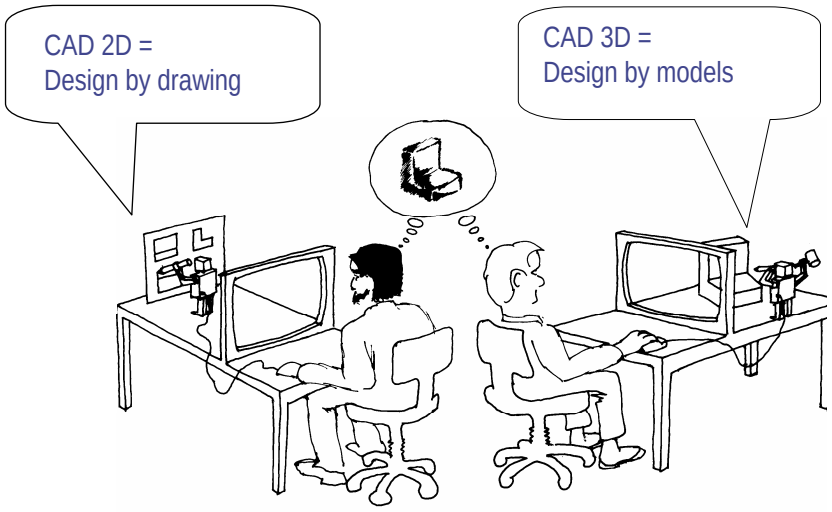


And this is not a good strategy while the designer is trying to fix visions

Poorly-defined, non-sequential ideas!

The TOOL is conditioning the TASK!

CAI

So, our goal is

design and implement
computer applications
aimed at
helping the designers
in the conceptual design step

We name them
CAI applications (Computer-Aided Ideation)...

…to differentiate from current CAD application

CAI

¡To upgrade from CAD to CAI,
the language must become “graphic”,
in the sense of non-sequential!

¡Many evidences support that

engineering sketches is such a graphic language

aimed at enhancing creativity!

SBIM

But
computers are blind
to engineering sketches!

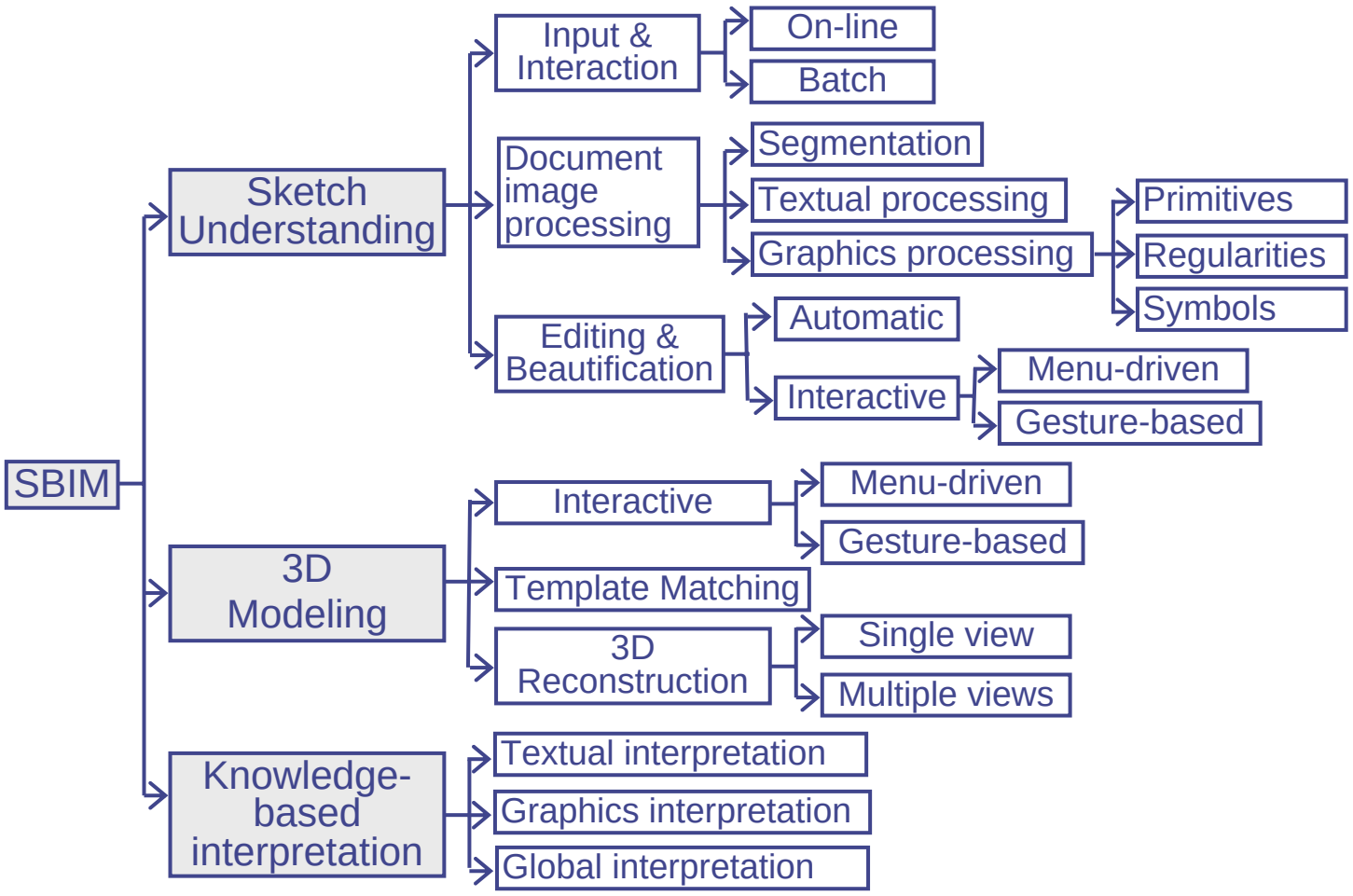
So, new computer
tools are required!

The scientific ambit aimed at solving this problem is known as:

SBIM
(SKETCH-BASED INTERFACES AND MODELING)

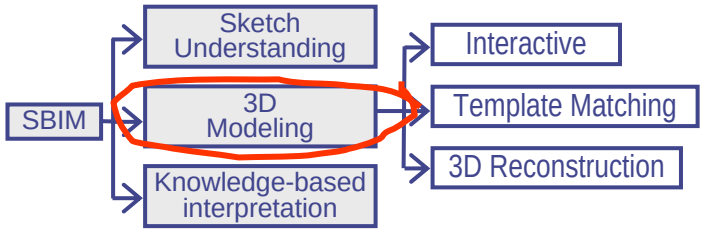
SBIM

SBIM includes three main areas, and different sub-areas:



Geometrical reconstruction

We were first interested in the automatic 3D modelling sub-area



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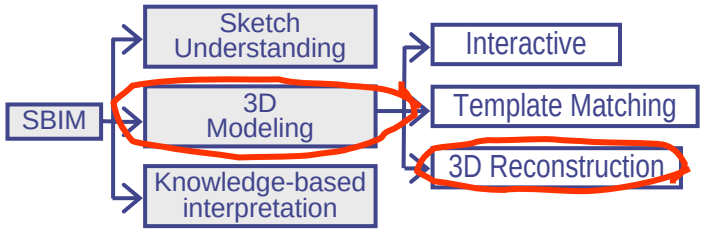
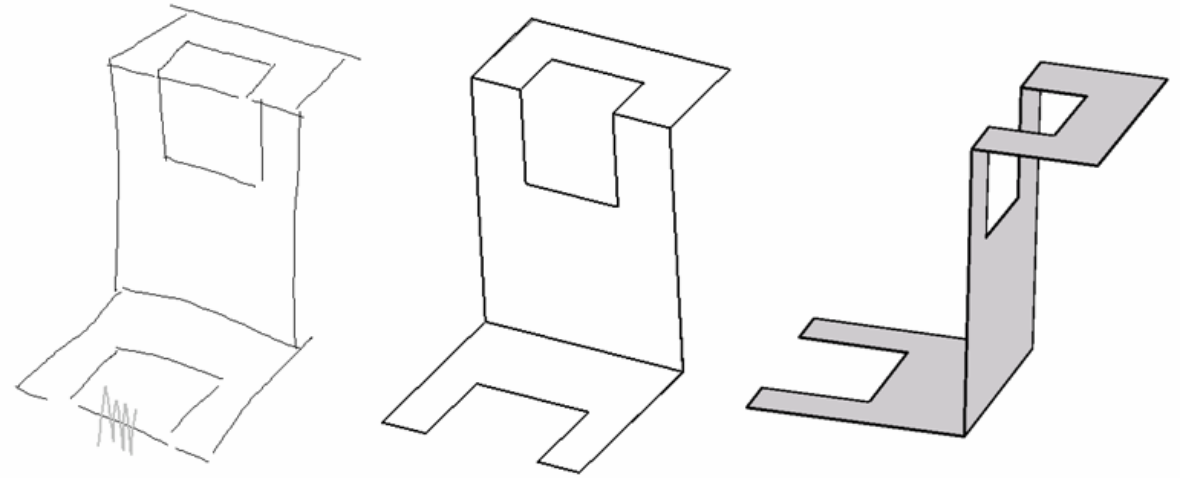


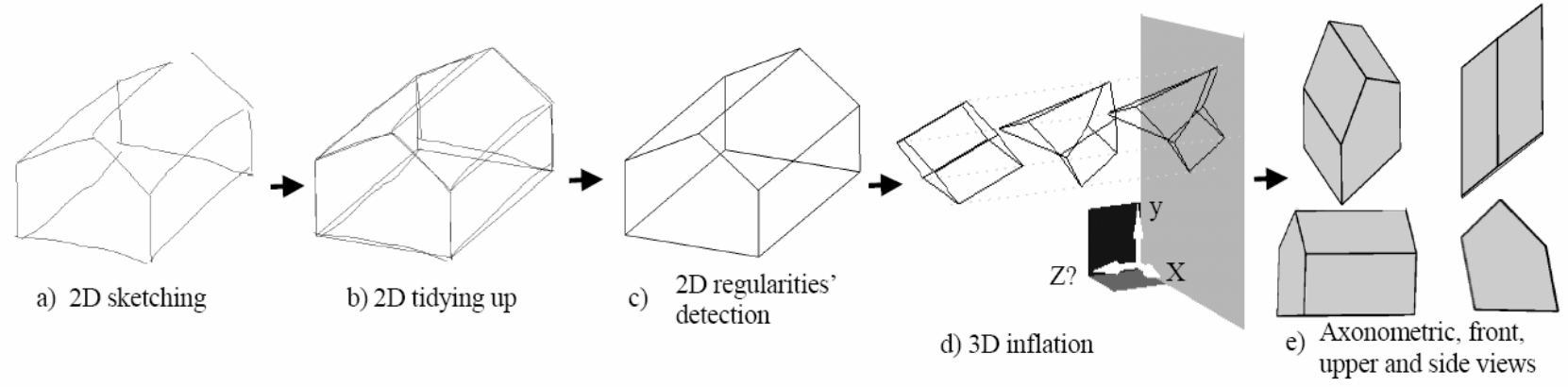
So, we began to work in:

GEOMETRICAL RECONSTRUCTION
the discipline aimed at automatic, or semi-automatically, obtaining
three-dimensional geometrical models
from two-dimensional line-drawings or sketches



Geometrical reconstruction

We have developed a system that outputs 3D models when the user inputs 2D sketches:

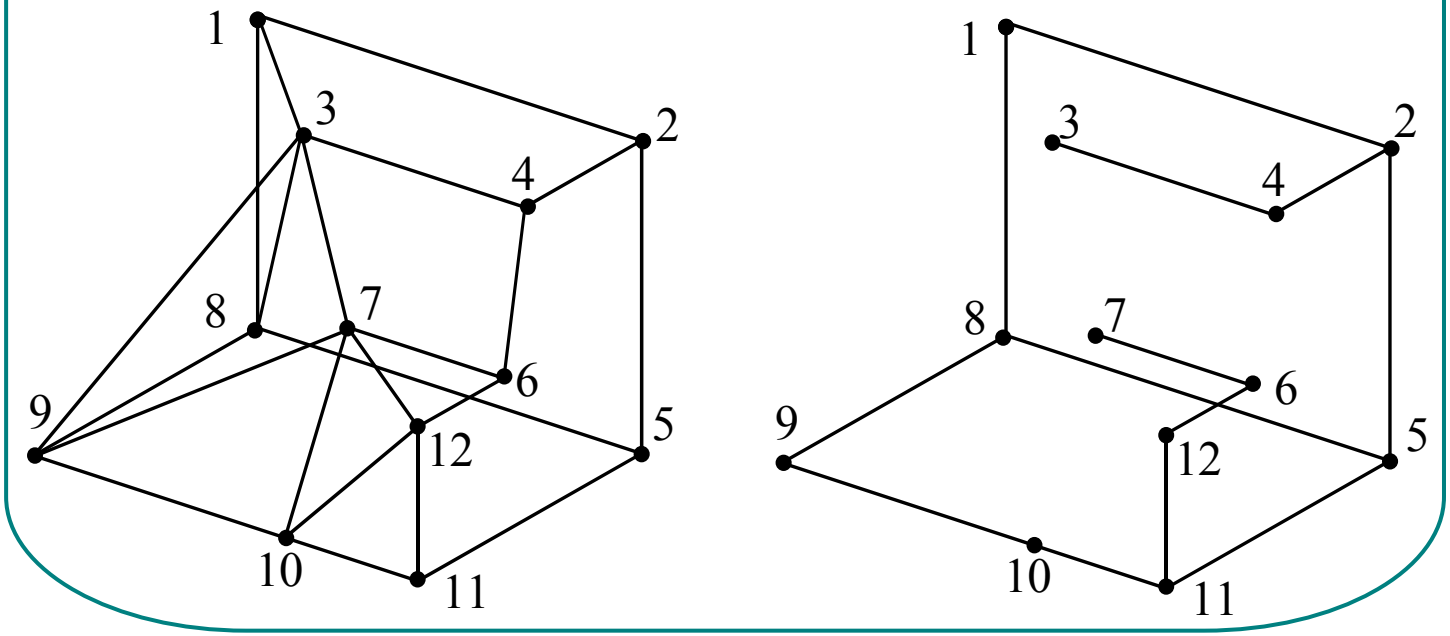


Geometrical reconstruction

Our main contributions have been centred in:

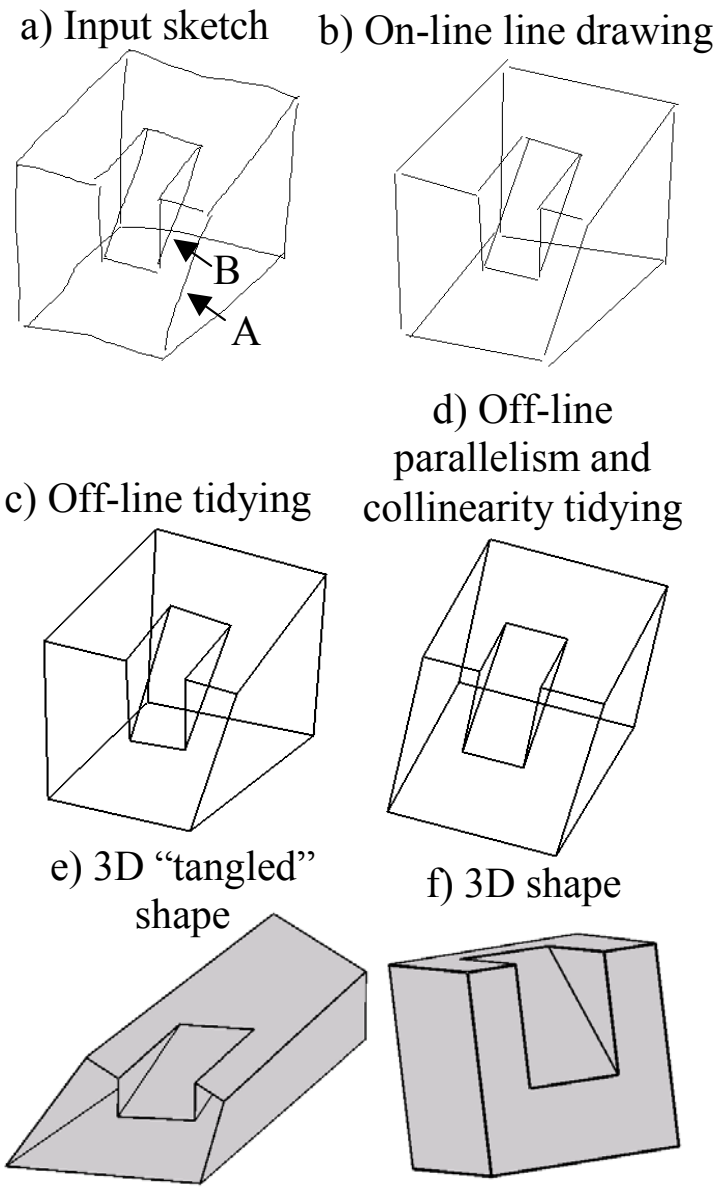
1. New approach to reconstruct polyhedral shapes of a particular class named "quasi-normalons"

Polyhedral that do not loose any vertex when removing edges non-parallel to the three main orthogonal directions



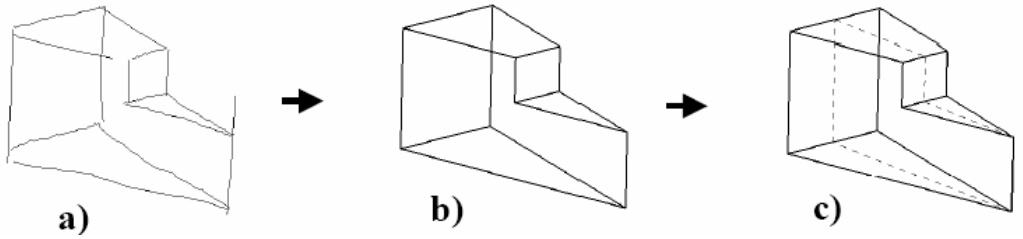
Geometrical reconstruction

2 Beautification of the line-drawing obtained from the sketch, to avoid "tangled" shapes during reconstruction

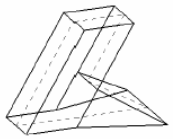
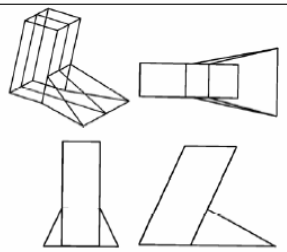
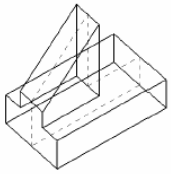
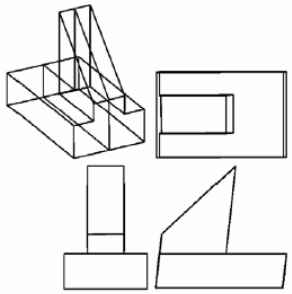


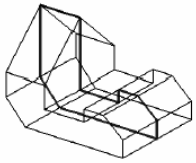
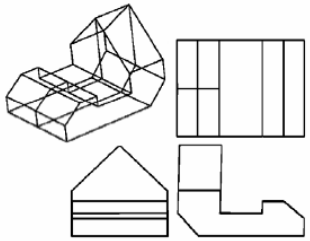
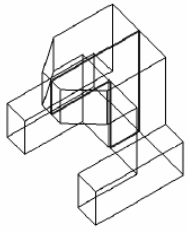
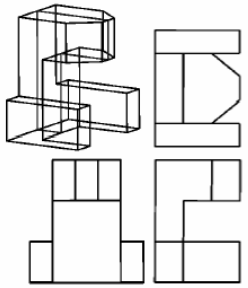
Geometrical reconstruction

3 Early detection of symmetry in the 2D line-drawing,



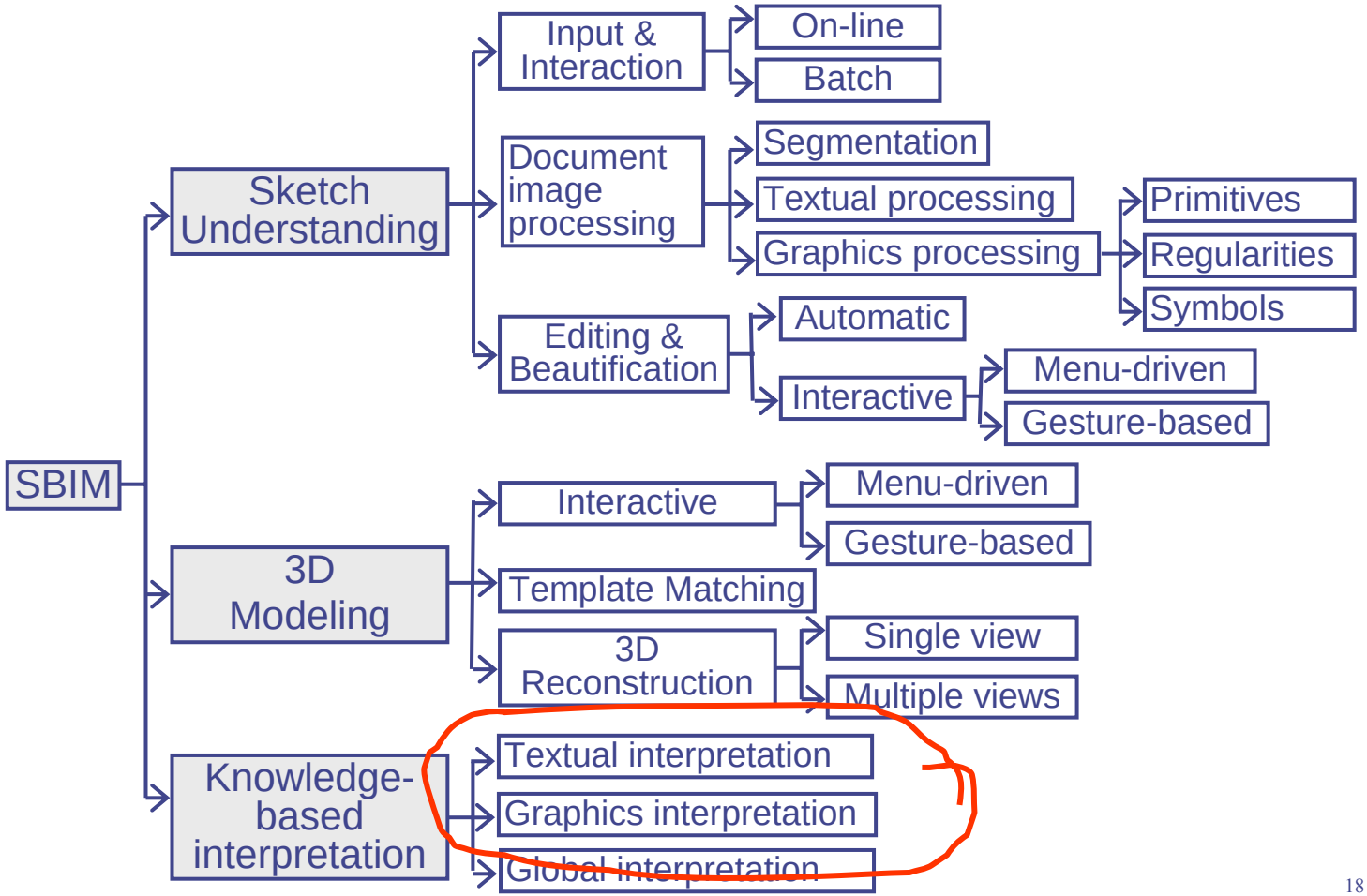
and improvement of the reconstruction process through symmetry regularity

Line drawing	3D model	Process
 19 edges 12 vertices		9 faces 1 plane of symmetry Inflation time: less than 1”
 24 edges 16 vertices		10 faces 1 plane of symmetry Inflation time: less than 1”

Line drawing	3D model	Process
 33 edges 22 vertices		13 faces 1 plane of symmetry Inflation time 1”
 46 edges 30 vertices		18 faces 1 plane of symmetry Inflation time 2”

Interpreting annotations

We have also seen that other “niches” exist in the discipline of “SKETCH-BASED INTERFACES AND MODELING”



Interpreting annotations

One of our current research lines is aimed at
Interpreting Annotated Engineering Drawings

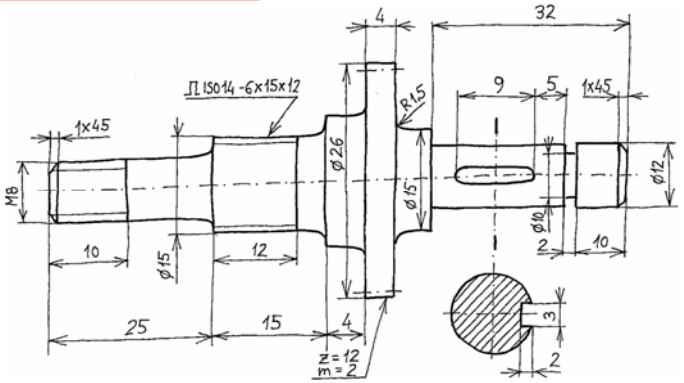
Reason ⇨ Engineering designers annotate their designs with symbols

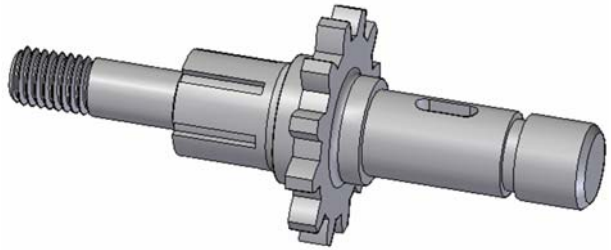
- Make concentric
- Make parallel
- Make perpendicular

Goal ⇨ CAI systems should be able to interpret designers annotations

Approach ⇨

- Capture and record the data
- Separate annotation data from drawing data
- Interpret annotations
- Apply the annotations to create the model





Interpreting annotations

Currently, we can interpret:

- ✓ Four types of strokes
- ✓ Twelve annotations

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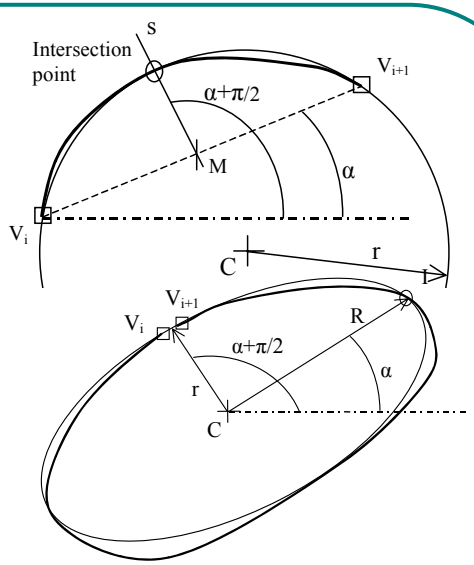
Segments

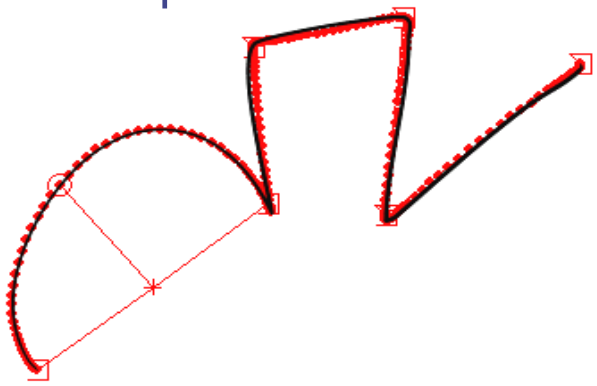
Arcs

Circles

Ellipses



Separate entities are obtained from a simple stroke!



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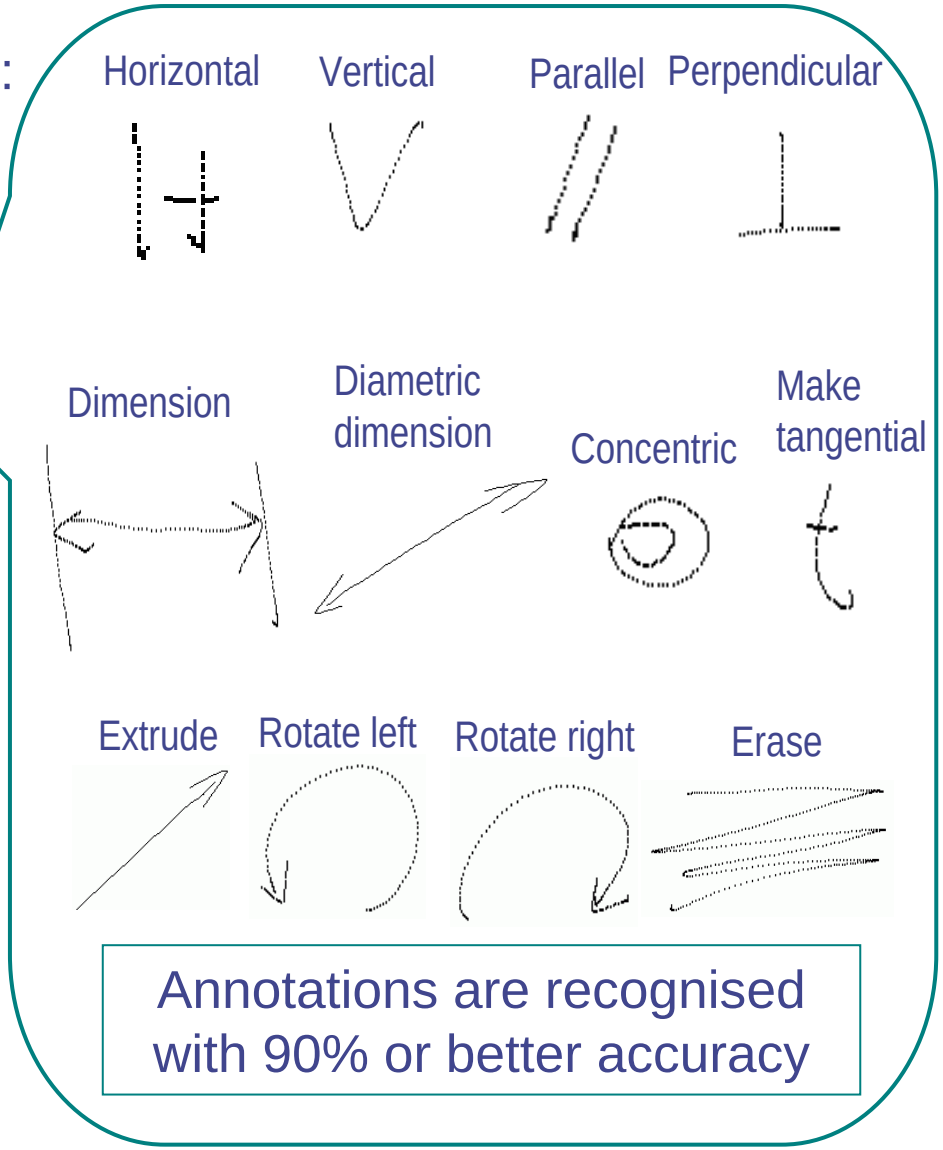
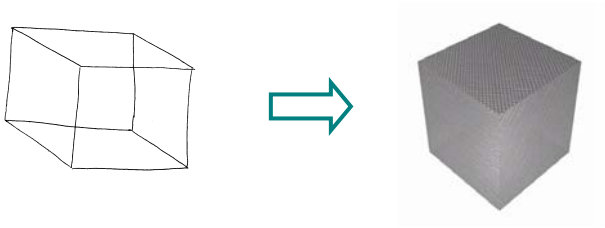


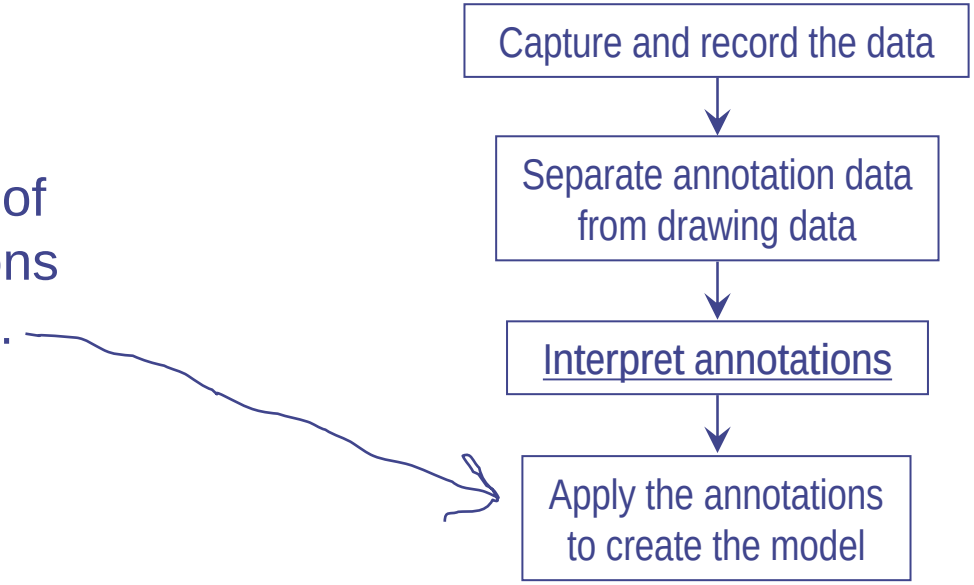
Annotations are recognised with 90% or better accuracy

Next step

Currently, we are limited to reconstruct isolated parts.



But, in our pursuit of applying annotations to create models…



… we want to be able to create assemblies from sketches!

Next step

Our vision is
to define and implement a set of symbols
that can help a CAI system
to assemble 3D models obtained from 2D sketches.

The idea was first presented at:

Saorín J.L., Contero M., Naya F. y Conesa J. (2003). Interfaz gestual para la definición de condiciones de ensamblaje para la generación de maquetas digitales. *Proceedings of the VII International Congress on Project Engineering*, (ISBN: 84-9769-037-0), p. 124.

http://www.regeo.uji.es/publicaciones/CIIP03.pdf

Next step

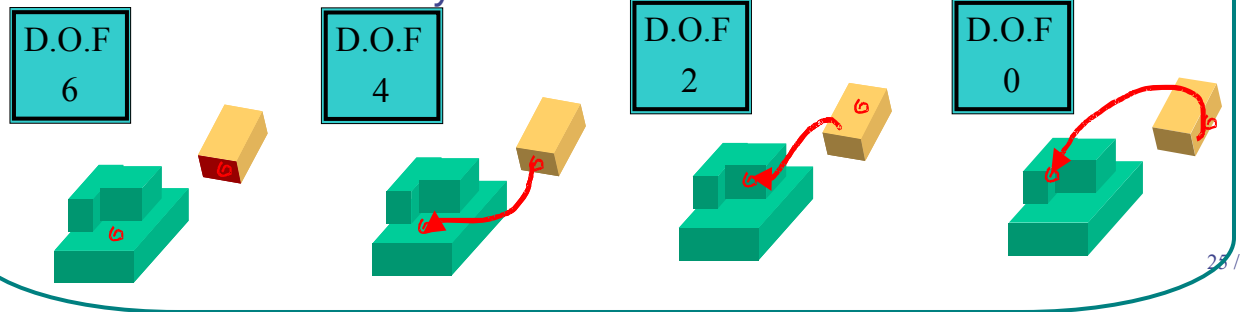
The basic guidelines of our approach should be:

- The symbols must be sketched themselves, as part of a “natural” design process
- The meaning of the symbols must be “robust”

In the sense of being understood without mistakes
by the geometrical engine in charge of assembling the parts

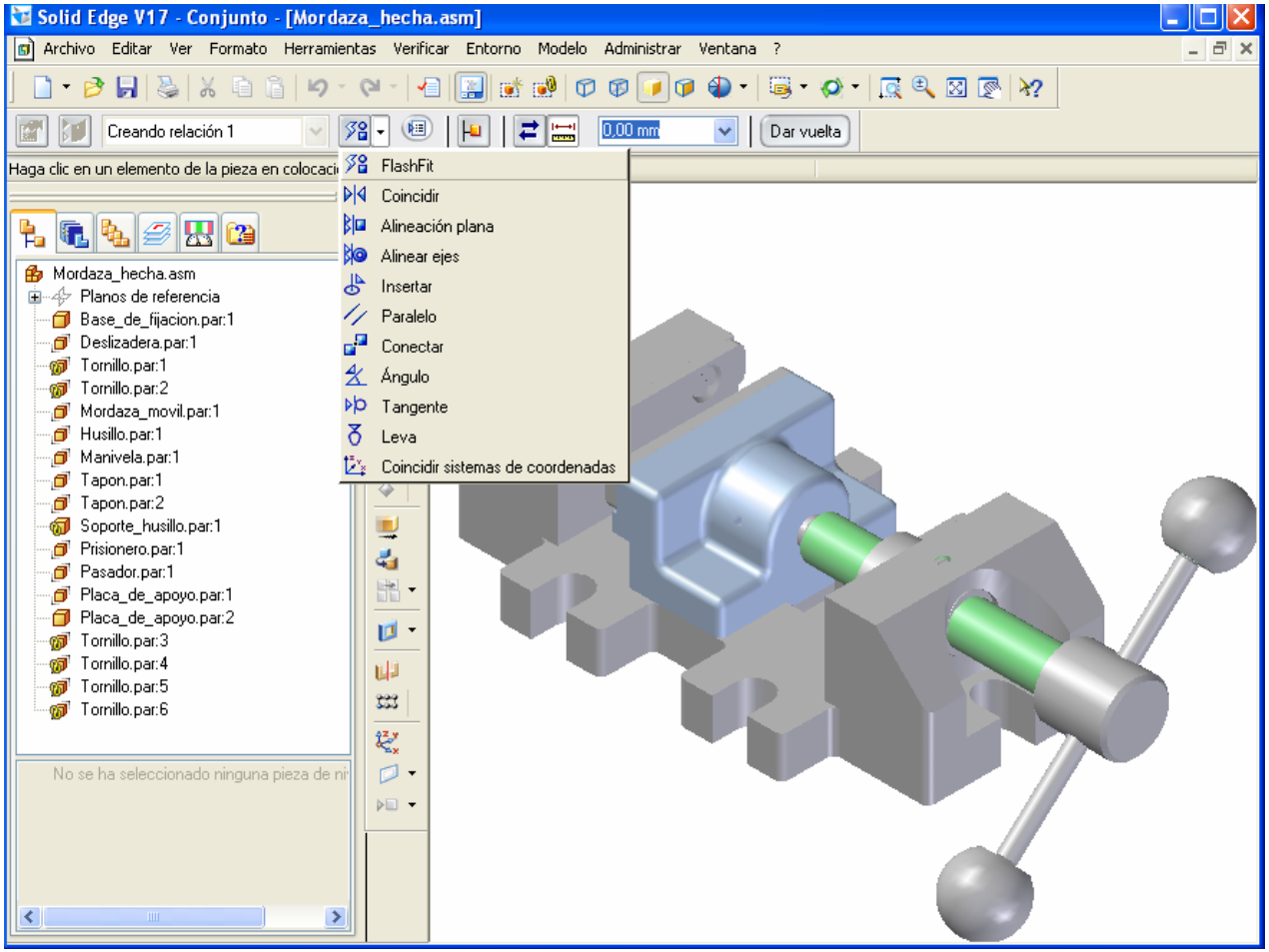
- The symbols should overtake the faults of current sets of CAD operations

They are neither full usability-driven,
nor full manufacturability-driven



Next step

What is wrong with current CAD applications?



SolidEdge: originally developed and release by Intergraph in 1996
using the ACIS geometric modeling kernel
it later changed to using the Parasolid kernel

Next step

Assembly Modelling is the technology and methods used by CAD and other computer software systems to handle multiple files that represent components within a product.

Components can be positioned within the product assembly using:

- ✓ absolute coordinate placement methods
- ✓ mating conditions.

Mating conditions are definitions of the relative position of components between each other.
For example alignment of axis of two holes or distance of two faces from one another.

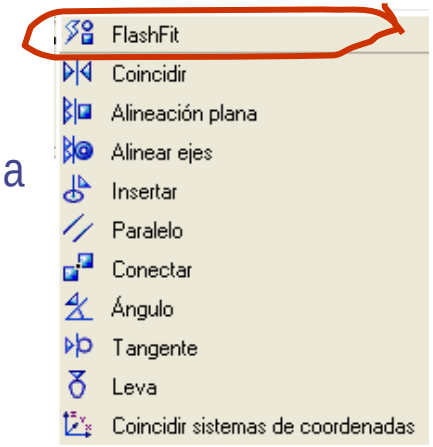
The final position of al components based on these relationships is calculated using a geometry constraint engine built into the CAD or visualization package.

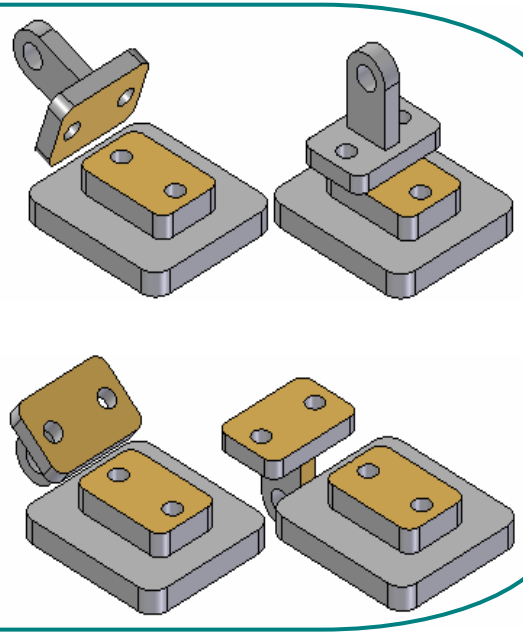
Next step

In fact, some mating conditions tools assist the user to get an intuitive and friendly set of constraints:

1. As users place parts in an assembly, assembly relationships position new parts relative to parts already in the assembly.
2. There are several relationship types for positioning parts relative to each other.

Starting with v8 (2000), Solid Edge also has a FlashFit option that can reduce steps required to position parts.





Next step

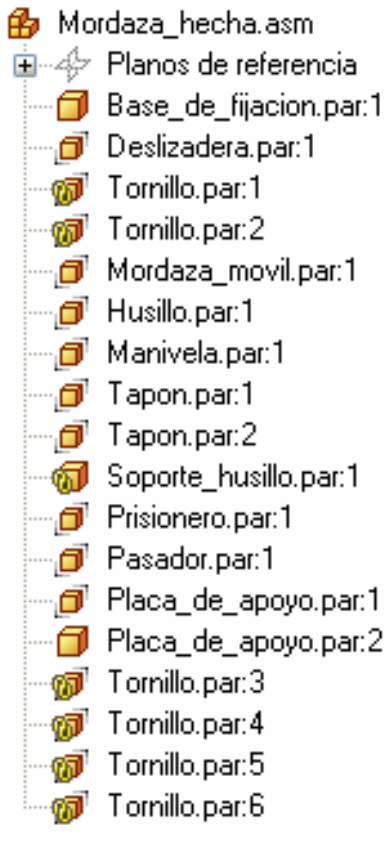
However, we can find two main drawbacks:

- ✗ Only finished parts can be assembled
- ✗ Assembly relationships still require taxonomies

Next step

1 Only complete and consistent parts can be assembled:

CAD assembly sub-systems require
standard CAD parts input



Detailed design of parts is an assembly pre-requisite!

Next step

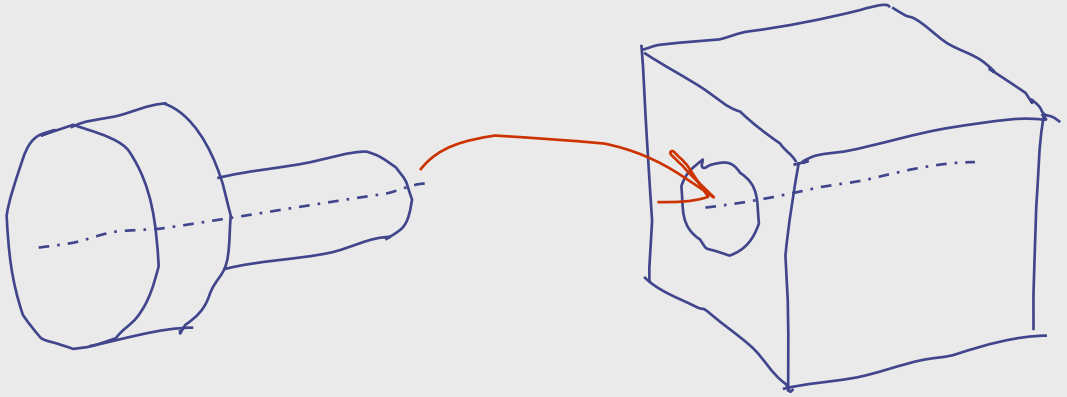
Our vision is creating a sketch-based environment …

… able to assemble different parts…

… that are not yet fully defined.

In other words:

Assemble conceptual designs of parts!

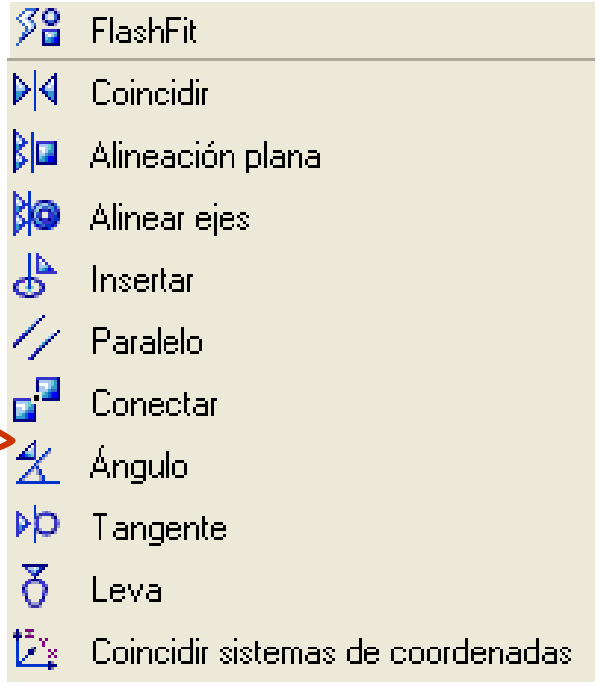


Next step

2 Current CAD applications merge different kind of assembling tools:

some are oriented to functionality and manufacturability

but other that are "geometry-driven"



Next step

Our vision is developing a new set of mating conditions:

- ✓ Valid to assemble sketched parts
- ✓ Containing design intents, instead of geometrical constraints
- ✓ Useful as input information for tolerancing purposes

Next step

Our vision is developing a new set of mating conditions:

- ✓ Valid to assemble sketched parts
- ✓ Containing design intents, instead of geometrical constraints
- ✓ Useful as input information for tolerancing purposes

We believe that this makes sense, because…

tolerances should ensure that parts within tolerance specification are:

- ✓ functionally equivalent
- ✓ interchangeable in assembly

Next step

Some tolerancing representation and specification approaches seem more promising than others:

T.T.R.S.

Clement A., Valade C. and Riviere A., 1997, The TTRSs: 13 oriented constraints for dimensioning, tolerancing and inspection. In P. Ciarlini, M. G. Cox, F. Pavese, and D. Ritcher (eds.), *Advanced Mathematical Tools in Metrology III* (World Scientific Publishing Company), pp. 24-42.

Clement A., Riviere A., Serre P. and Valade C., 1998, The TTRSs: 13 oriented constraints for dimensioning and tolerancing. In H. A. ElMaraghy (ed.), *Geometric Design Tolerancing: Theories, Standards and Applications*, pp. 122-131, presented at the 5th *CIRP Seminar on Computer-Aided Tolerancing*, Toronto, Canada.

FROOM

Salomons, O. W., 1995, *Computer support in the design of mechanical products*. PhD thesis, University of Twente, The Netherlands, available at http://www.pt.wb.utwente.nl/staff/otto/thesis/.

…but we have found important problems still unsolved…

Next step

Current tolerancing standards and practices
must be tightened (formalized) considerably
if we are to represent tolerancing information
in computer-based geometric systems
in a form suitable for automatic tolerance analysis;
automatic planning of manufacturing, assembly, and
inspection operations;
and design and production activities.

The above paragraph comes from Requicha (1983)

Requicha A.A.G. (1983), Toward a theory of geometric tolerancing. *The international Journal of Robotics Research*, 2 (4), 45-60.

But it was cited by Zhang and Huq… in 1993!

Zhang H.C. and Huq M.E. (1993) Tolerancing techniques: the state-of-the-art. *International Journal of Production Research*, 30 (9), 2111-2135.

Next step

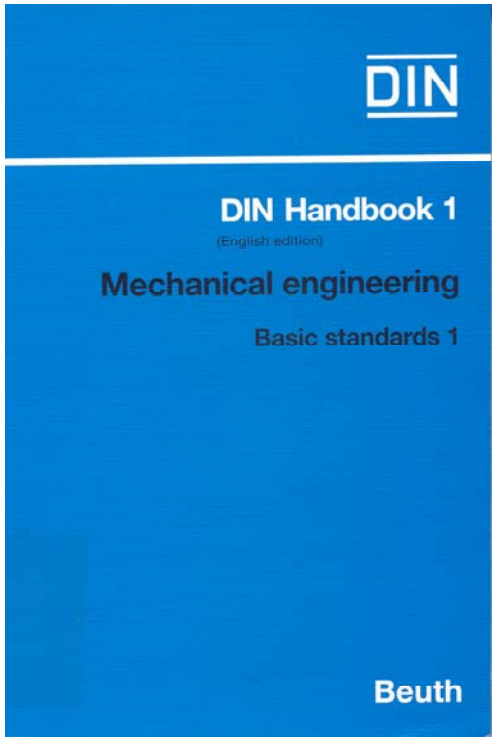
In its state-of-the-art, Zhang and Huq, cited a former work by Ali et al (1988) to assert that:

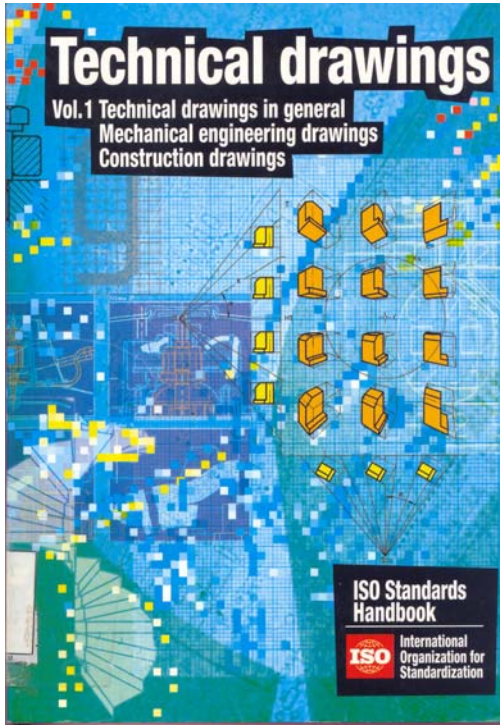
Zhang H.C. and Huq M.E. (1993) Tolerancing techniques: the state-of-the-art. *International Journal of Production Research*, 30 (9), 2111-2135.

"standardization of the interfacing of the geometric modeller with other components of computer integrated manufacturing is needed"

Next step

New standards have appeared since that time:





…but they are 2D standards!

Next step

A new state-of-the-art appeared in 2002.

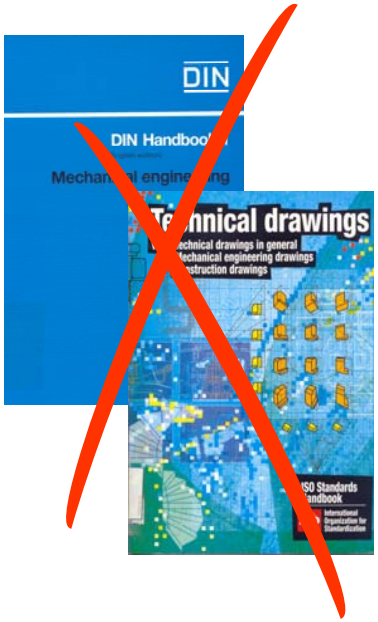
Hong Y.S. and Chang T.C. (2002) A comprehensive review of tolerancing research. *International Journal of Production Research*, 40 (11), 2425-2459.

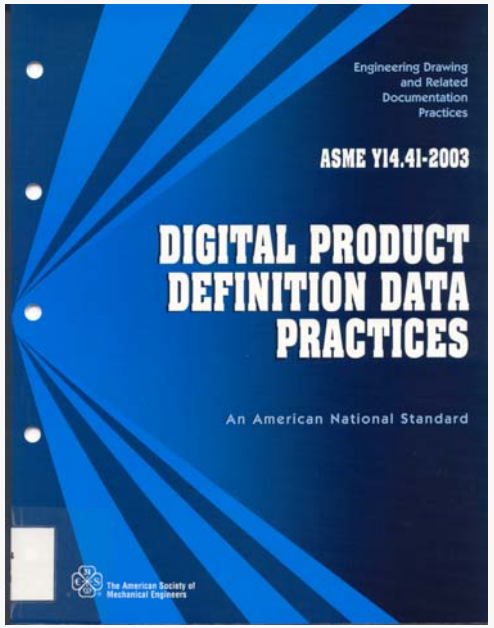
And the problem was quoted again:

Although geometric tolerancing addresses the weakness and intrinsic ambiguities of parametric tolerancing, it still poses its own weakness, mainly due to its informal way of defining the core concepts

Next step

Just one year later, a new “3D” standard was released:



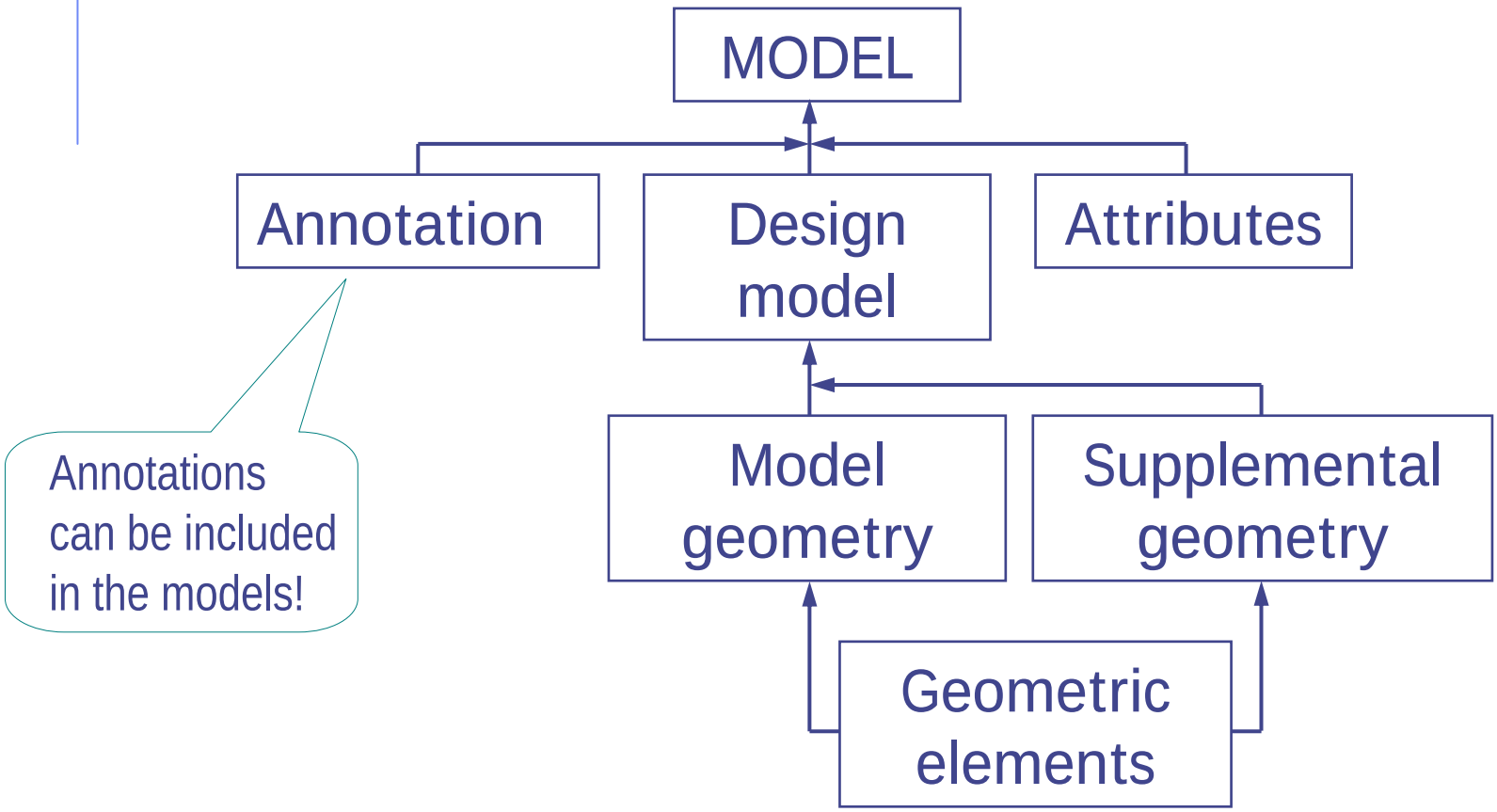


ASME Y14.41-2003

Next step

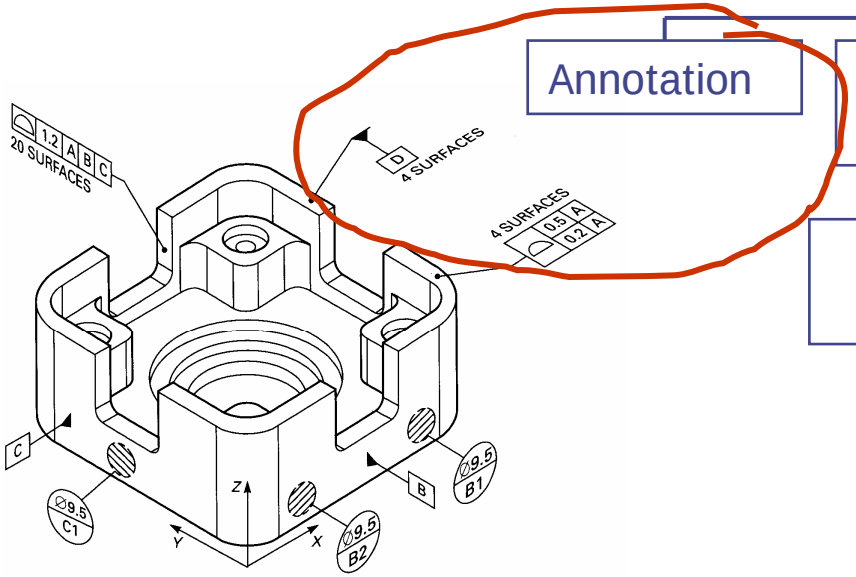
According to ASME Y14.41-2003,

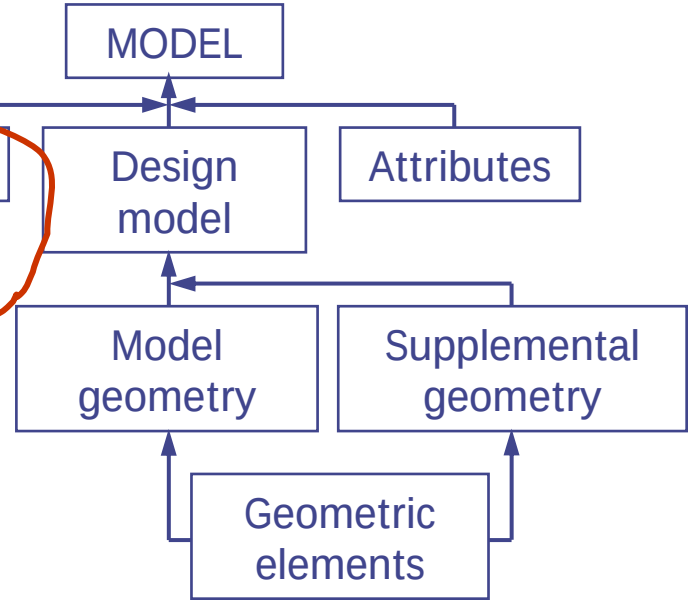
the model may contain the following information:



Next step

But the computer is blind to those annotations!



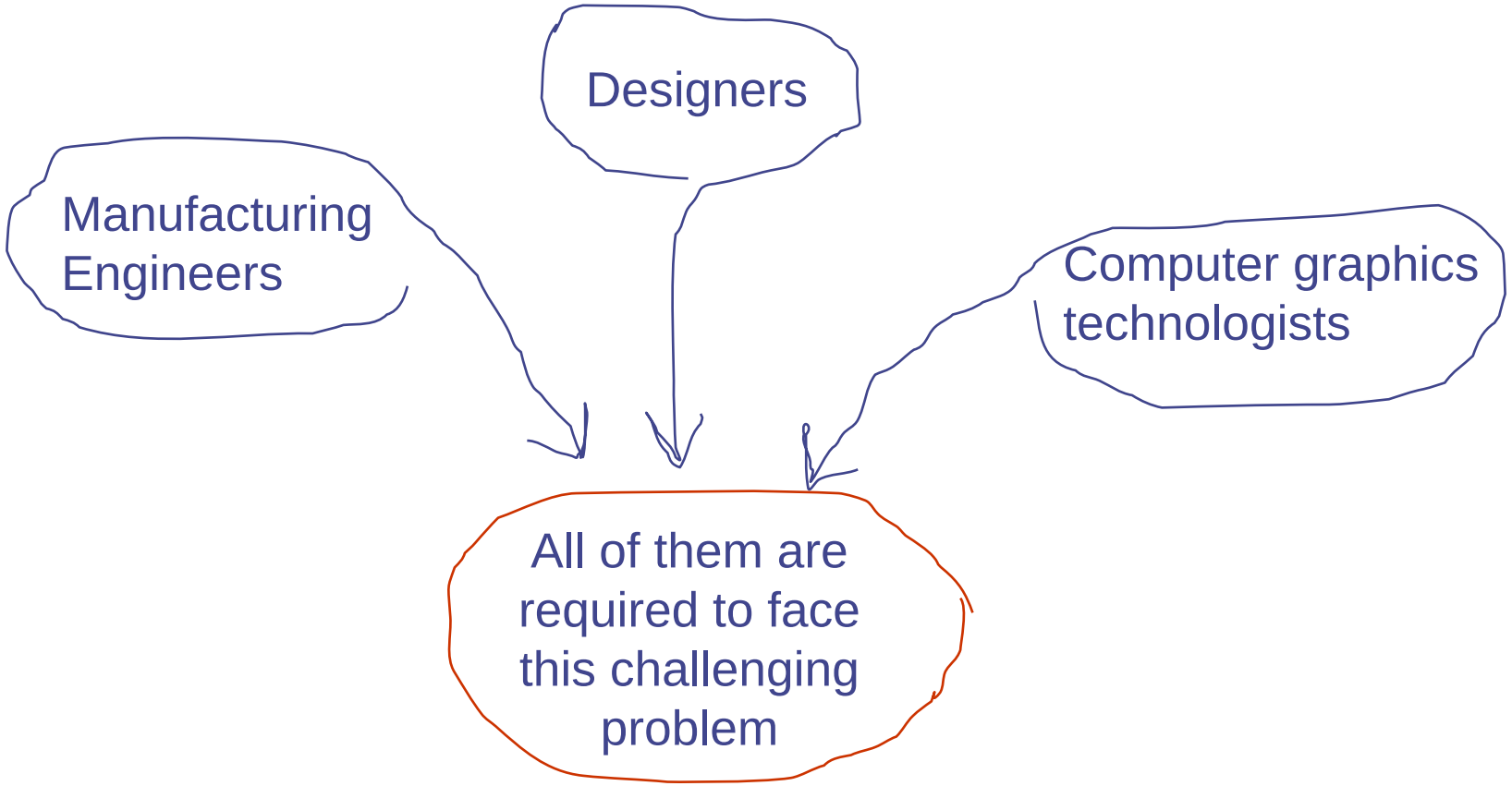


The annotations are just “labels” added to the model

✓ than the user can read and modify,

✗ but the geometrical engine does not use them, neither to construct, nor to edit or validate the model.

Conclusions



Tools for easing the Human-Computer Interaction during Virtual Assembly Process, by way of Sketch-Based Interfaces

Pedro Company

Thank you

Special thanks
for his friendship

and my most effusive FAREWELL to Professor CAPUTO !