Computer-Aided Ideation Through Sketch-Based Modeling

Pedro Company

Some group's antecedents

We began to work in this line towards 1994

REGEO

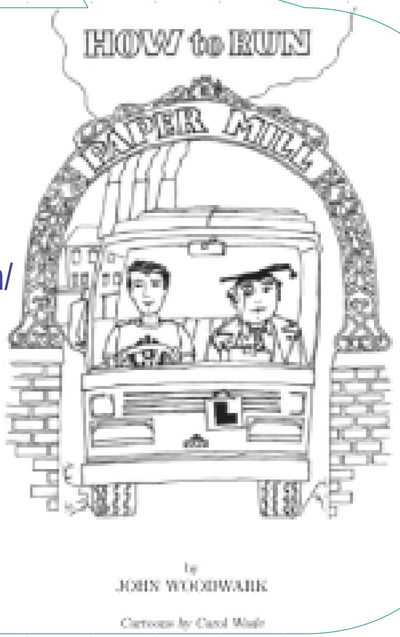
We were searching for a research subject.......“in the area”

Because we had accepted the sentence “Publish or perish”

Because it was a challenge for us to make research in “Engineering's graphic expression”

Because we were said that EVERYTING was already done

http://www.johnwoodwark.com/inge/docs/Pmill.pdf

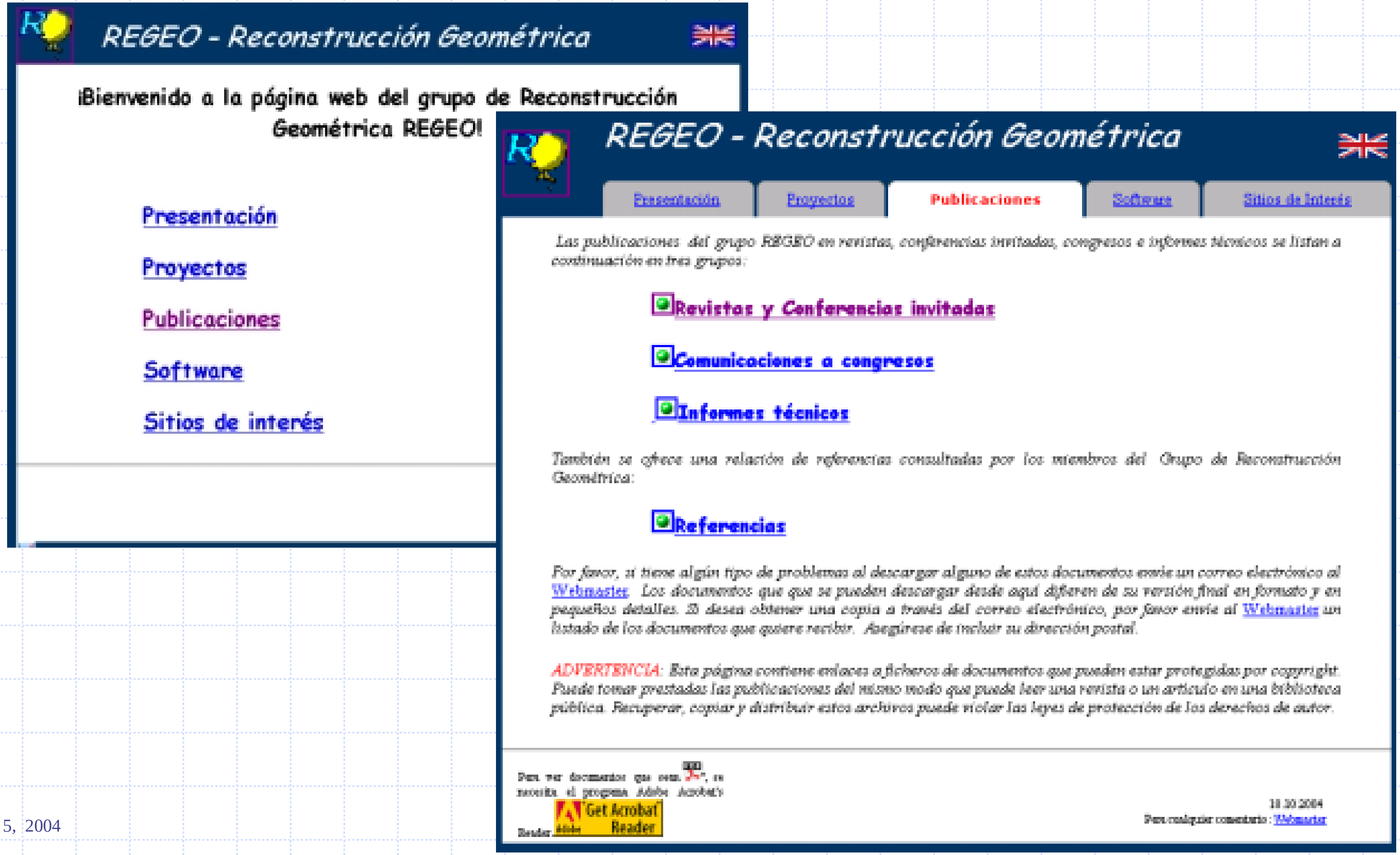


Some group's antecedents

Antecedents
Summary
Introduction
Language?
Discussion
Areas
Conclusions

The research line began to give some fruit from 2000 on

current situation can be known in: **www.tec.uji.es/d/regeo**



Summary

CAI

In the ambit of “***Computer-aided Ideation***”...

...the computer must perceive what the designer has in his/her mind’s eye...

... through a LANGUAGE...

The language must have the goal of an **artificial perception of ideation process information**.

The information is complex.
For instance, a fundamental aspect in the IDEATION of a new design is the determination of its geometry

... and with the AID of the computer.

Languages and **tools** are being developed, oriented to get an **artificial perception** of the information in the ideation process.

Introduction

The goal is difficult, since...

...current CAD applications have graphical outputs (non sequential),
but accept just verbal input (sequential).

Hence, a graphical language is needed to improve the current communication between designers and CAD applications.

“graphic”, in the sense of non sequential!

Introduction

Sketch based interfaces are oriented through this purpose...

¡...but the emphasis must be putted on the **language**, and is **non sequential** character!

For instance,

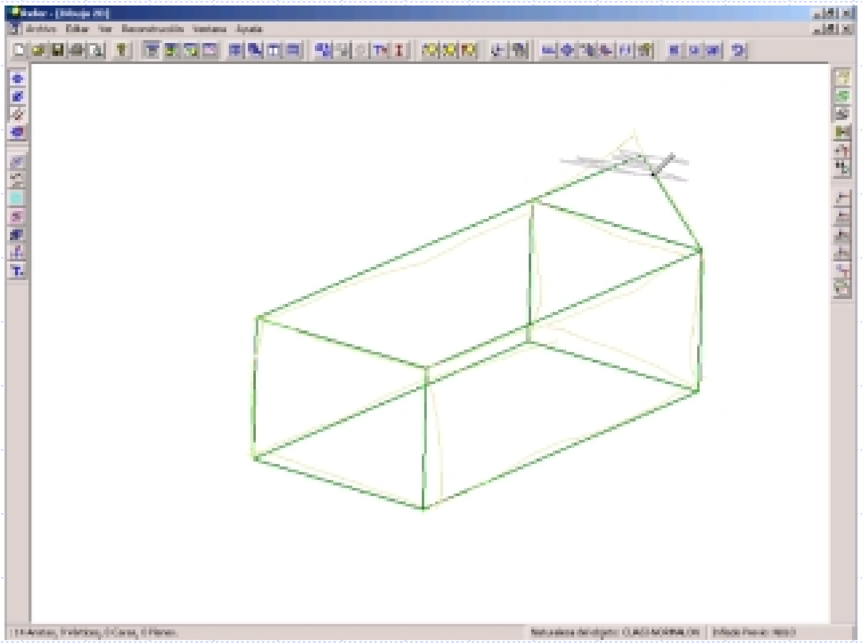
Sets of sequential orders, do not constitute any graphic language,

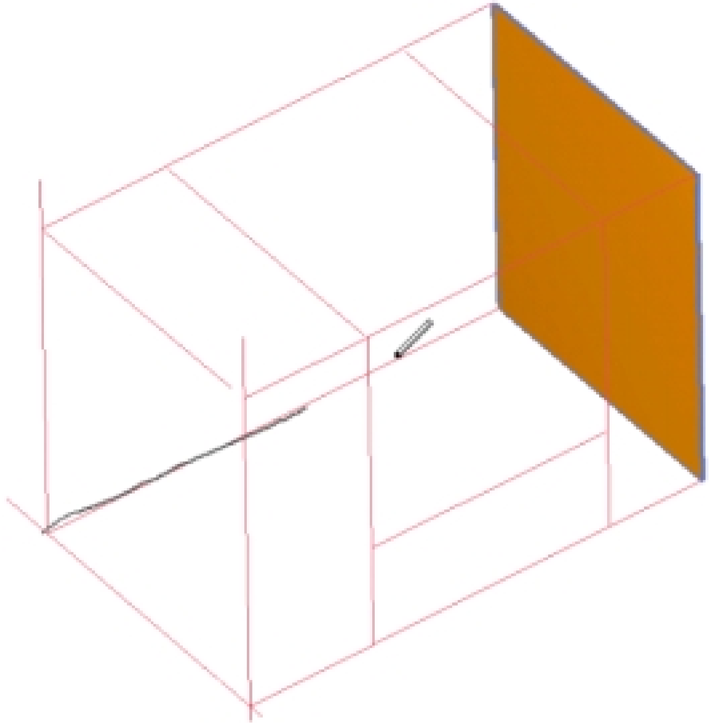
including those that serve *to generate graphics, or those that are transmitted through icons, gestures, etc*!

Introduction

GEOMETRICAL RECONSTRUCTION is a CAI tool, and constitutes the kernel of SKETCH-BASED MODELING

GEOMETRICAL RECONSTRUCTION
is the discipline that deals with the automatic or semi-automatic obtaining of three dimensional geometrical models from drawings





Introduction

The initial goal of geometrical reconstruction was to extract information from paper done engineering plans

i.e., the "archeology" of know how filed in plans

Today, most of the systems are oriented towards **conceptual design**

through "**sketch-based modeling**"

using sketches generated by the user as input data to construct models

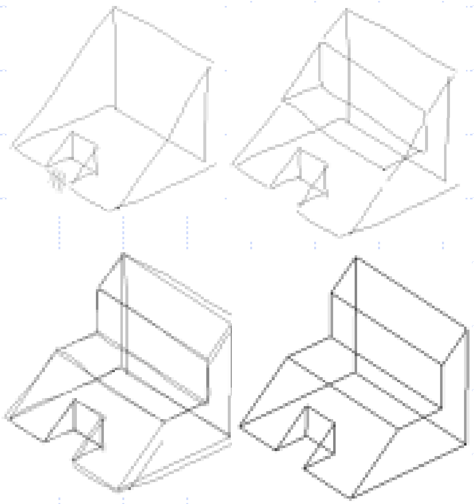
Sketching

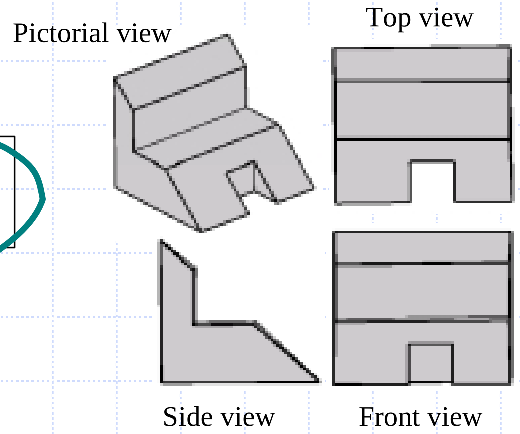
↓

2D Reconstruction (or Beautification)

↓

3D Reconstruction





Language?

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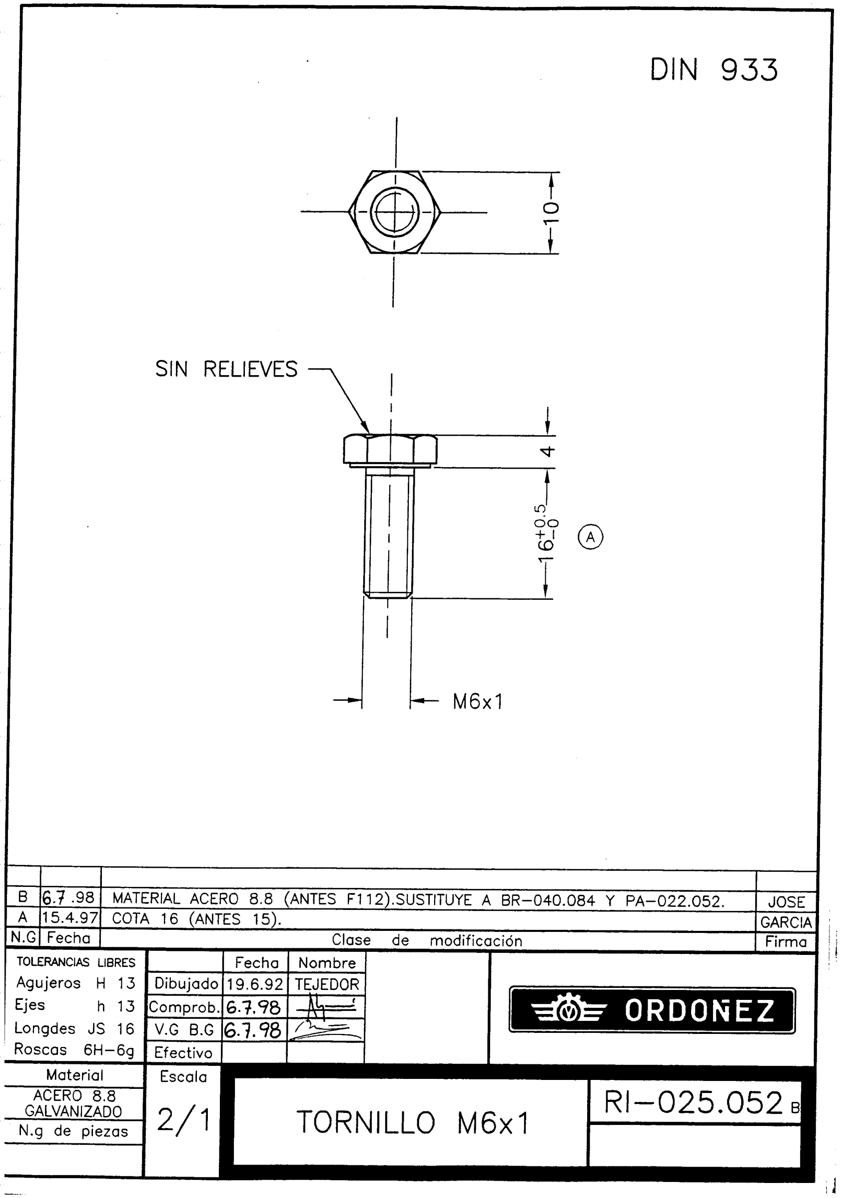
- Conclusions

Behind drawings apparently quite simples...



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Behind drawings apparently quite simples...

...there are hundreds of **standards**

Technical drawings — Screw threads and threaded parts —

Part 1:
General conventions

1 Scope

This part of ISO 6410 specifies methods for representing screw threads and threaded parts on technical drawings.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 6410. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 6410 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 128:1982, *Technical drawings — General principles of presentation.*

ISO 129:1985, *Technical drawings — Dimensioning — General principles, definitions, methods of execution and special indications.*

ISO 225:1983, *Fasteners — Bolts, screws, studs and nuts — Symbols and designations of dimensions.*

ISO 4753:1983, *Fasteners — Ends of parts with external metric ISO thread.*

ISO 6410-3:1993, *Technical drawings — Screw threads and threaded parts — Part 3: Simplified representation.*

3 Representation

3.1 Detailed representation of threads

In certain types of technical product documentation (e.g. publications, user manuals, etc.) the detailed representation of a thread either in a side view or in a section (see figures 1 to 3) may be needed to illustrate single or assembled parts. Neither pitch nor profile of the threads need usually be drawn exactly to scale.

In technical drawings, the detailed representation of threads (see figures 1 to 3) should only be used if absolutely necessary and whenever possible the helix should be represented by straight lines (see figure 2).

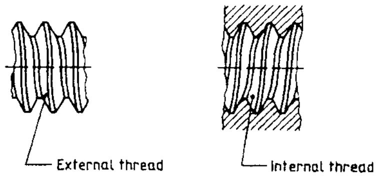

Figure 1

Language?

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ISO 6410-1:1993(E)

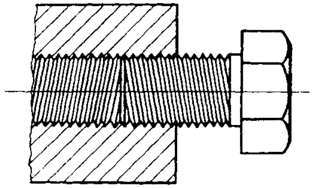

Figure 2

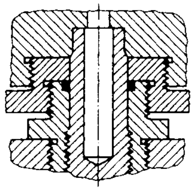

Figure 3

3.2 Conventional representation

Normally, by convention, the representation of threads and threaded parts in all types of technical drawings is simplified as shown in figures 4 to 7.

3.2.1 Views and sections of screw threads

For visible screw threads in side views and sections, the crests[1] of threads shall be defined by a continuous thick line (type A, ISO 128), and the roots[2] of threads by a continuous thin line (type B, ISO 128), as shown in figures 4 to 13.

The space between the lines representing the crest and root of the thread should approximate as closely as possible the depth of the thread, but, in all cases, this spacing shall be not less than

- twice the thickness of the thick line, or
- 0,7 mm,

whichever is the larger.

NOTE 1 In certain cases, for example computer-aided draughting,

- a distance of 1,5 mm for threads of nominal diameter $d \geqslant 8$ mm is generally acceptable;
- a simplified representation is recommended for threads of nominal diameter $d \leqslant 6$ mm, see ISO 6410-3.

3.2.2 End view of screw threads

On an end view of a screw thread, the thread roots shall be represented by a portion of a circle, drawn with a continuous thin line (type B, ISO 128) approximately equal to three-quarters of the circumference (see figures 4 and 5), preferably open in the right-hand upper quadrant. The thick line representing the chamfer circle is generally omitted on the end view (see figures 4 and 5).

NOTE 2 The portion of the circle may also have any other position relative to the intersecting axes (see figure 6).

3.2.3 Hidden screw threads

Where it is necessary to show hidden screw threads, the crests[1] and the roots[2] shall be represented by dashed thin lines (type F, ISO 128), as shown in figure 7.

3.2.4 Hatching of sections of threaded parts

For threaded parts shown in section, hatching shall extend to the line defining the crests of the thread (see figures 5 to 8).

1) "Crest" normally refers to the major diameter for external threads and to the minor diameter for internal threads.

2) "Root" normally refers to the minor diameter for external threads and to the major diameter for internal threads.

Language?

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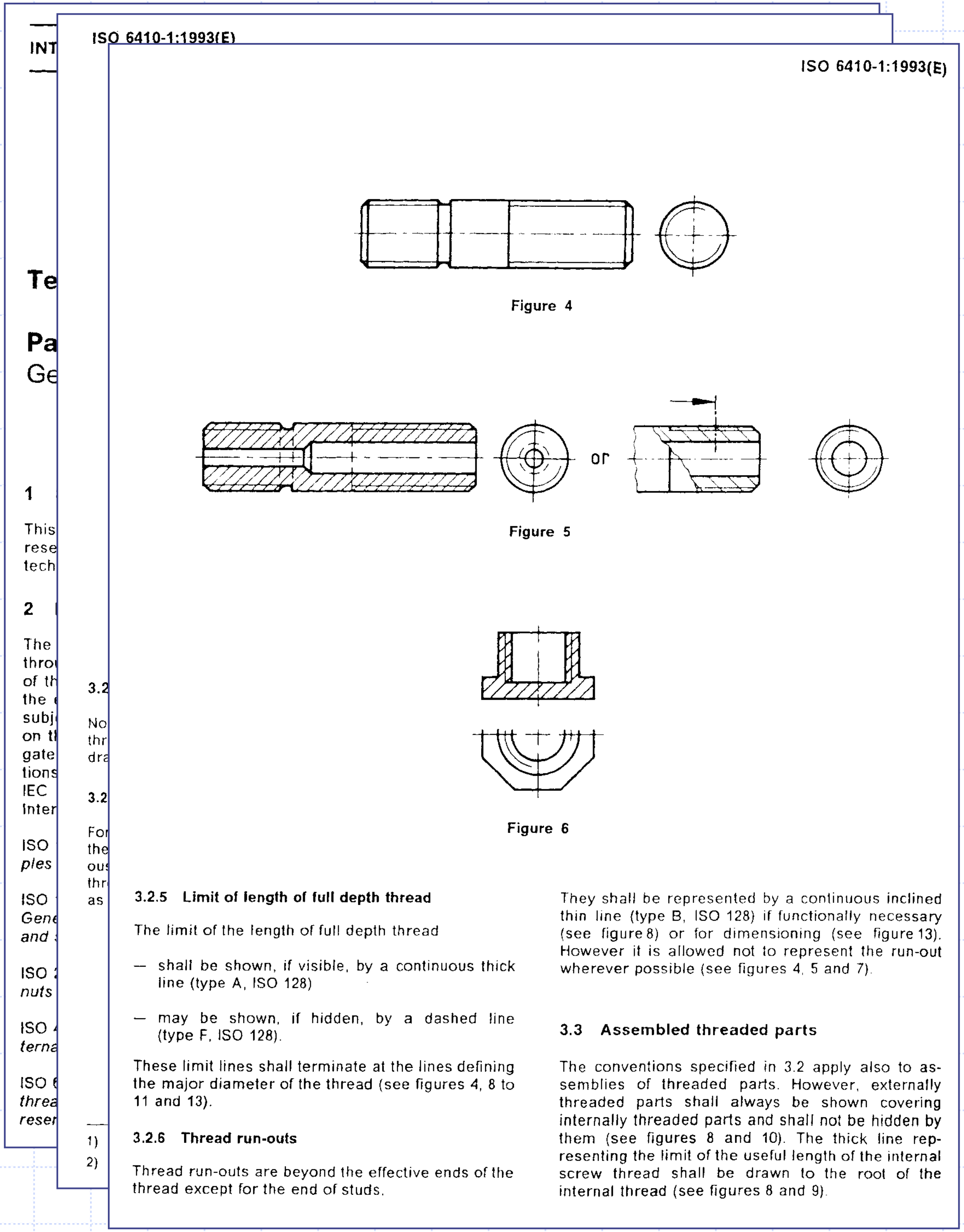

ISO 6410-1:1993(E)

Figure 4

Figure 5

Figure 6

3.2.5 Limit of length of full depth thread

The limit of the length of full depth thread

— shall be shown, if visible, by a continuous thick line (type A, ISO 128)

— may be shown, if hidden, by a dashed line (type F, ISO 128).

These limit lines shall terminate at the lines defining the major diameter of the thread (see figures 4, 8 to 11 and 13).

3.2.6 Thread run-outs

Thread run-outs are beyond the effective ends of the thread except for the end of studs.

They shall be represented by a continuous inclined thin line (type B, ISO 128) if functionally necessary (see figure 8) or for dimensioning (see figure 13). However it is allowed not to represent the run-out wherever possible (see figures 4, 5 and 7).

3.3 Assembled threaded parts

The conventions specified in 3.2 apply also to assemblies of threaded parts. However, externally threaded parts shall always be shown covering internally threaded parts and shall not be hidden by them (see figures 8 and 10). The thick line representing the limit of the useful length of the internal screw thread shall be drawn to the root of the internal thread (see figures 8 and 9).

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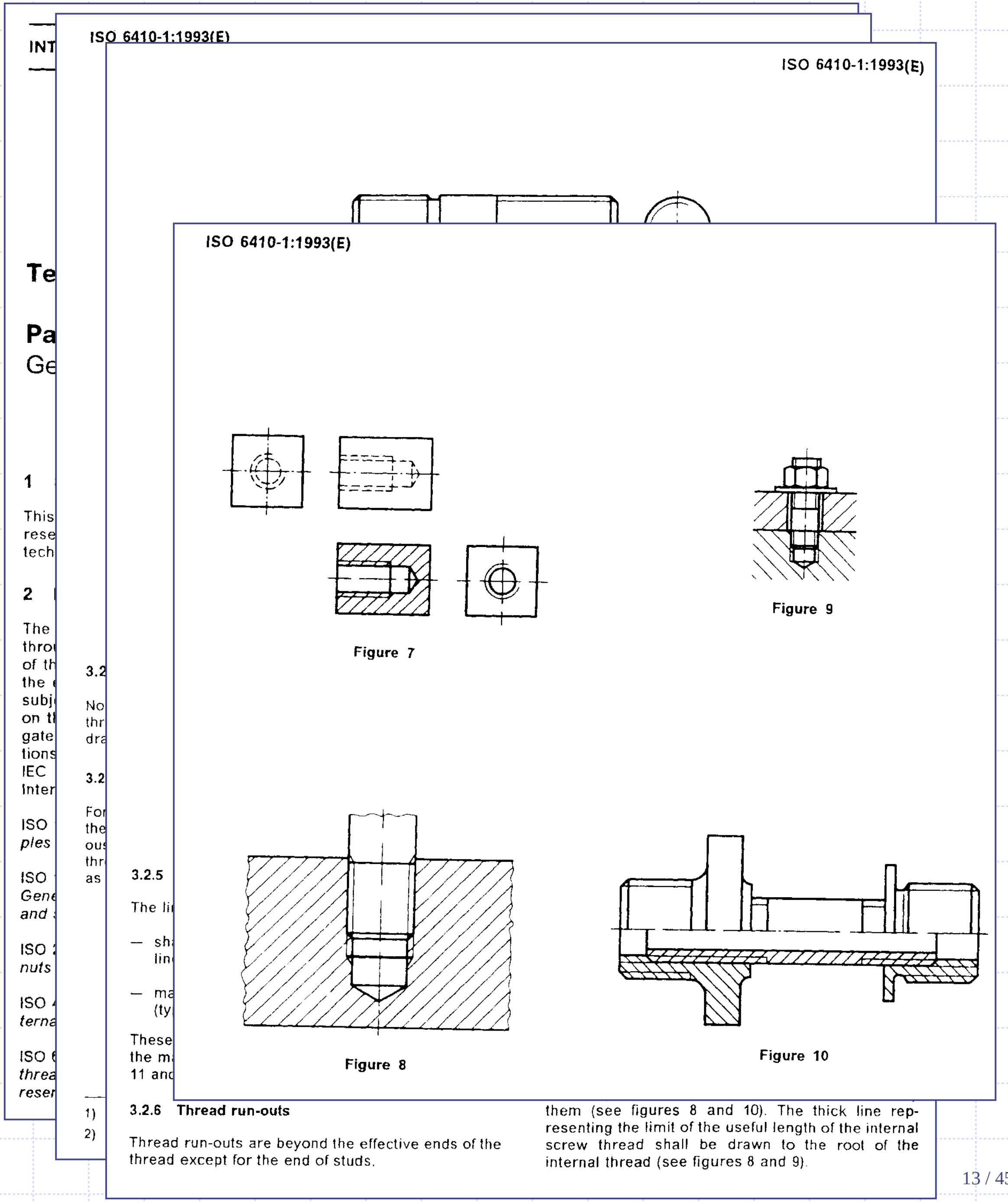

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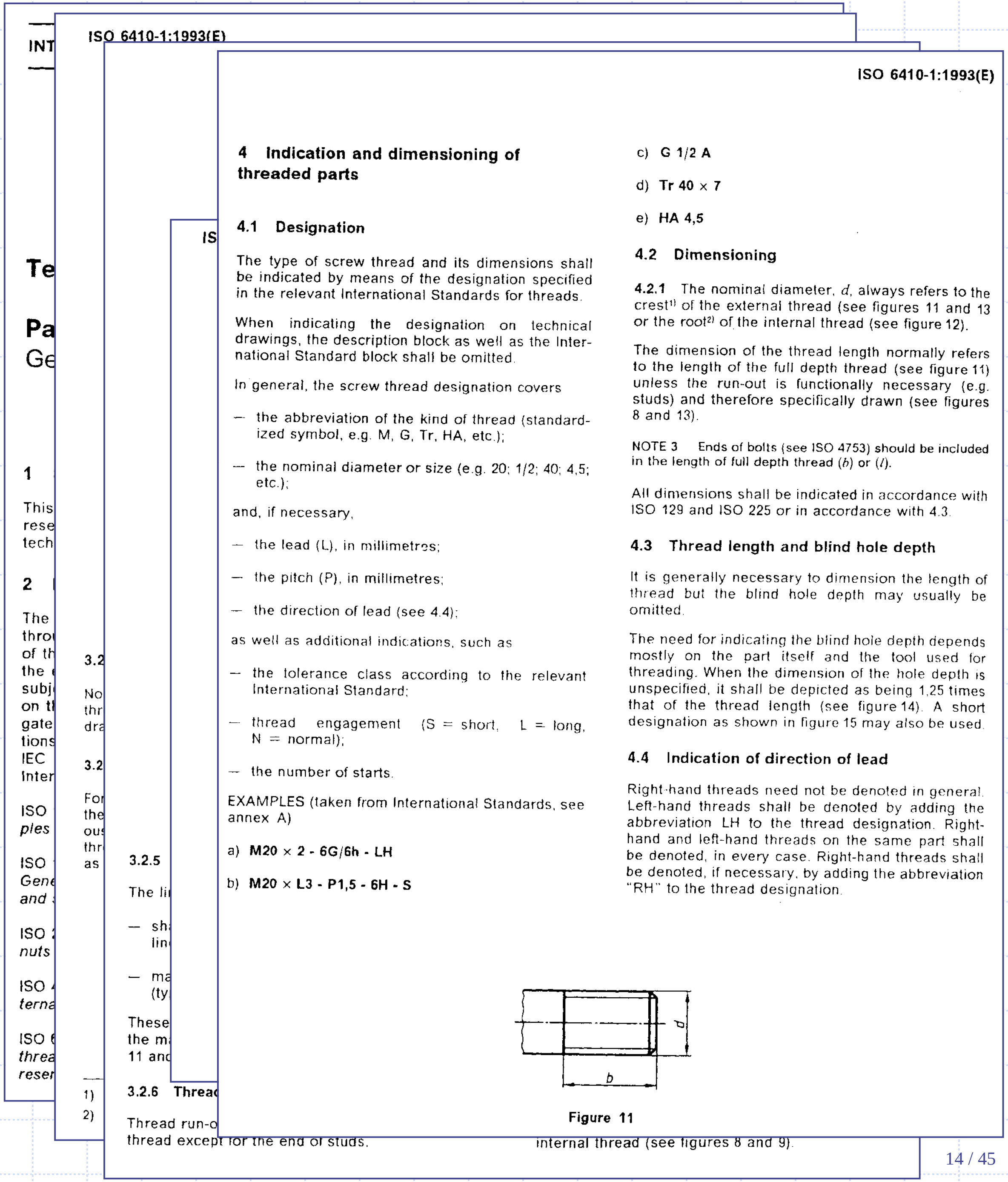

4 Indication and dimensioning of threaded parts

4.1 Designation

The type of screw thread and its dimensions shall be indicated by means of the designation specified in the relevant International Standards for threads.

When indicating the designation on technical drawings, the description block as well as the International Standard block shall be omitted.

In general, the screw thread designation covers

— the abbreviation of the kind of thread (standardized symbol, e.g. M, G, Tr, HA, etc.);

— the nominal diameter or size (e.g. 20; 1/2; 40; 4,5; etc.);

and, if necessary,

— the lead (L), in millimetres;

— the pitch (P), in millimetres;

— the direction of lead (see 4.4);

as well as additional indications, such as

— the tolerance class according to the relevant International Standard;

— thread engagement (S = short, L = long, N = normal);

— the number of starts.

EXAMPLES (taken from International Standards, see annex A)

a) **M20 × 2 - 6G/6h - LH**

b) **M20 × L3 - P1,5 - 6H - S**

c) **G 1/2 A**

d) **Tr 40 × 7**

e) **HA 4,5**

4.2 Dimensioning

4.2.1 The nominal diameter, *d*, always refers to the crest[1)] of the external thread (see figures 11 and 13) or the root[2)] of the internal thread (see figure 12).

The dimension of the thread length normally refers to the length of the full depth thread (see figure 11) unless the run-out is functionally necessary (e.g. studs) and therefore specifically drawn (see figures 8 and 13).

NOTE 3 Ends of bolts (see ISO 4753) should be included in the length of full depth thread (*b*) or (*l*).

All dimensions shall be indicated in accordance with ISO 129 and ISO 225 or in accordance with 4.3.

4.3 Thread length and blind hole depth

It is generally necessary to dimension the length of thread but the blind hole depth may usually be omitted.

The need for indicating the blind hole depth depends mostly on the part itself and the tool used for threading. When the dimension of the hole depth is unspecified, it shall be depicted as being 1,25 times that of the thread length (see figure 14). A short designation as shown in figure 15 may also be used.

4.4 Indication of direction of lead

Right-hand threads need not be denoted in general. Left-hand threads shall be denoted by adding the abbreviation LH to the thread designation. Right-hand and left-hand threads on the same part shall be denoted, in every case. Right-hand threads shall be denoted, if necessary, by adding the abbreviation "RH" to the thread designation.

d
b

Figure 11

Language?

Behind drawings apparently quite simples...

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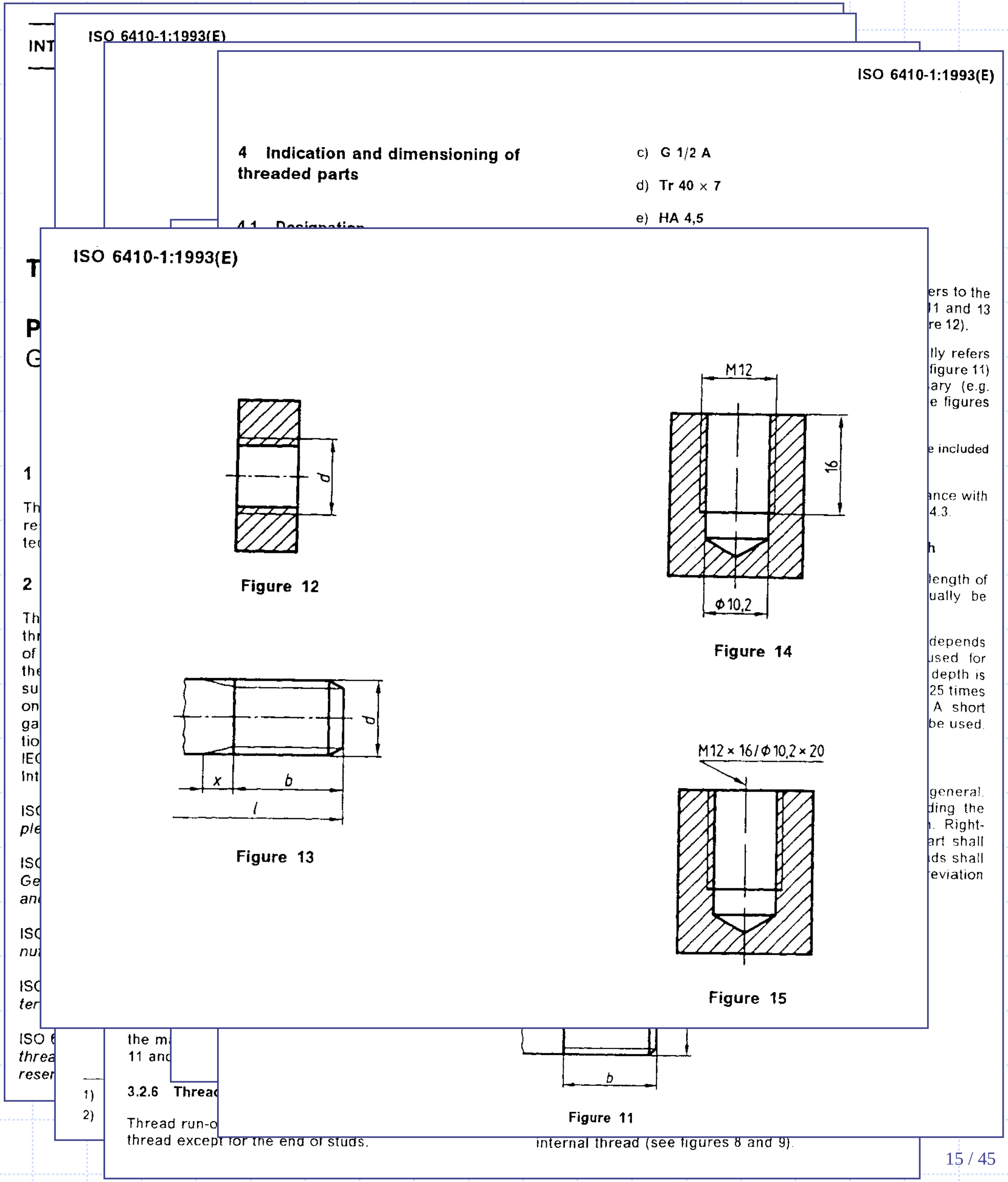

Language?

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Technical drawings — Screw threads and threaded parts —

Part 3:
Simplified representation

1 Scope

This part of ISO 6410 establishes rules for the simplified representation of threaded parts, with the exception of screw thread inserts, which are covered in ISO 6410-2. This representation is applicable when it is not necessary to show the exact shape and details of the parts (see ISO 6410-1), for example in assembly drawings.

2 Normative references

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ISO 225:1983, *Fasteners — Bolts, screws, studs and nuts — Symbols and designations of dimensions*.

ISO 6410-1:1993, *Technical drawings — Screw threads and threaded parts — Part 1: General conventions*.

3 Simplified representation

3.1 General

In simplified representation only essential features shall be shown. The degree of simplification depends on the kind of object represented, the scale of the drawing and the purpose of the documentation.

Therefore, the following features shall not be drawn in simplified representations of threaded parts:

— edges of chamfers of nuts and heads;

— thread run-outs;

— the shape of ends of screws;

— undercuts.

3.2 Screws and nuts

When it is essential to show the shapes of screw heads, drive patterns or nuts, the examples of simplified representations shown in table 1 shall be used. Combinations of features, not shown in table 1, may also be used. A simplified representation of the opposite (threaded) end view is not necessary.

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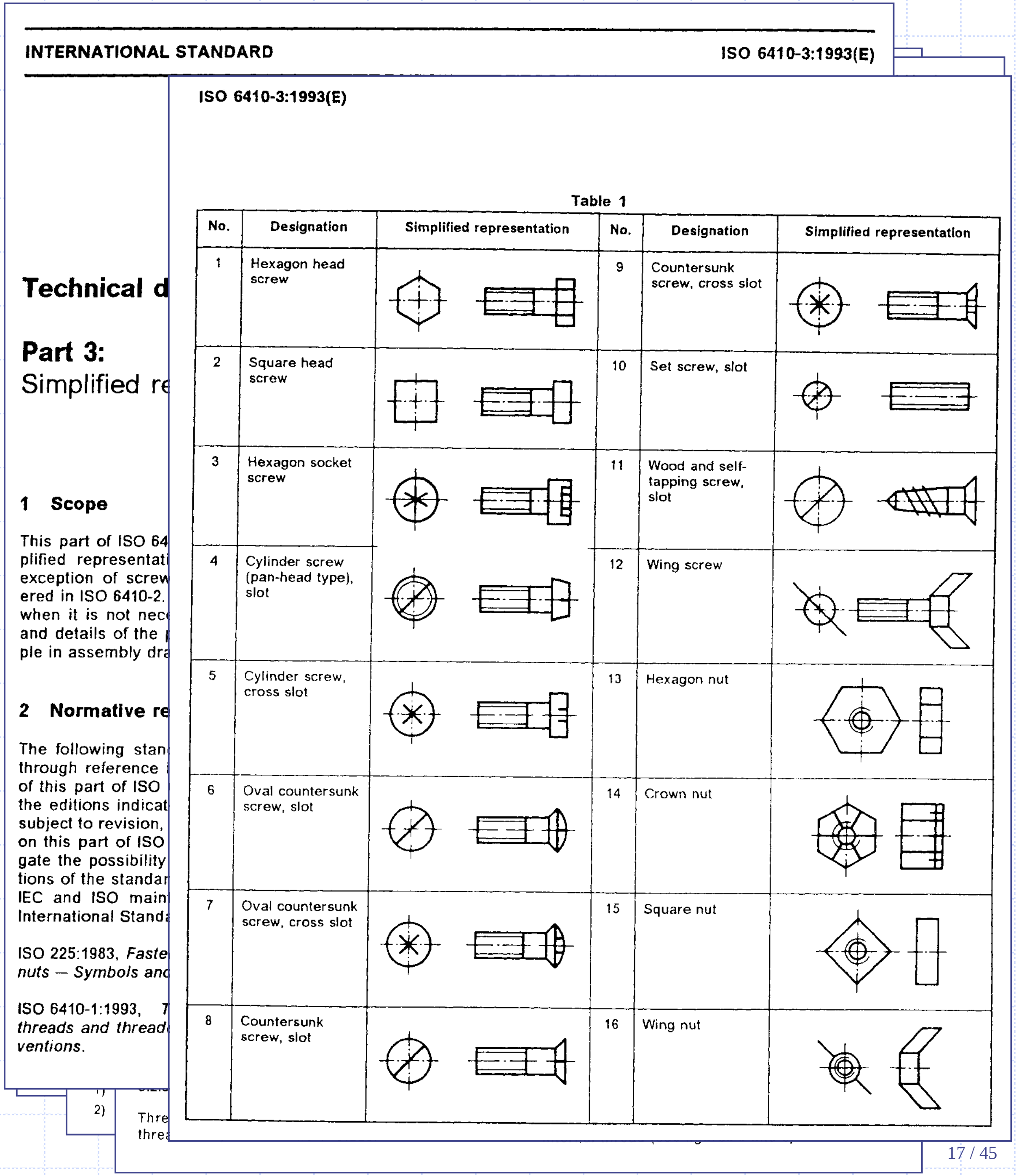

INTERNATIONAL STANDARD ISO 6410-3:1993(E)

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Part 3:
Simplified re

1 Scope

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nuts — Symbols and

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threads and thread
ventions.

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2) Thre
threa

ISO 6410-3:1993(E)

Table 1

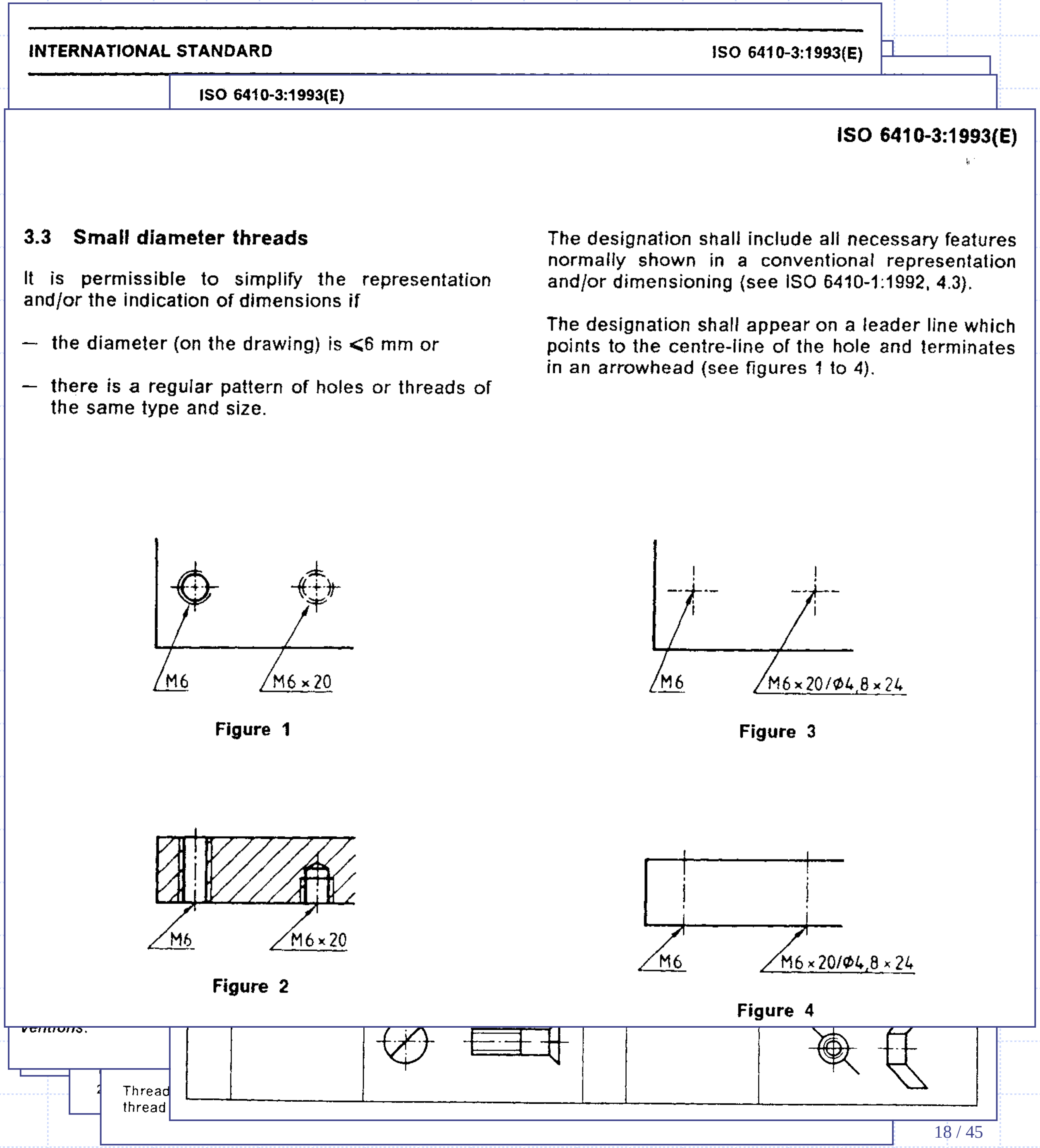
No.	Designation	Simplified representation	No.	Designation	Simplified representation
1	Hexagon head screw		9	Countersunk screw, cross slot	
2	Square head screw		10	Set screw, slot	
3	Hexagon socket screw		11	Wood and self-tapping screw, slot	
4	Cylinder screw (pan-head type), slot		12	Wing screw	
5	Cylinder screw, cross slot		13	Hexagon nut	
6	Oval countersunk screw, slot		14	Crown nut	
7	Oval countersunk screw, cross slot		15	Square nut	
8	Countersunk screw, slot		16	Wing nut	

Language?

Behind drawings apparently quite simples...

...there are hundreds of **standards**

...and what is the most important thing, is the great amount of symbols and conventions they do contain


INTERNATIONAL STANDARD ISO 6410-3:1993(E)

ISO 6410-3:1993(E)

ISO 6410-3:1993(E)

3.3 Small diameter threads

It is permissible to simplify the representation and/or the indication of dimensions if

— the diameter (on the drawing) is ≤6 mm or

— there is a regular pattern of holes or threads of the same type and size.

The designation shall include all necessary features normally shown in a conventional representation and/or dimensioning (see ISO 6410-1:1992, 4.3).

The designation shall appear on a leader line which points to the centre-line of the hole and terminates in an arrowhead (see figures 1 to 4).

Figure 1

Figure 3

Figure 2

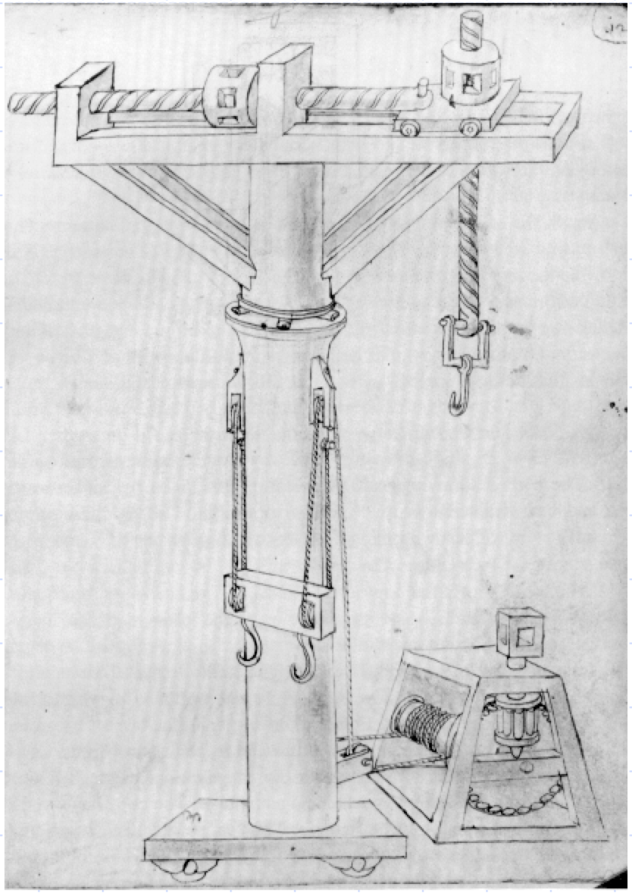
Figure 4

ventions.

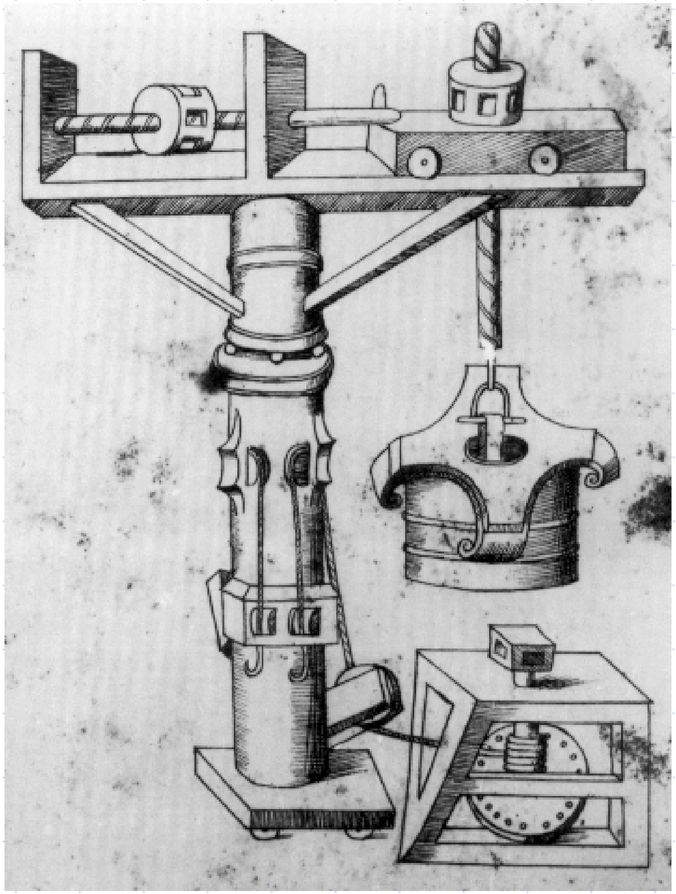
Thread
thread

Language?

It is quite obvious than the communication of relevant information depends on the **meaning** of **symbols**:



Original crane



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Language?

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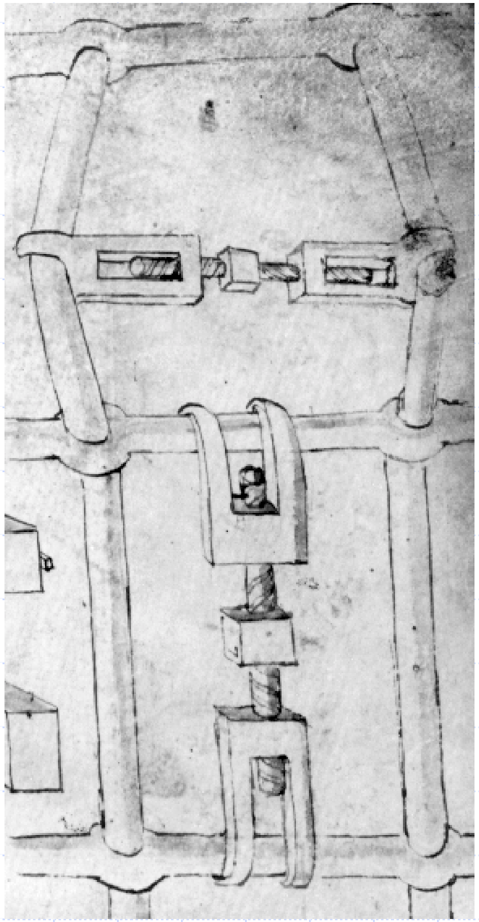
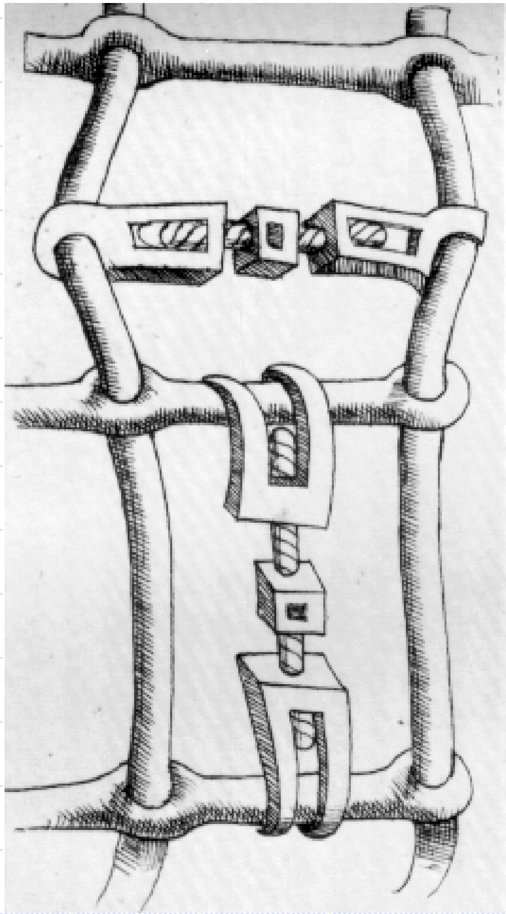


Original turnbuckle



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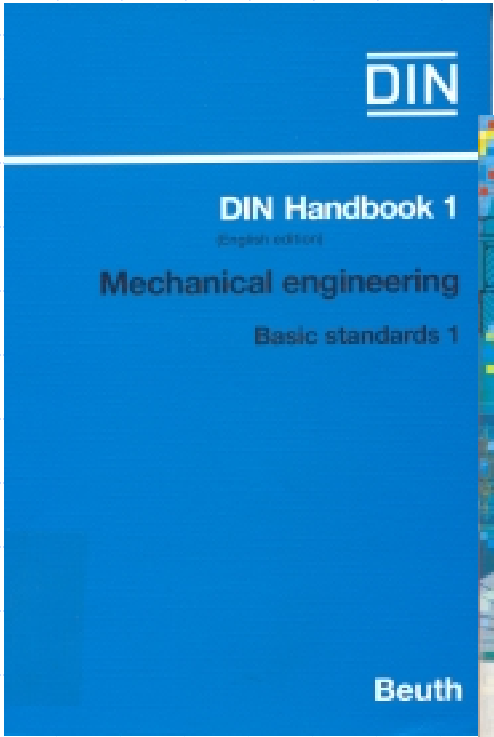
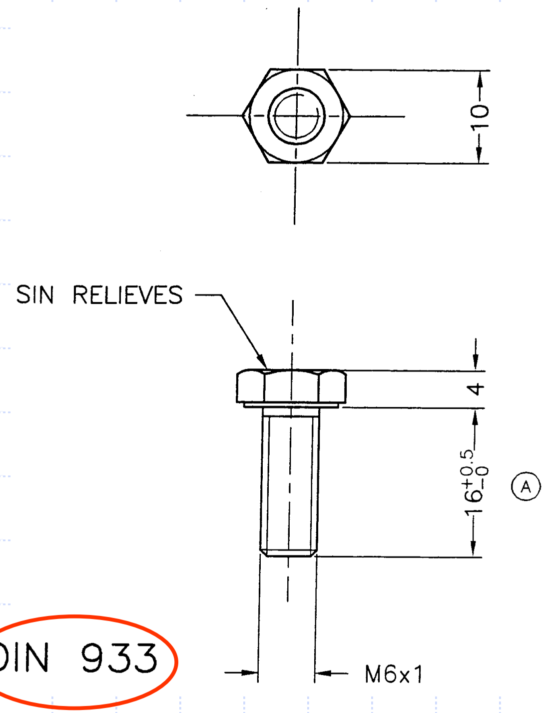
[Fer92] FERGUSON E.S. ***Engineerign and the Mind's Eye***, MIT Press (1992)

Language?

Hence, engineering drawing is a LANGUAGE, which is strongly based on standardized symbols...





...and specifically adapted to "technical information" communication

Discussion

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But...

DESIGN-BY-DRAWINGS
has been consolidating since the end of the 17th century

⇩

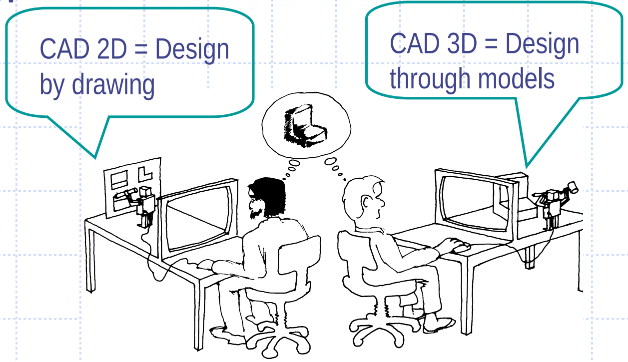
Later, it was empowered by the computer (CAD 2D)

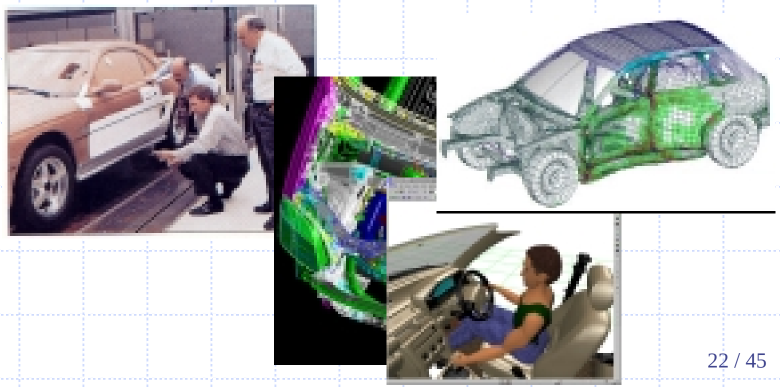
⇩

Finally, it has been overcome by the computer (CAD 3D)

⇩

Current paradigm is
DESING BY “VIRTUAL” MODELS





Discussion

In the **design by drawing** approach, plans were massively used...

while sketches were ignored

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In the **design by drawing** approach, plans were massively used...

while sketches were ignored

The first “revolution” produced by computers in the design process (**2D CAD**) was to assist, and almost automate, the drawing process...

while sketches still were ignored.

Discussion

In the **design by drawing** approach, plans were massively used...

while sketches were ignored

The first "revolution" produced by computers in the design process (**2D CAD**) was to assist, and almost automate, the drawing process...

while sketches still were ignored.

The second revolution (**3D CAD**) has let the paradigm to change to **design through virtual models**...

and, finally, SKETCHES begin to receive some attention...

Discussion

¡But, the idea of LANGUAGE, which was always present...

¡Because the designer included it when using drawings as a language

Are the new designers paying less attention to this language!?

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¡But, the idea of LANGUAGE, which was always present...

¡Because the designer included it when using drawings as a language

Are the new designers paying less attention to this language!?

The designer is asked for action (well defined and sequential) to be executed by CAD application

And this is NOT a good strategy when the designer is trying to fix visions, i.e., bad defined and non sequential ideas.

The TOOLS are conditioning the use of the language

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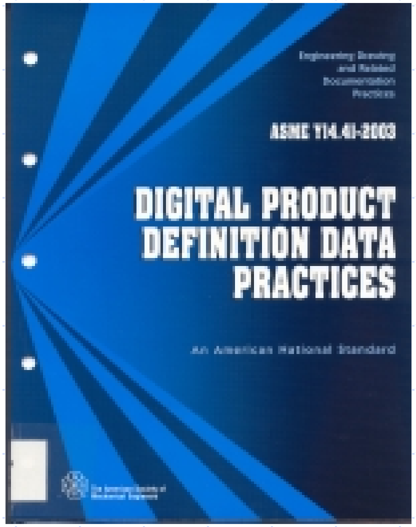
Discussion

In addition,

PAPER still has too much weight and a big inertia

The new language is not yet standardized



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Discussion

The question is:

- Every LANGUAGE allows communication between emiter and receiver
- Engineering drawings are fitted to communicate design ideas from **technicians** to **technicians**
- Today a new goal exist: communicate design ideas from **technicians** to **computers**

Is it useful the same language?

design by drawings, and
design through virtual models

both plans
and sketches

In our oppinion,
all engineering drawings
can take benefit in *both* contexts
provided that a **strongly standardized language**
exist!

Research areas

During discussion we have argued that a language for Computer –Assisted Ideation (CAI)

We have concluded that this language exists, and can be valid, provided it to be updated and standardized

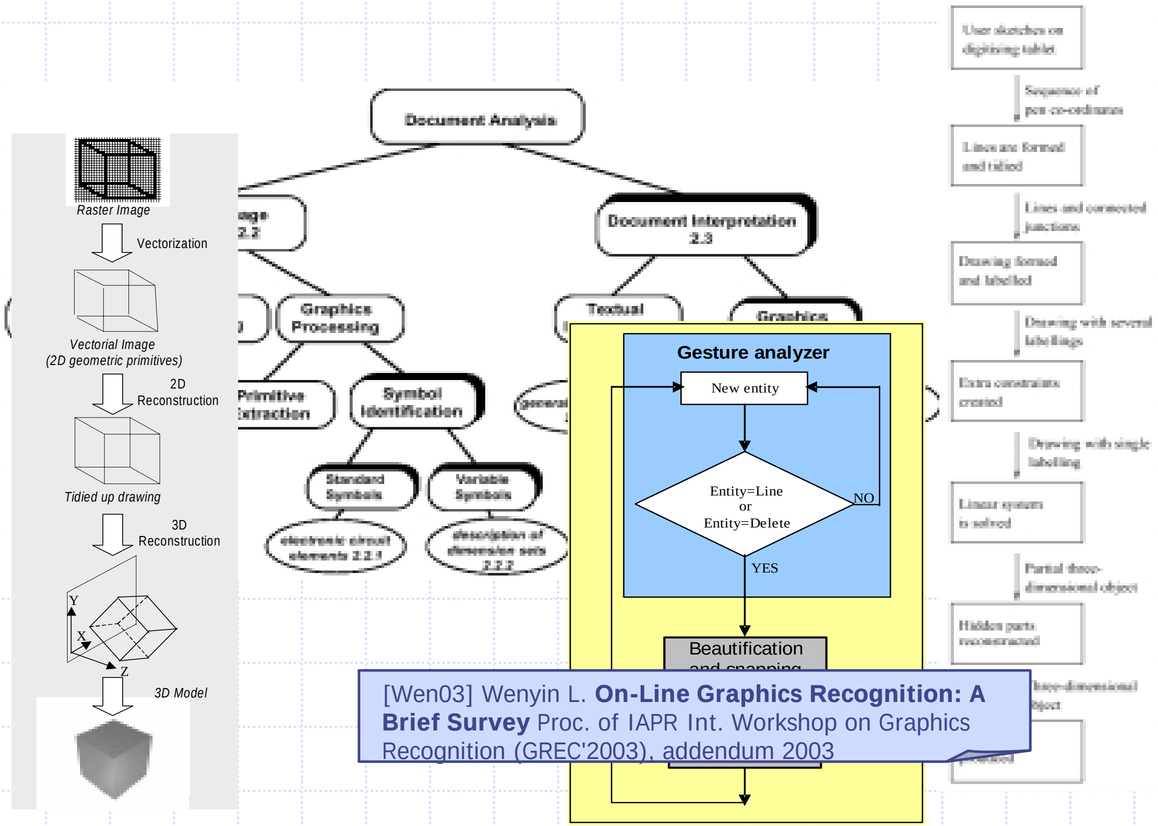
But, now, we add that this language must be integrated in a tool that ASSISTS in the ideation phase that a design process contains

Those tools are being developed in the ambit of so-called “SKETCH-BASED MODELING”

Research areas

"niches"

In order to determine candidate ambits of study, we have analyzed some studies and flow diagrams :



[Wen03] Wenyin L. **On-Line Graphics Recognition: A Brief Survey** Proc. of IAPR Int. Workshop on Graphics Recognition (GREC'2003), addendum 2003

...and we have developed our own taxonomy on "sketch-based interfaces and modeling"

Research areas

Special attention has received the fact that, according to Watanabe and Fukumura, current approaches for line-drawing interpretation can be classified as:

bottom-up They tend to begin with the image and move towards abstract-entities levels of description.

top-down They concentrate on relations among graphical primitives, objects and scenes.

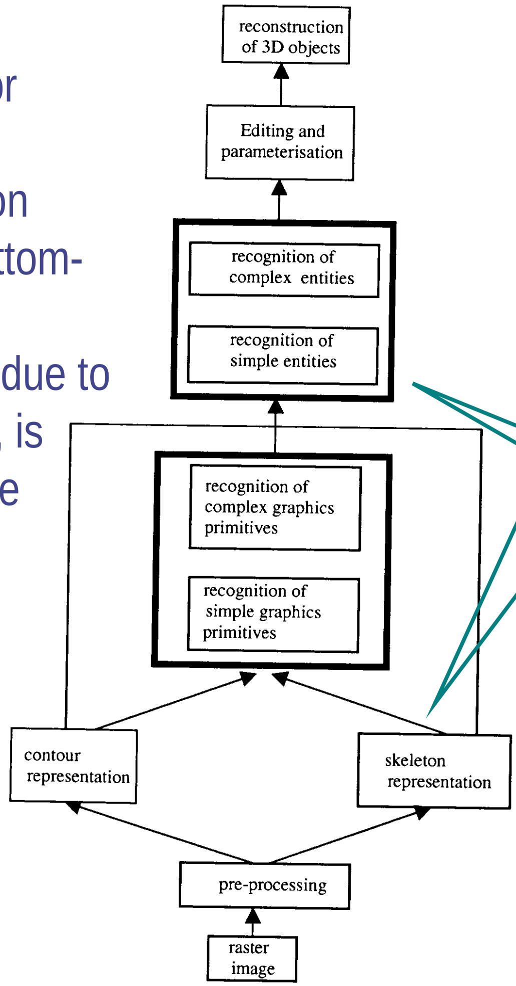
Research areas

Special attention has received the fact that, according to Watanabe and Fukumura, current approaches for line-drawing interpretation can be classified as:

bottom-up

top-down

A system for drawing interpretation which is bottom-up and sequential, due to Ablameyko, is shown in the figure



The lowest level tasks differ from which are required in a "Sketch-based interface and modeling" interface...

...but the rest fit very well.

Sketch understanding

3D modeling

Research areas

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Special attention has received the fact that, according to Watanabe and Fukumura, current approaches for line-drawing interpretation can be classified as:

bottom-up

top-down

because they use the a-priori knowledge, in order to guide the object's recognition

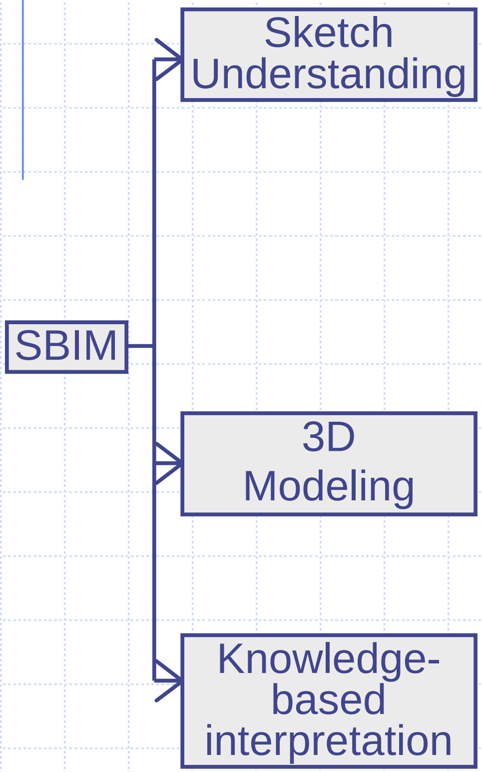
Top-down approaches thed to be called **knowledge based**.

⇩

Hence, an important ambit of study is searching for this "knowledge" ⇨ Knowledge-based interpretation

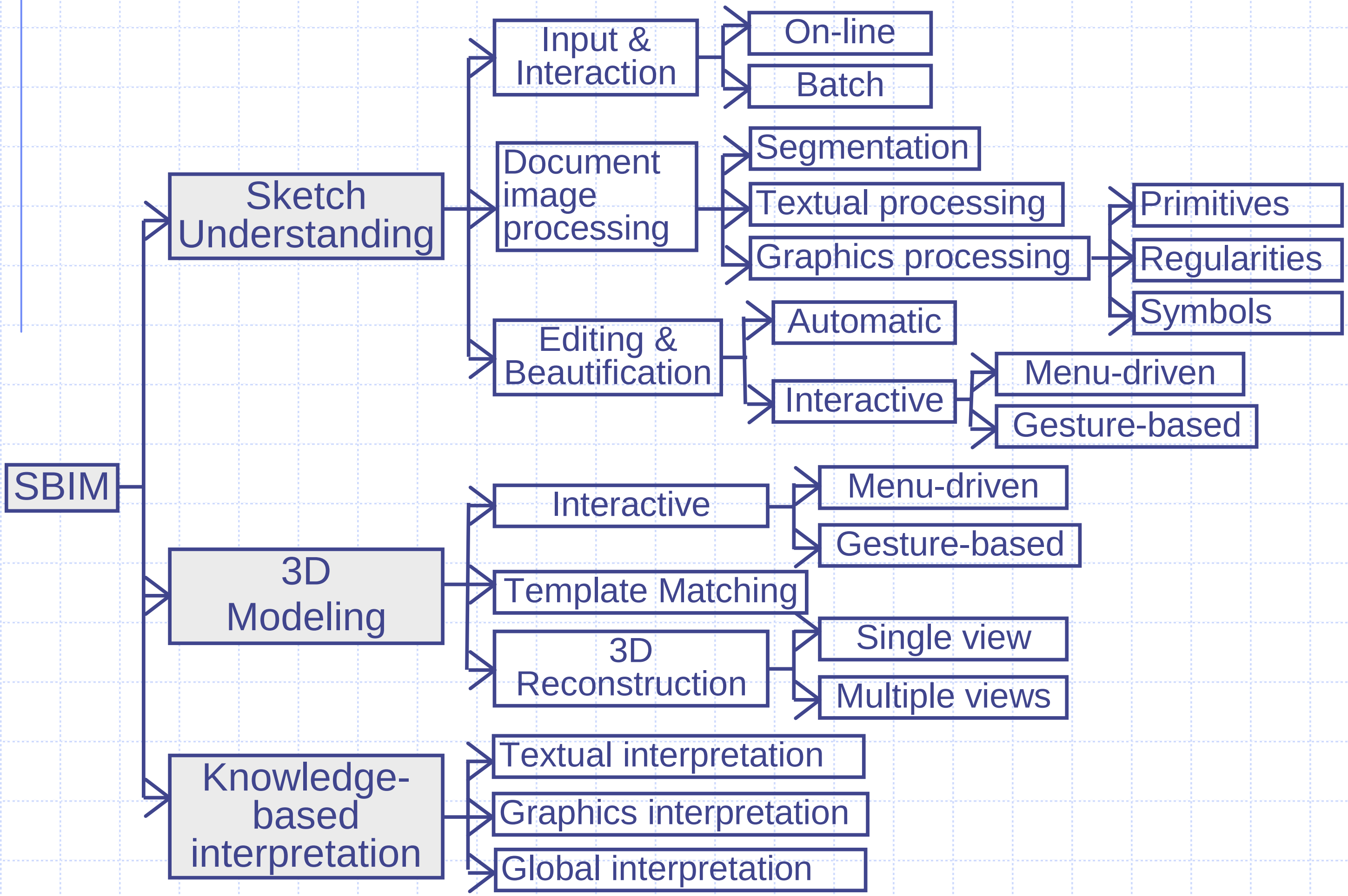
Research areas

Hence, we do consider three main areas in the "Sketch-Based Interfaces and Modeling (SBIM)" field:



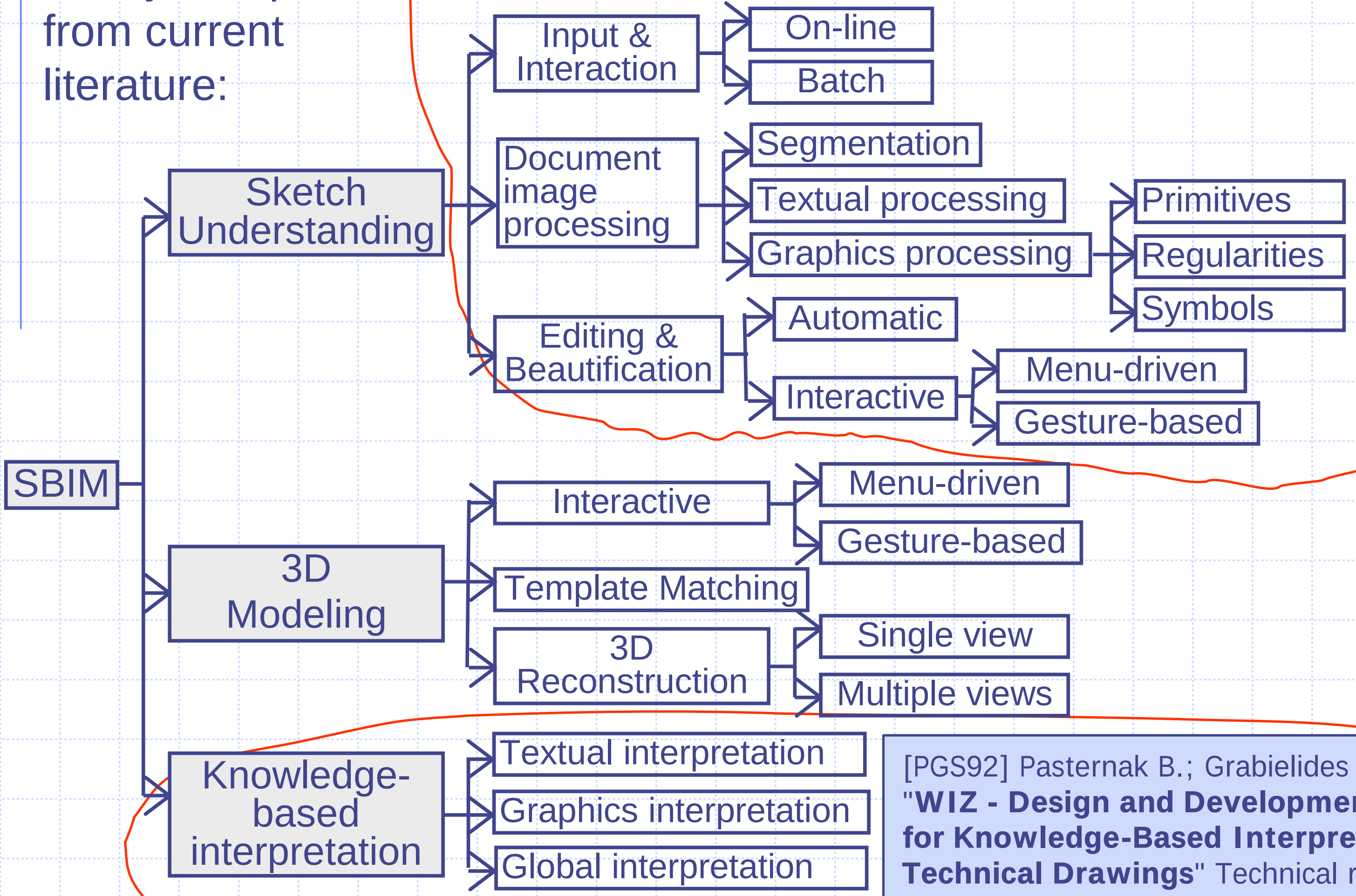
Research areas

And different "sub-fields" have been taken into consideration":



Research areas

Some have been "freely" adapted from current literature:

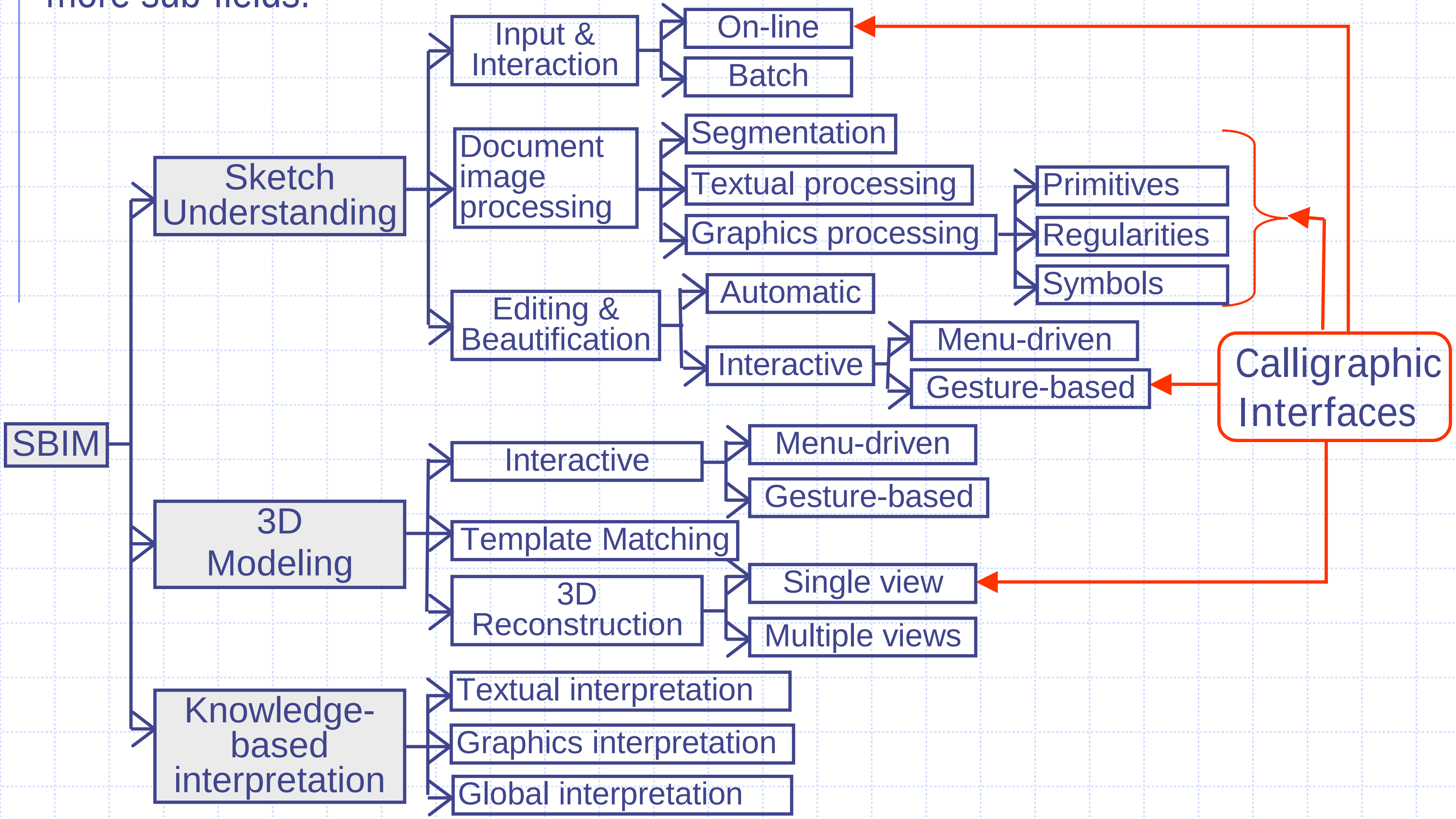


[Wen03] Wenyin L. **On-Line Graphics Recognition: A Brief Survey** Proc. of IAPR Int. Workshop on Graphics Recognition (GREC'2003), addendum 2003

[PGS92] Pasternak B.; Grabielides G. ; Sprengel R. "**WIZ - Design and Development of Prototype for Knowledge-Based Interpretation of Technical Drawings**" Technical report LKI-M-92/1. Labor für Künstliche Intelligenz, Fachbereich Informatik, Universität Hamburg, 1992

Research areas

Validation has been limited to check that many of current approaches fit in one or more sub-fields:



Research areas

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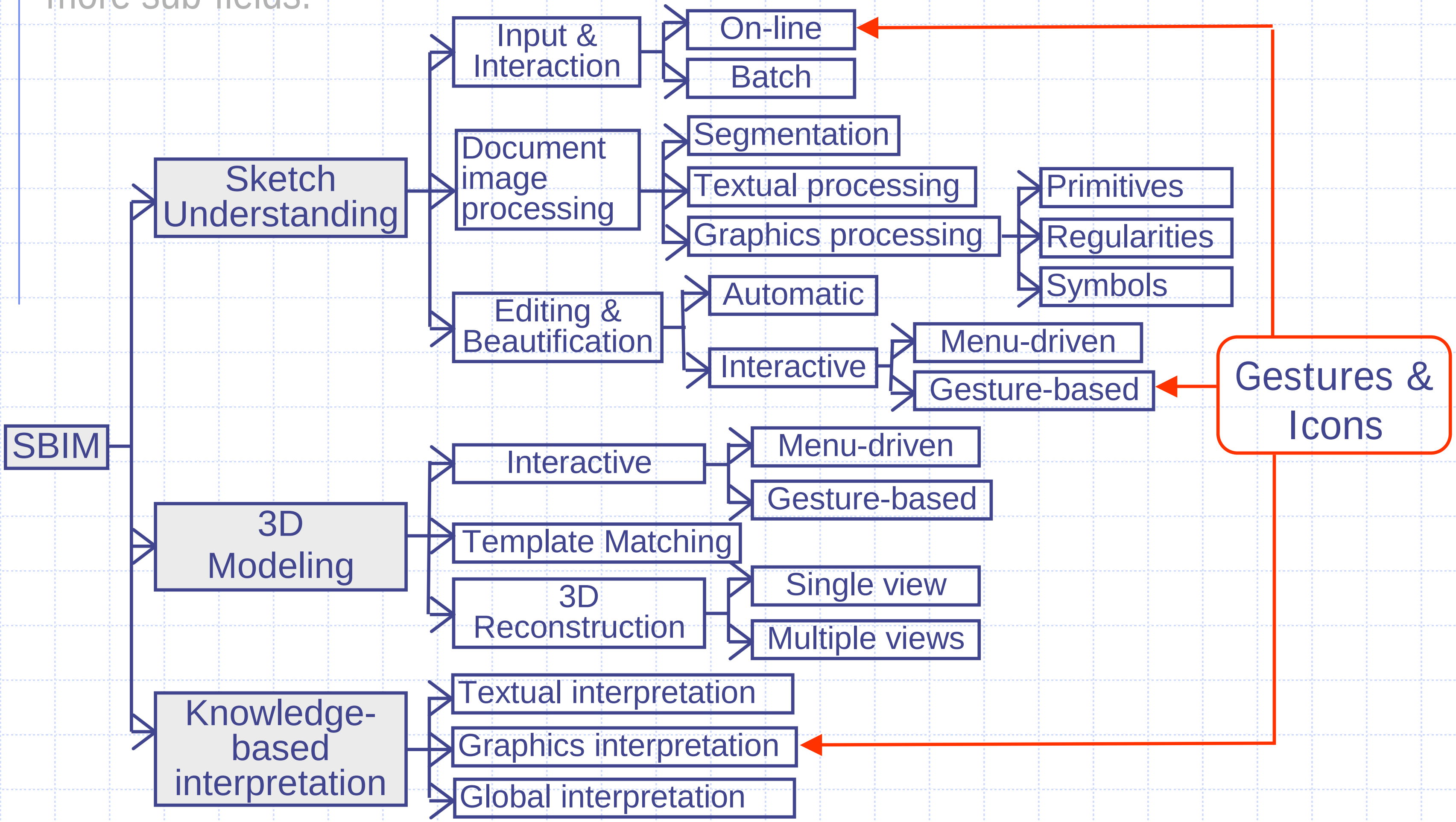

Research areas

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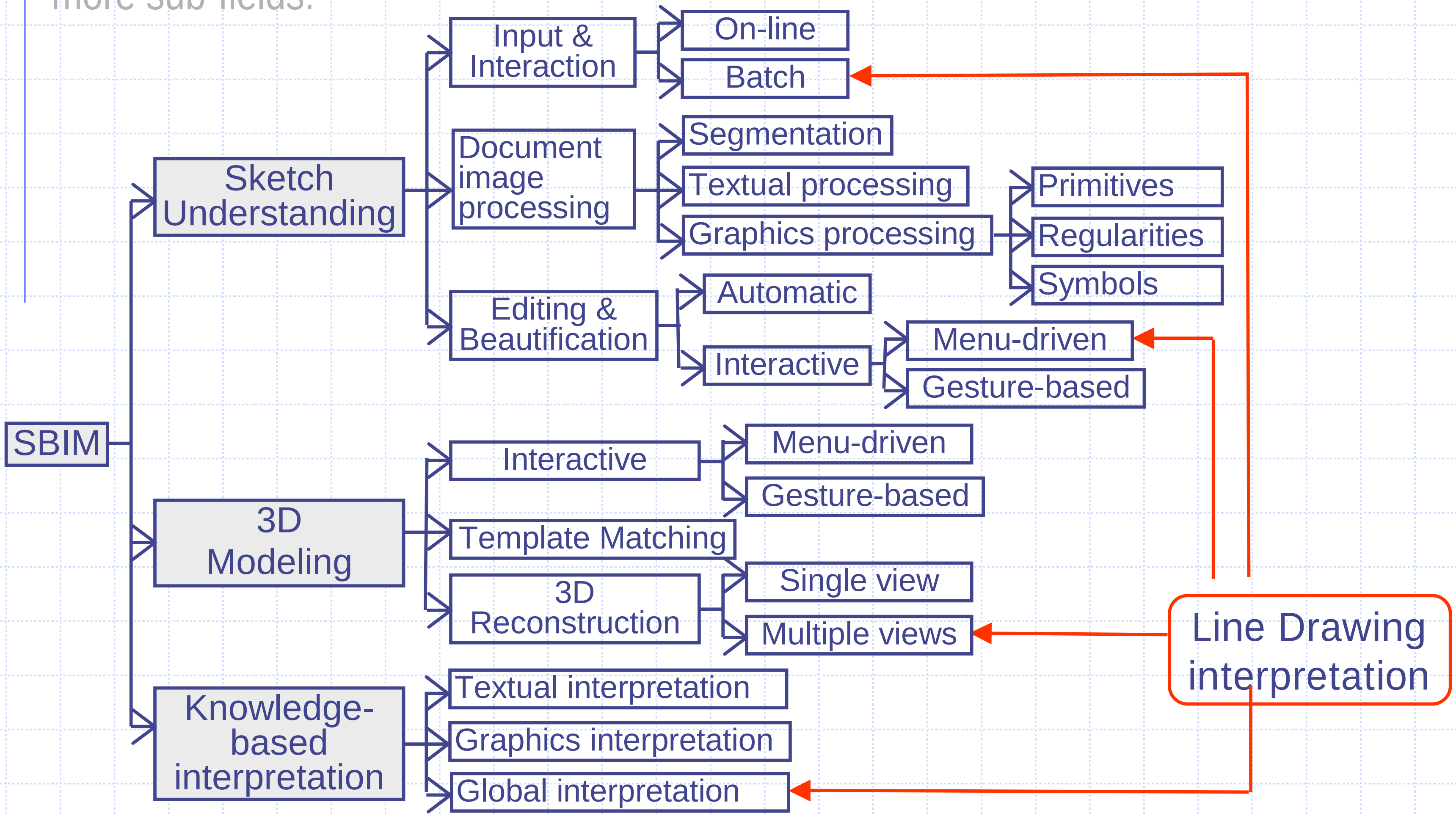

Conclusions

- Antecedents
- Summary
- Introduction
- Language?
- Discussion
- Areas
- **Conclusions**

We have seen that the objective has changed:

2D + Paper $\Longrightarrow$ 2D + Computer

2D + Paper $\Longrightarrow$ 3D + Computer

Conceptual design $\Longrightarrow$ 3D + Computer

vECTORIZATION

$\Downarrow$

RECONSTRUCTION

$\Downarrow$

CAI

Conclusions

- Antecedents
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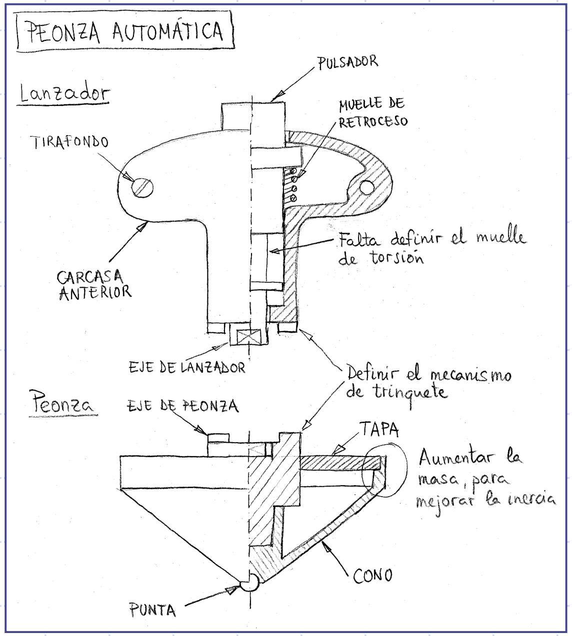
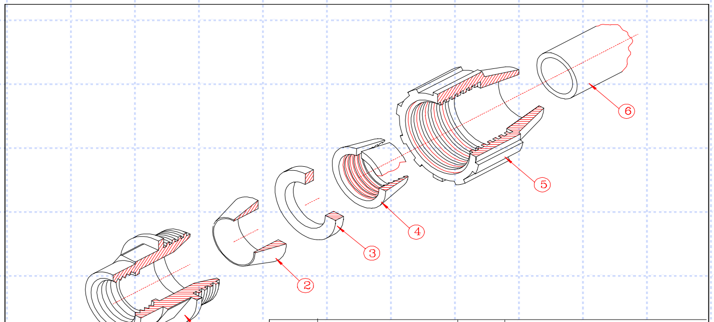
It is already known that what is “true” in a drawing depends no the *intention* of such a representation and the *standards* that control the LANGUAGE.

But the language available encompasses all ambits.
In fact, engineering graphics differ depending on it purpose and audience.

The dependency is on the amount of information (clarity, precision, level of detail) that the receiver requires and/or can process.





Nº piezas	Denominación	Marca	Material
1	Manguera	6	Polietileno (PE), tubo de ½”, negro
1	Hembra	5	Polipropileno copolímero de color negro
1	Cono de fijación	4	Poliacetal POM de color blanco
1	Junta	3	Polipropileno de color negro
1	Cono de presión	2	NBR de dureza 70 shore A, en color gris
1	Cuerpo	1	Polipropileno copolímero negro

Conclusions

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Hence, **engineering drawings** may become a universal language for the entire **computer-aided ideation** process.

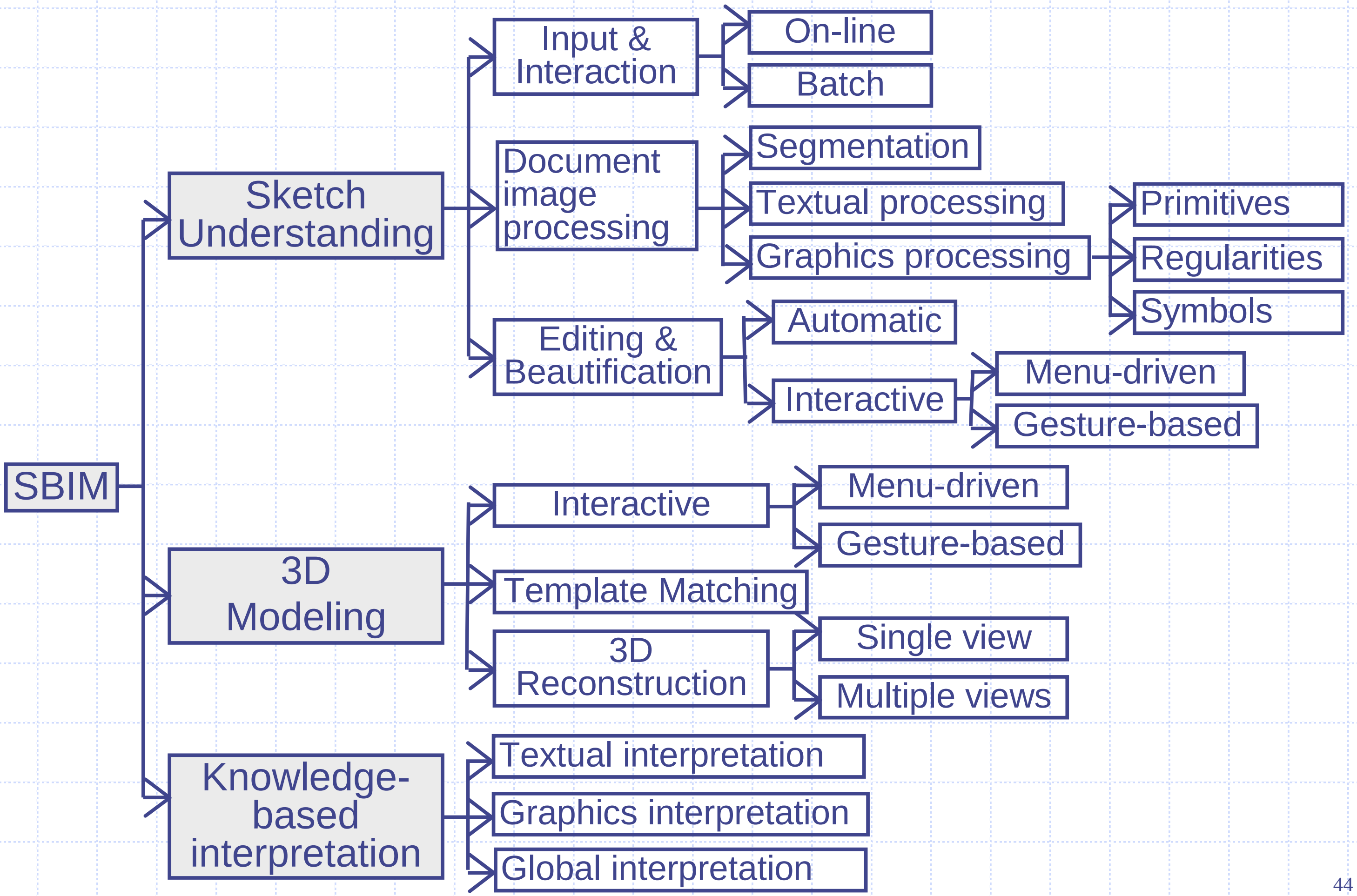
Geometrical reconstruction must play a fundamental role as powering technology in this process,...

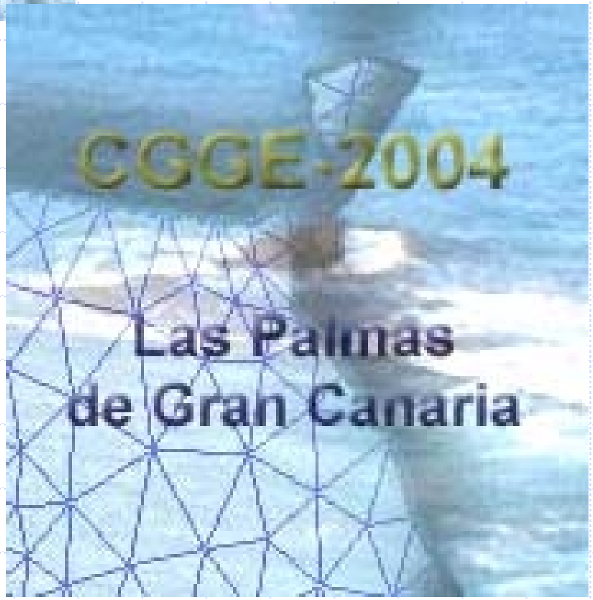
because automatic generation of solids from standardized drawings is the most efficient way to establish a fluid communication between designers and CAD applications

...and, we add now, **perception** must play a relevant role in this process.

Conclusions

At last, we have seen that other “niches” of working fields, exist in “**SKETCH-BASED MODELING**” discipline





Computer-Aided Ideation Through Sketch-Based Modeling

Thank you

Pedro Company

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