Computer-Aided Ideation
Through
Sketch-Based Modeling

Pedro Company
Some group’s antecedents

We began to work in this line towards 1994

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 EVERYTHING was already done

http://www.johnwoodwark.com/inge/docs/Pmill.pdf
Some group’s antecedents

The research line began to give some fruit from 2000 on

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

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

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

... through a LANGUAGE...

... 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.

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.
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!
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.
Language?

Behind drawings apparently quite simples...
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.


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).
Language?

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ISO 6410-1:1992(E)

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 > 6 mm is generally acceptable.
- a simplified representation is recommended for threads of nominal diameter d ≤ 6 mm, see ISO 6410-2.

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 and the roots 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).

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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.
Behind drawings apparently quite simples...

...there are hundreds of standards

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).
Behind drawings apparently quite simples...

...there are hundreds of standards
Behind drawings apparently quite simples...

...there are hundreds of standards
Language?

Behind drawings apparently quite simples...

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Behind drawings apparently quite simples...

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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

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.


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;
— undertcuts.

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.
Behind drawings apparently quite simples...

...there are hundreds of standards
...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

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 \( \leq 8 \) 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).
It is quite obvious than the communication of relevant information depends on the **meaning** of symbols:
It is quite obvious that the communication of relevant information depends on the **meaning** of symbols:
Hence, engineering drawing is a LANGUAGE, which is strongly based on standardized symbols...

...and specifically adapted to “technical information” communication
Discussion

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 DESIGN BY “VIRTUAL” MODELS
Discussion

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

*while sketches were ignored*
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!?
Discussion

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

¡Because the designer included it when using drawings as a 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

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

In addition,

PAPER still has too much weight and a big inertia

The new language is not yet standardized
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?

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

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

...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

Antecedents
Summary
Introduction
Language?
Discussion
Areas
Conclusions
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**

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

- **top-down**

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

  Hence, an important ambit of study is searching for this “knowledge”

Knowledge-based interpretation
Hence, we do consider three main areas in the “Sketch-Based Interfaces and Modeling (SBIM)” field:

- **Sketch Understanding**
- **3D Modeling**
- **Knowledge-based interpretation**
And different “sub-fields” have been taken into consideration:

- **Input & Interaction**
  - On-line
  - Batch
- **Document image processing**
- **Editing & Beautification**
- **Segmentation**
- **Textual processing**
- **Graphics processing**
  - Primitives
  - Regularities
  - Symbols
- **Automatic**
- **Interactive**
  - Menu-driven
  - Gesture-based
- **3D Modeling**
- **Template Matching**
- **3D Reconstruction**
  - Single view
  - Multiple views
- **Segmentation**
- **Textual interpretation**
- **Graphics interpretation**
- **Global interpretation**

**Sketch Understanding**

**Knowledge-based interpretation**

**SBIM**

**Areas**

- Antecedents
- Summary
- Introduction
- Language?
- Discussion
- Conclusions
Research areas

Some have been “freely” adapted from current literature:

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

- Input & Interaction
  - On-line
  - Batch
- Segmentation
- Textual processing
- Graphics processing
- Automatic
- Interactive
  - Menu-driven
  - Gesture-based
- 3D Reconstruction
  - Single view
  - Multiple views
- Menu-driven
- Gesture-based
- Primitives
- Regularities
- Symbols
- Sketch Understanding
  - Document image processing
- Editing & Beautification
- Interactive
- Gesture-based
- Textual interpretation
- Graphics interpretation
- Global interpretation
- Knowledge-based interpretation
- SBIM
- 3D Modeling
- Template Matching
- 3D Reconstruction
- Calligraphic Interfaces
- Language?
Validation has been limited to check that many of current approaches fit in one or more sub-fields:

**Research areas**

- **Sketch Understanding**
- **Document image processing**
- **Editing & Beautification**
- **Input & Interaction**
  - On-line
  - Batch
- **Segmentation**
- **Textual processing**
- **Graphics processing**
- **Automatic**
- **Interactive**
  - Menu-driven
  - Gesture-based
- **Primitives**
- **Regularities**
- **Symbols**
- **3D Modeling**
  - Interactive
  - Gesture-based
- **Template Matching**
- **3D Reconstruction**
  - Single view
  - Multiple views
- **Textual interpretation**
- **Graphics interpretation**
- **Global interpretation**

**Gestures & Icons**

**On-line**

**Batch**

**Primitives**

**Regularities**

**Symbols**

**Menu-driven**

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

- **Input & Interaction**
  - On-line
  - Batch
- **Document Image Processing**
  - Segmentation
  - Textual processing
  - Graphics processing
- **Editing & Beautification**
  - Automatic
  - Interactive
  - Menu-driven
  - Gesture-based
- **3D Modeling**
  - Interactive
  - Template Matching
  - 3D Reconstruction
  - Menu-driven
  - Gesture-based
  - Single view
  - Multiple views
- **Knowledge-based Interpretation**
  - Textual interpretation
  - Graphics interpretation
  - Global interpretation
- **SBIM**
- **Line Drawing Interpretation**

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Las Palmas, novembre 5, 2004
Conclusions

We have seen that the objective has changed:

- 2D + Paper $\rightarrow$ 2D + Computer
- 2D + Paper $\rightarrow$ 3D + Computer
- Conceptual design $\rightarrow$ 3D + Computer
Conclusions

It is already known that what is “true” in a drawing depends not 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 its purpose and audience.

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

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,...

...and, we add now, **perception** must play a relevant role 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
At last, we have seen that other “niches” of working fields, exist in “SKETCH-BASED MODELING” discipline.
Computer-Aided Ideation Through Sketch-Based Modeling

Pedro Company

Thank you