Computer-aided Ideation
through
Sketch-based interfaces and modelling

Pedro Company

REGEO

Some antecedents of the group

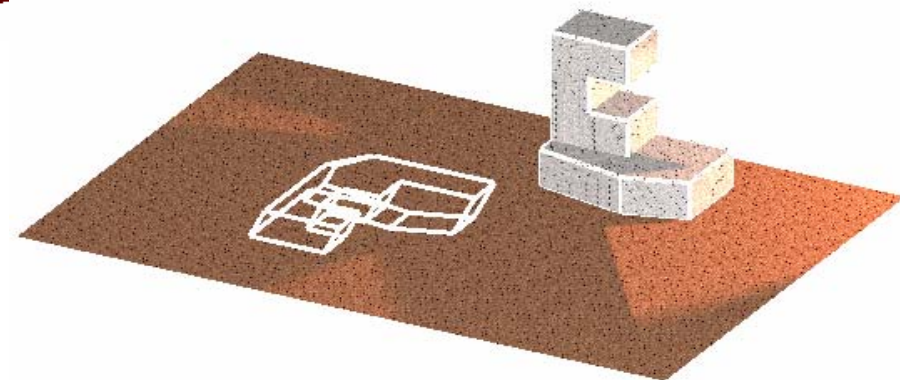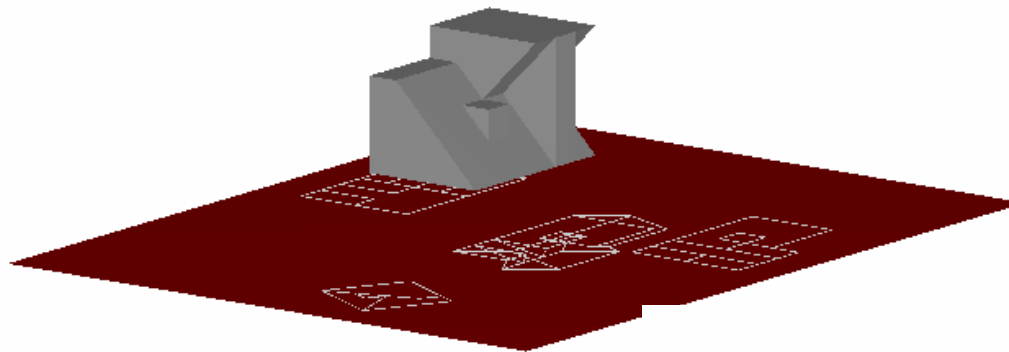*We began to work in this line in 1994*

REGEO

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Some antecedents of the group

We began to work in this line in 1994

REGEO

We were looking for a research subject.....

Because we had assumed the sentence "publish or perish"

To read funny, but interesting comments about this sentence:

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

HOW to RUN PAPER MILL

by JOHN WOODWARK

Cartoons by Carol Wade

Some antecedents of the group

We began to work in this line in 1994

REGEO

We were looking for a research subject.....in our "area"

Because we had assumed the sentence "publish or perish"

Because making research in "engineering graphics" was a challenge for us

To read funny, but interesting comments about this sentence:

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

HOW to RUN
PAPER MILL

by
JOHN WOODWARK

Cartoons by Carol Wade

As some people told us that "everything was already known"

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Some antecedents of the group

The line began to be fruitful since 2000

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

CAI

What the "line" is?

In a nutshell…

Today, computers still cannot help
in the more conceptual steps of industrial products design...

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

In other words,
CAD applications
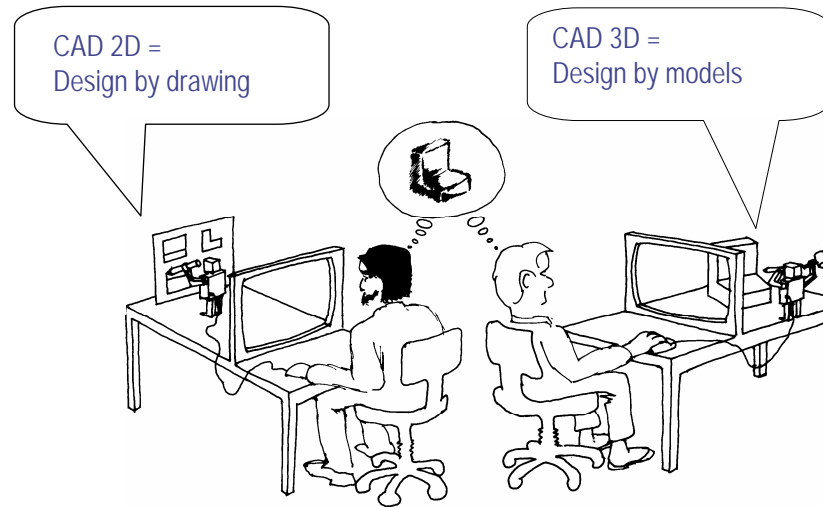cannot manage
the "visions" of the designers

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CAI

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

well defined and sequential!

CAD 2D = Design by drawing

CAD 3D = Design by models

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CAI

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

well defined
and sequential!

CAD 2D =
Design by drawing

CAD 3D =
Design by models
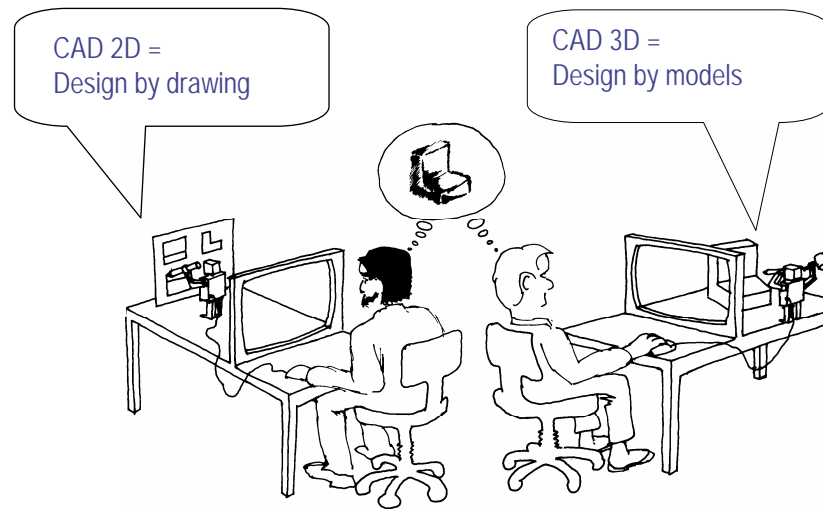
And this is not a good strategy
while the designer is trying to fix visions

Poorly-defined,
non-sequential ideas!

The TOOL is conditioning the TASK!

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CAI

So, our aim 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!

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SBIM

But
computers are blind
to engineering sketches!

So, new computer
tools are required!

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

SBIM
(SKETCH-BASED INTERFACES AND MODELING)

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SBIM

To find current subjects of interest   "niches"
in SBIM, we have analysed previous work...

[Wen03] Wenyin L. **On-Line Graphics Recognition: A Brief Survey** Proc. of IAPR Int. Workshop on Graphics Recognition (GREC'2003), addendum 2003
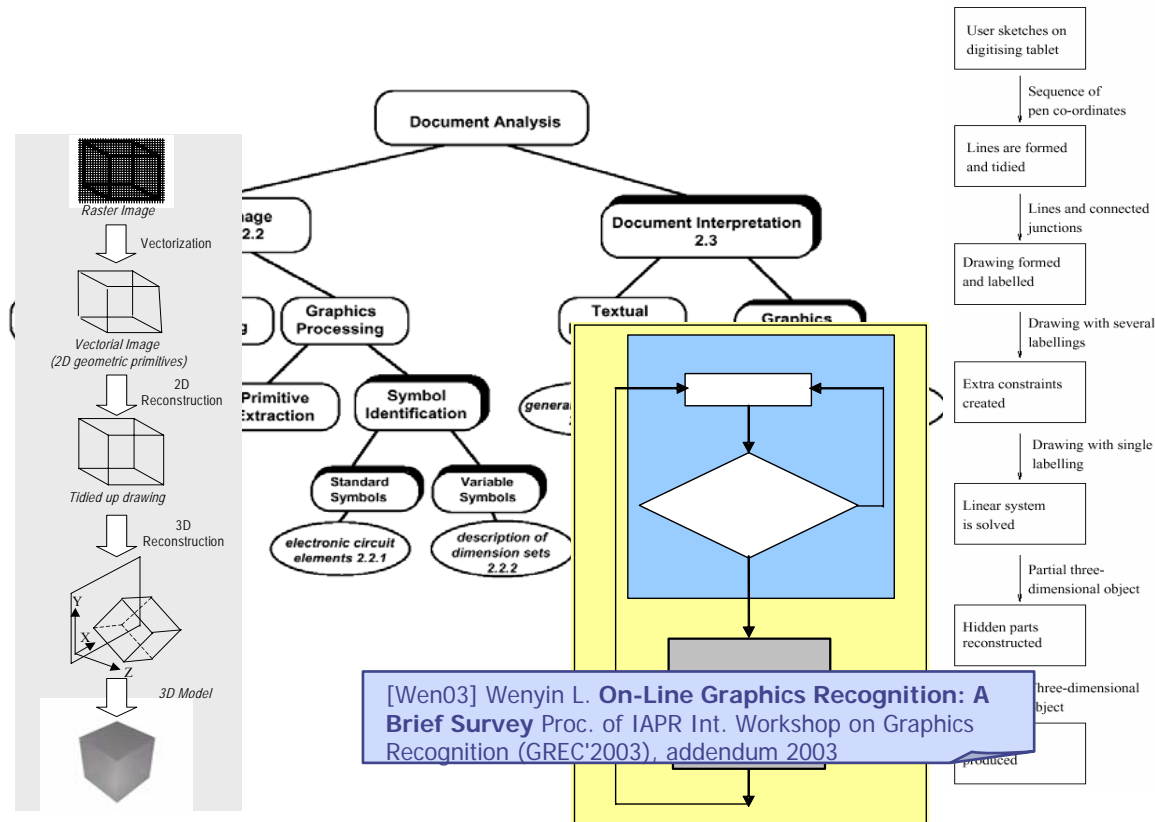
...and we have developed our own taxonomy…

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SBIM

In sum, we do consider three main areas:

```
                    ┌──────────────────┐
                  ┌>│     Sketch       │
                  │ │  Understanding   │
                  │ └──────────────────┘
                  │
    ┌──────┐      │ ┌──────────────────┐
    │ SBIM │──────┼>│       3D         │
    └──────┘      │ │    Modeling      │
                  │ └──────────────────┘
                  │
                  │ ┌──────────────────┐
                  └>│   Knowledge-     │
                    │     based        │
                    │  interpretation  │
                    └──────────────────┘
```

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SBIM

And different sub-areas:

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

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SBIM

And different sub-areas:

To be noticed that our taxonomy is not fully developed, since some current approaches in the literature fit more than one sub-area

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Geometrical reconstruction

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

So, we began to work in:

Sketch Understanding

SBIM → 3D Modeling

Knowledge-based interpretation
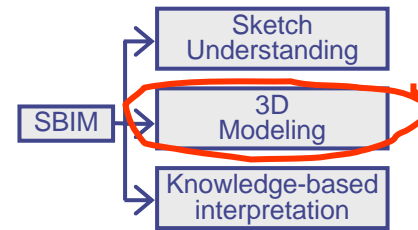
GEOMETRICAL RECONSTRUCTION
the discipline aimed at automatic, or semi-automatically, obtaining
three-dimensional geometrical models
from two-dimensional line-drawings
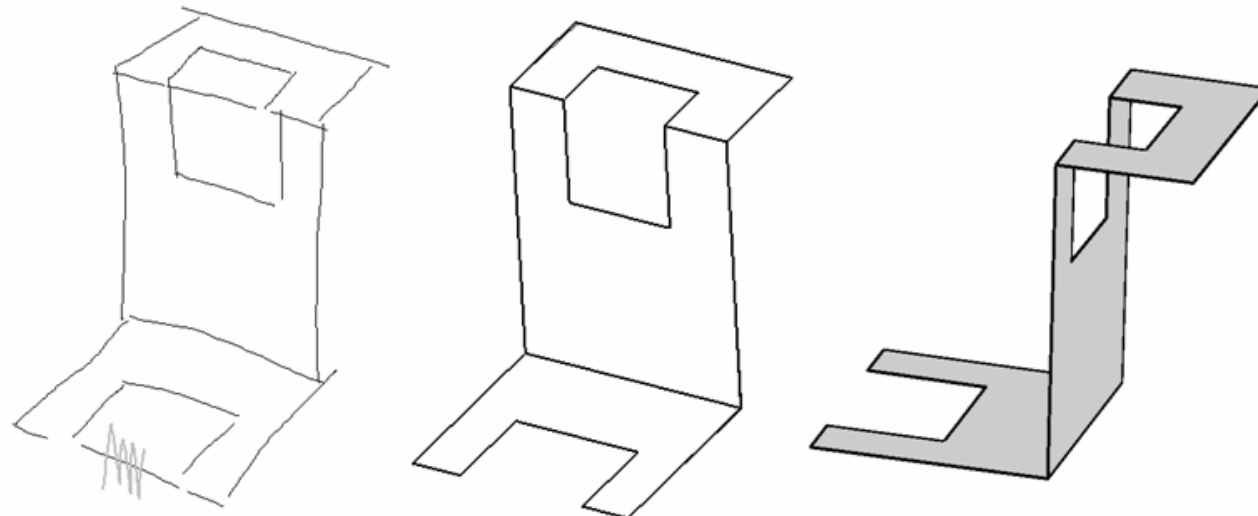
Geometrical reconstruction

The former goal of
geometrical reconstruction was
to extract information from
old engineering blueprints

In other words, "archaeological"
recovery of old know-how

Scanning

*Drawing or Sketch
on paper*

Raster Image

Vectorization

*Vectorial Image
(2D geometric primitives)*

2D Reconstruction

Tidied up drawing

3D Reconstruction

Y

X

Z

Finishing

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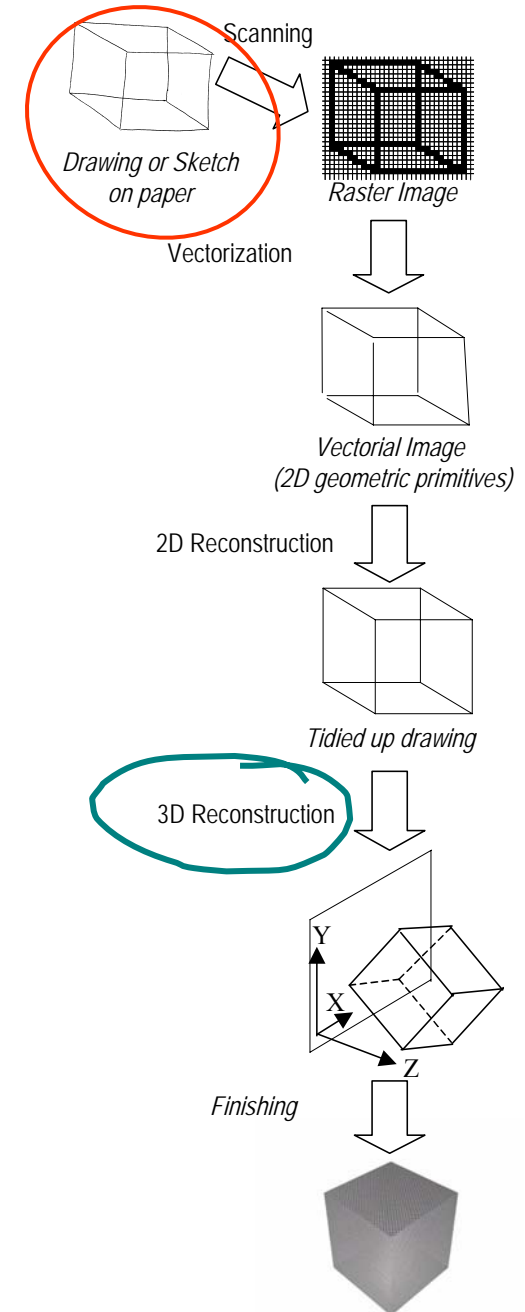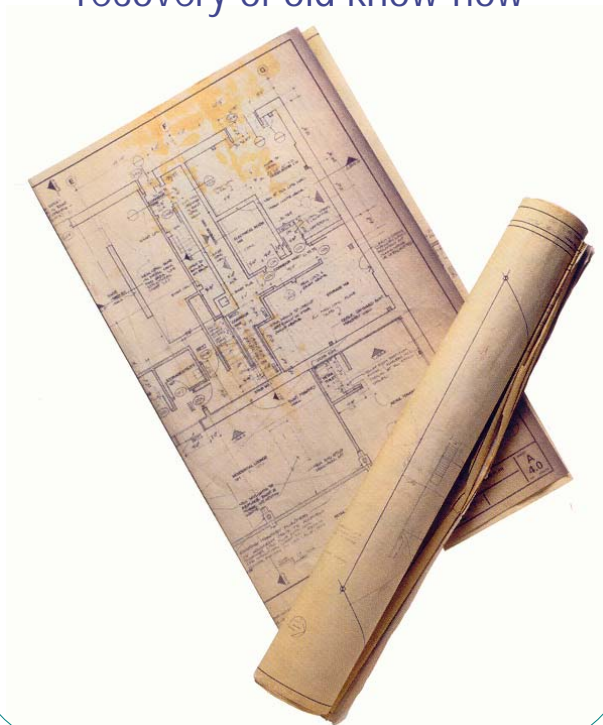
Geometrical reconstruction

Antecedents

CAI

SBIM

Geom. Reconst.

Annotations

Conclusions

However, the short term problem was solved trough "brute force":

Translation services were offered!

Geometrical reconstruction

The problem still remains open,
as paper has not fully disappeared!

"So we threw away our drawing boards and got computers."

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Geometrical reconstruction

Current situation can be outlined in:
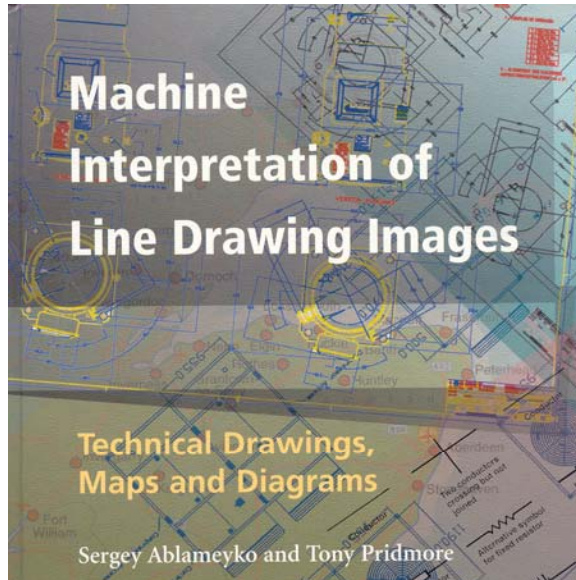
[AP00] Ablameyko S.; Pridmore T. **Machine Interpretation of Line Drawing Images: Technical Drawings, Maps and Diagrams** Springer Verlag ISBN: 3-540-76207-8 2000
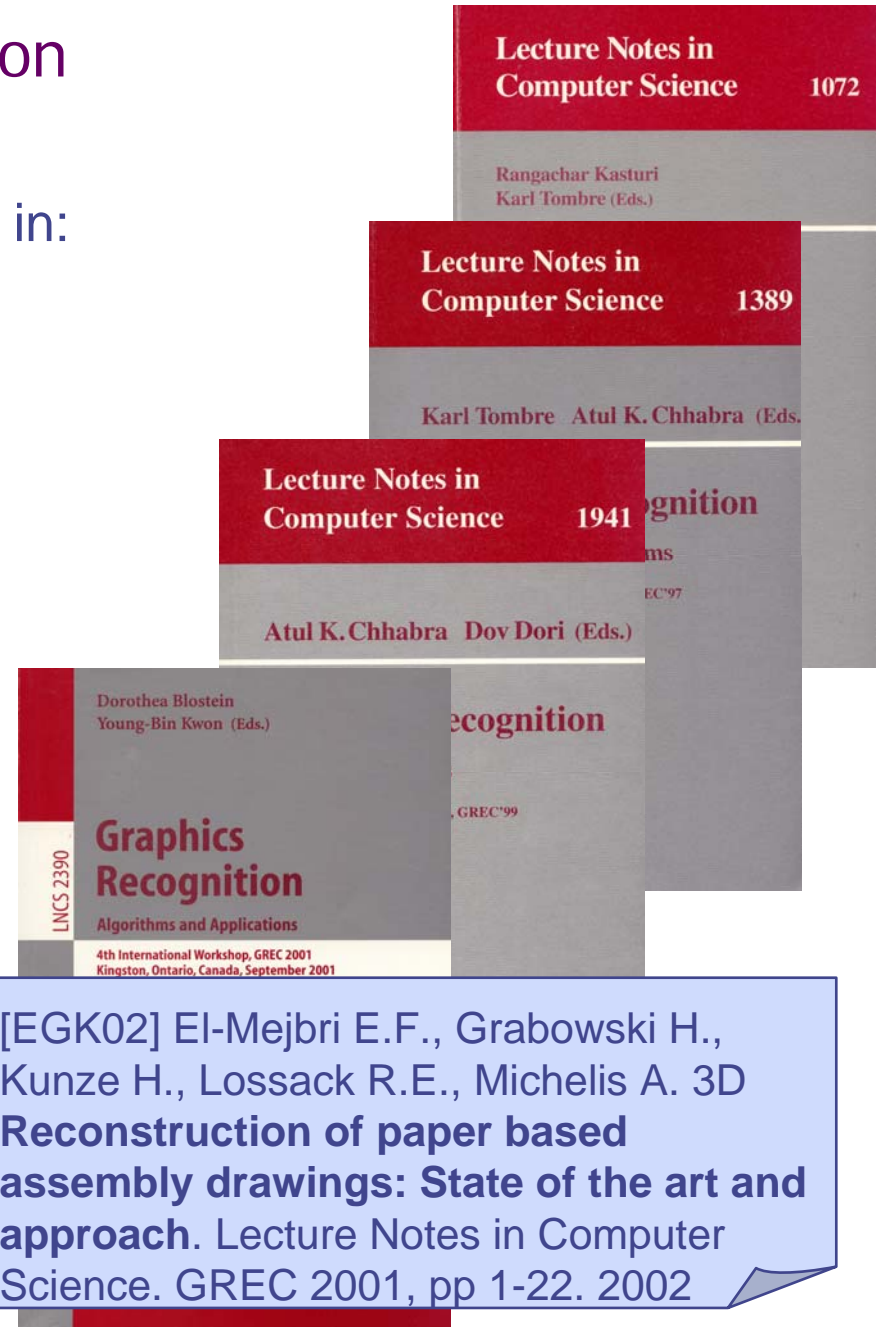
[EGK02] El-Mejbri E.F., Grabowski H., Kunze H., Lossack R.E., Michelis A. 3D **Reconstruction of paper based assembly drawings: State of the art and approach**. Lecture Notes in Computer Science. GREC 2001, pp 1-22. 2002

Geometrical reconstruction

But, the main **goal** of the **reconstruction community** changed in the 1990s.

Today, most of the applications are aimed at conceptual design

Using sketches made by the users as inputs to construct 3D models

Sketching

2D Reconstruction (or Beautification)

3D Reconstruction

Pictorial view

Top view

Side view

Front view

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Geometrical reconstruction

In sum, the goal has changed
along the time:

| 2D + paper $\Longrightarrow$ 2D + computer |

| 2D + paper $\Longrightarrow$ 3D + computer |

| Conceptual design $\Longrightarrow$ 3D + computer |

VECTORIZATION

$\Downarrow$

RECONSTRUCION

$\Downarrow$

CAI

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Geometrical reconstruction

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

a) 2D sketching   b) 2D tidying up   c) 2D regularities' detection   d) 3D inflation   e) Axonometric, front, upper and side views

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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
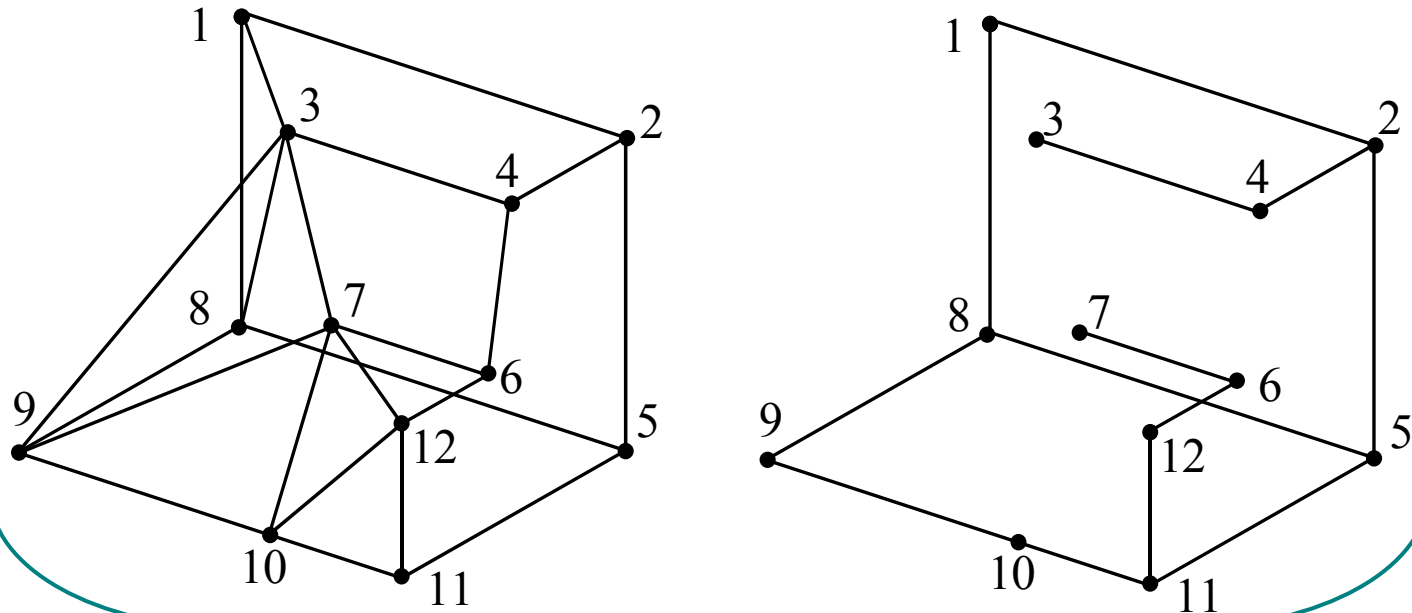
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Geometrical reconstruction

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

a) Input sketch
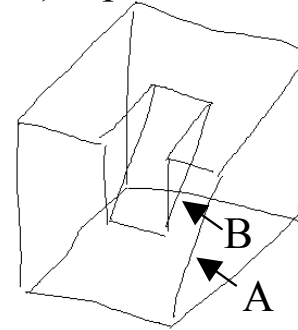
b) On-line line drawing
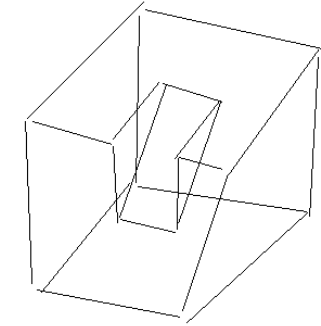
c) Off-line tidying
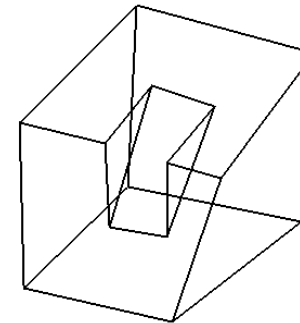
d) Off-line parallelism and collinearity tidying
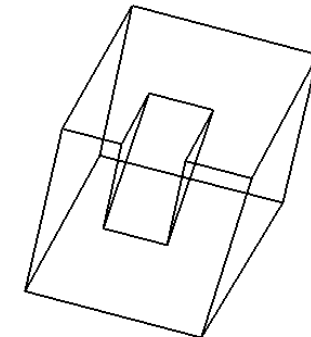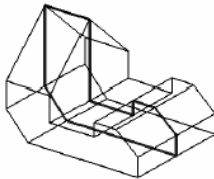
e) 3D "tangled" shape
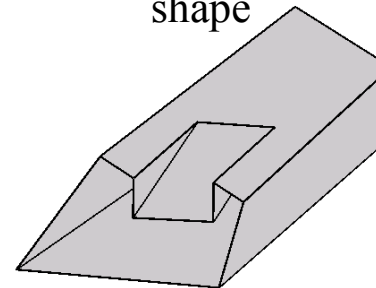
f) 3D shape
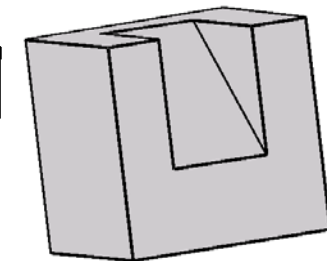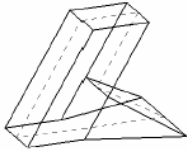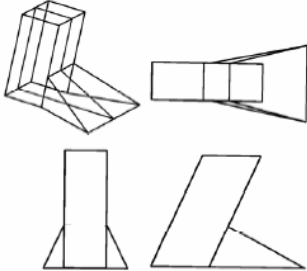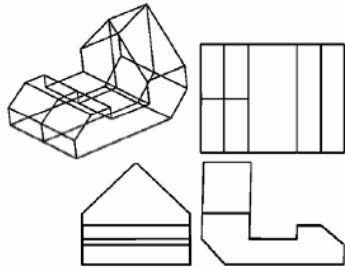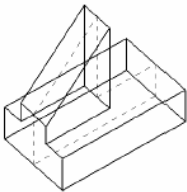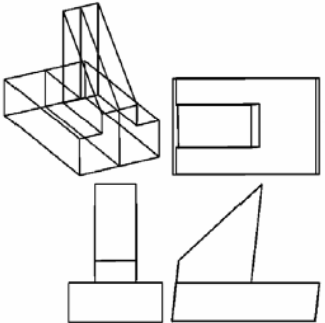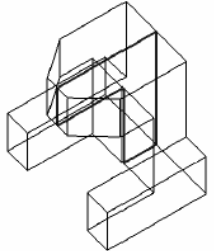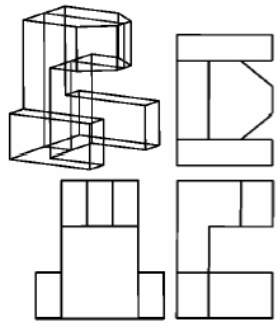
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Geometrical reconstruction

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

a)   b)   c)
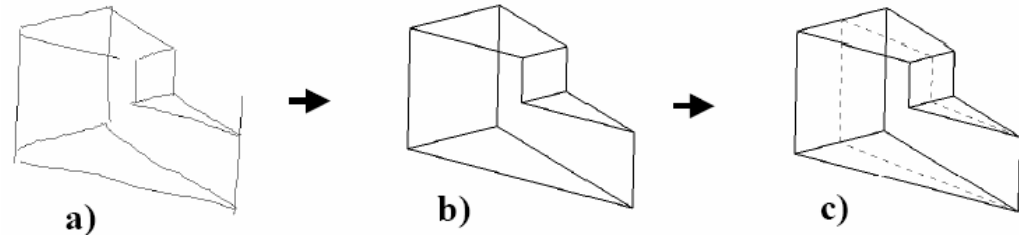
and improvement of the reconstruction process through symmetry regularity

Line drawing	3D model	Process	Line drawing	3D model	Process
19 edges 12 vertices		9 faces 1 plane of symmetry Inflation time: less than 1"	33 edges 22 vertices		13 faces 1 plane of symmetry Inflation time 1"
24 edges 16 vertices		10 faces 1 plane of symmetry Inflation time: less than 1"	46 edges 30 vertices		18 faces 1 plane of symmetry Inflation time 2"

the Design Society
a worldwide community

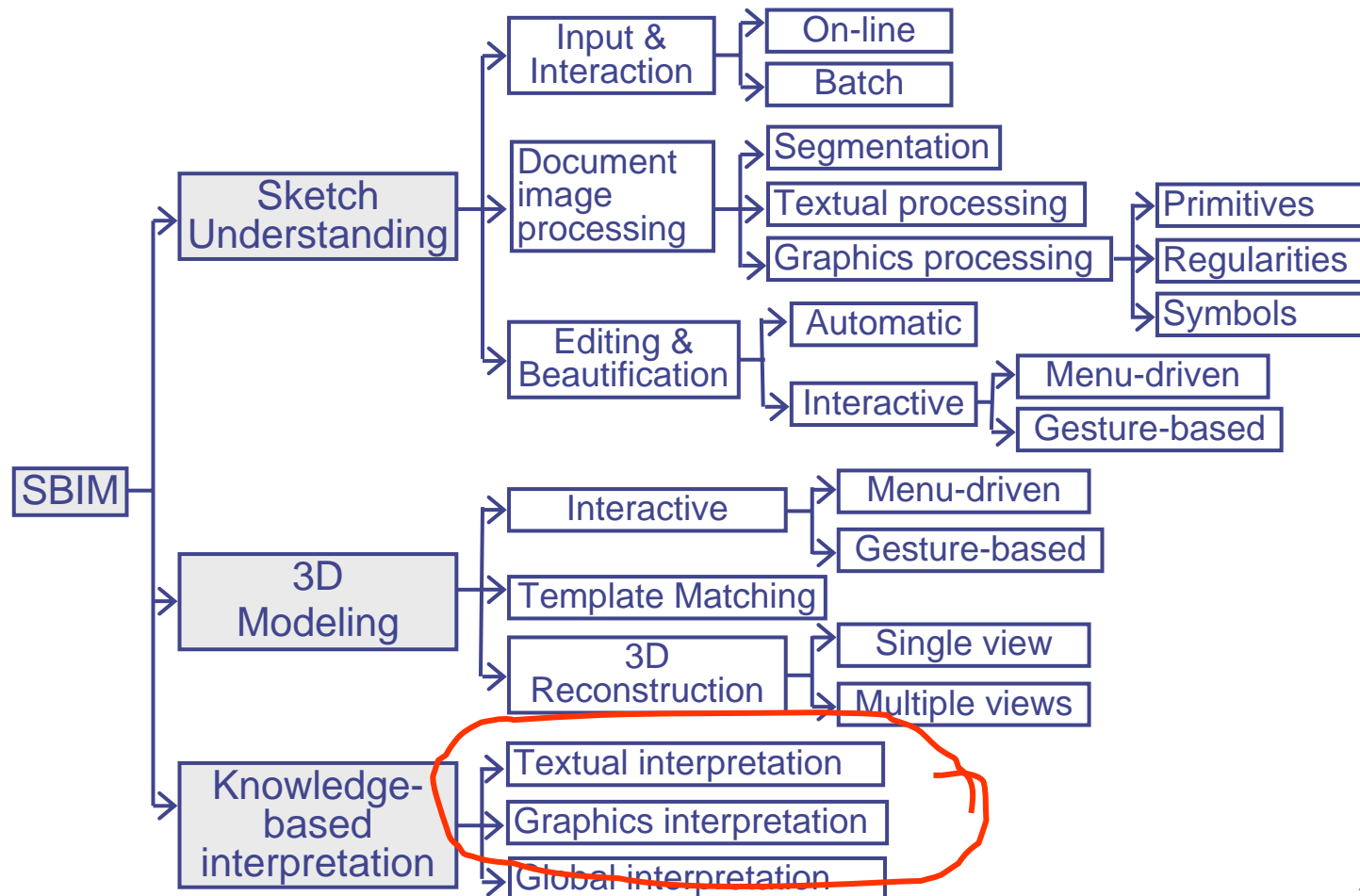# Interpreting annotations

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

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the **Design Society**
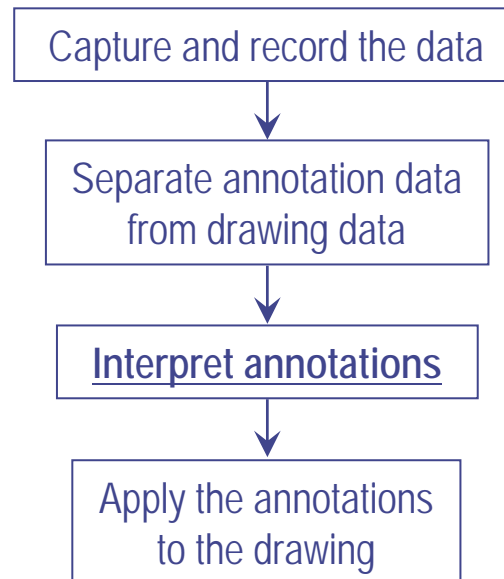a worldwide community

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 ⟹ Can the computer interpret designers annotations?

Approach ⟹

Capture and record the data

↓

Separate annotation data
from drawing data

↓

Interpret annotations

↓

Apply the annotations
to the drawing

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Interpreting annotations

Currently, we can interpret:

√ Four types of strokes

√ Twelve annotations

Interpreting annotations
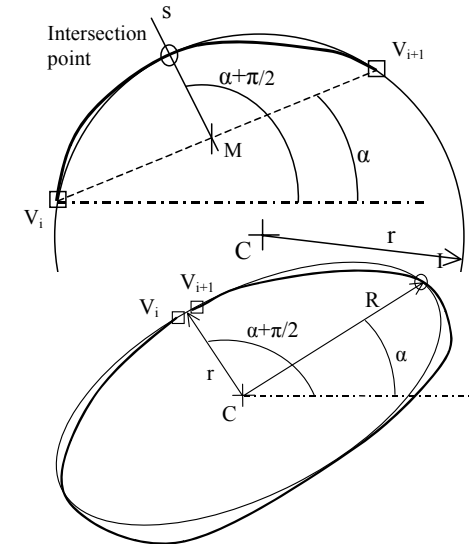
Currently, we can interpret:

✓ Four types of strokes

✓ Twelve annotations

Lines

Arcs

Circles

Ellipses

Separate entities are obtained from a simple stroke!
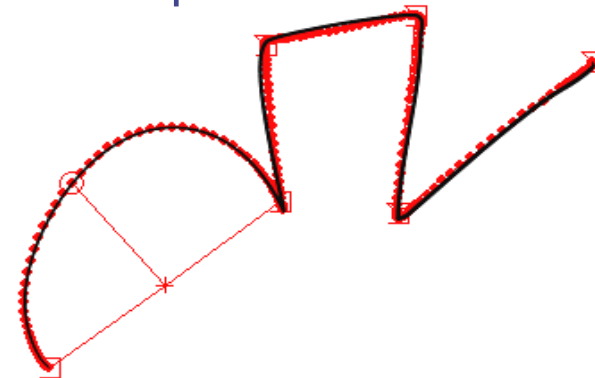
Interpreting annotations
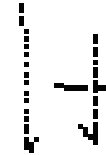
Currently, we can interpret:

✓ Four types of strokes
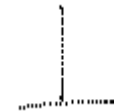
✓ Twelve annotations

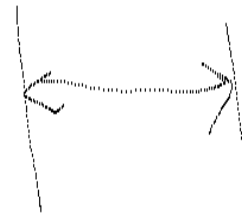Horizontal   Vertical   Parallel Perpendicular
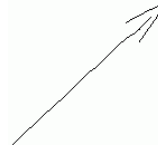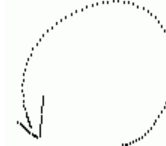
Dimension   Diametric dimension   Concentric   Make tangential

Extrude   Rotate left   Rotate right   Erase

Annotations are recognised
with 90% or better accuracy

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Conclusions

My research has been guided by:

√ Interest

√ Opportunity

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Conclusions

My research has been guided by:

✓ Interest

✓ Opportunity

I wanted to know was could be improved in the field of ENGINEERING GRAPHICS

ENGINEERING GRAPHICS is tied to Design-by-Drawing

ENGINEERING GRAPHICS is conditioned by CAD tools

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Conclusions

My research has been guided by:

✓ Interest

✓ Opportunity

I found the colleagues!

I found the funding!

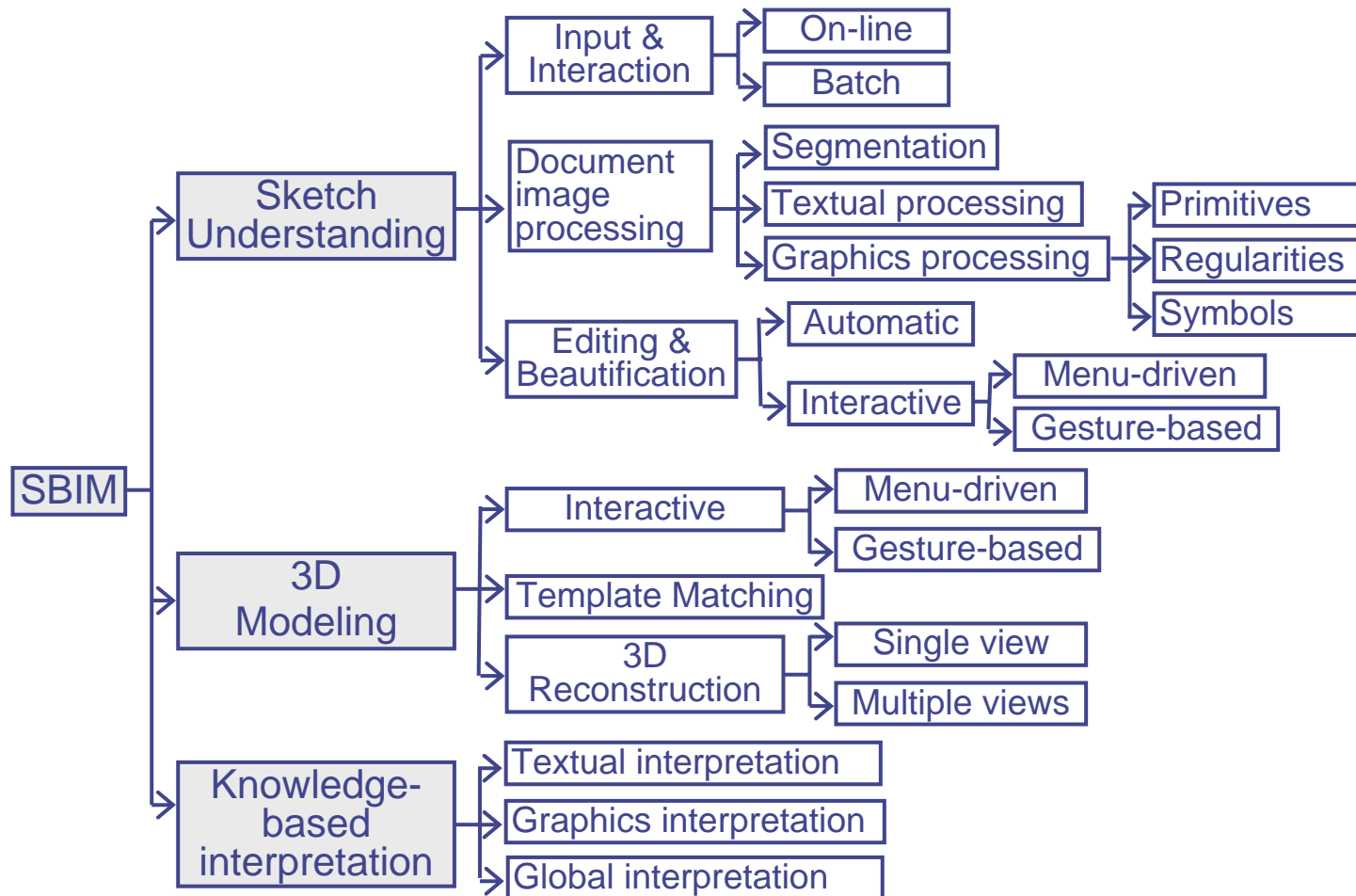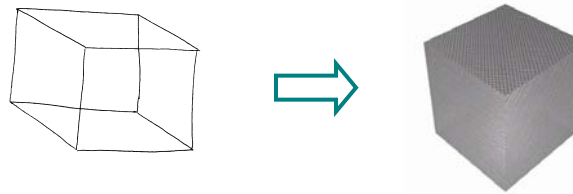I found results to publish!

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Conclusions

There is still room left for other people interested in the subject!

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Computer-aided Ideation through Sketch-based interfaces and modelling

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Thank you

REGEO