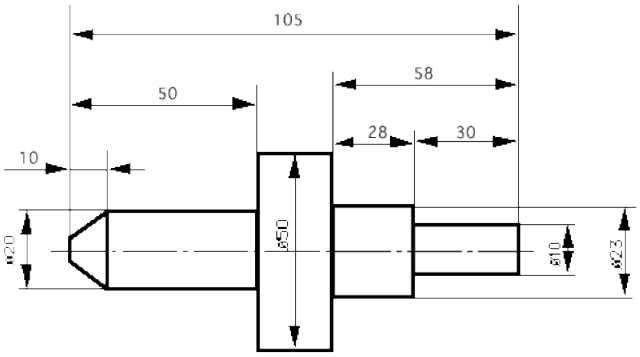
Case study: Drawing Interpretation

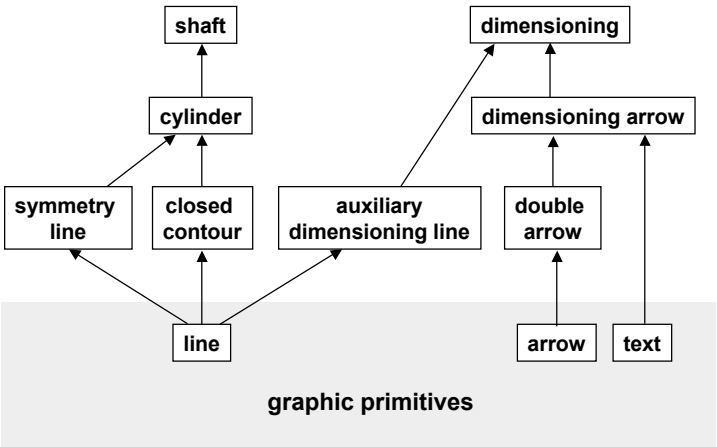
Transforming paper drawings into CAD formats (Pasternak 94)

=> recognition of contours, dimensioning, symmetry lines, surface markings etc.



1

Partonomy of Object Parts



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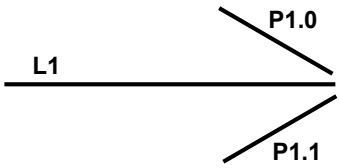
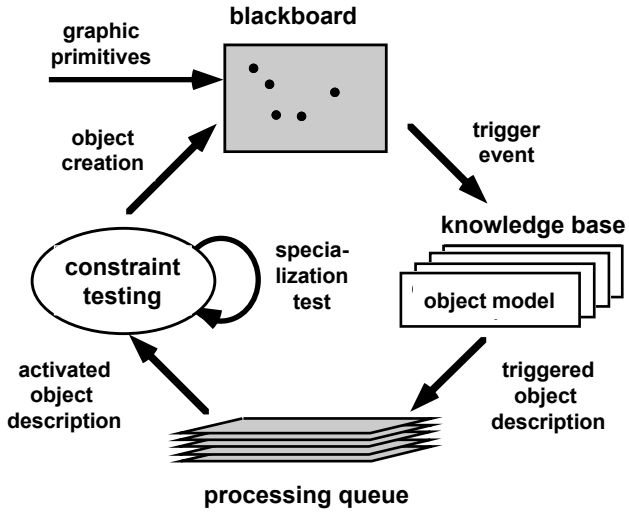
Specification of an Arrow



NAME:	arrow
KIND-OF:	symbol
PARTS:	L1 TYPE line, P1 TYPE polygon
TRIGGER:	P1
CONSTRAINTS:	NOT PART L1 P1 NEAR P1.0.end L1.start ANGLE P1.0.end L1.start [5 30] => ang NEAR P1.1.start L1.start ANGLE P1.10.start L1.start ang

3

Processing Cycle



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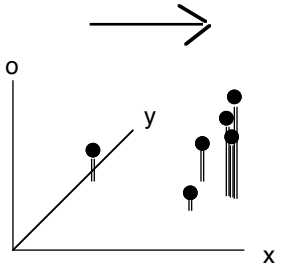
Property Spaces

Representation of graphical objects in multi-dimensional property spaces to allow effective object retrieval and access via their properties

Example:

arrow in 3D property space with endpoint coordinates x, y und orientation o



How to construct property spaces:

- **discretization (coarse quantization) of property values**
- **set-type property space cells to accommodate multiple objects with identical properties**
- **overlapping value ranges to avoid boundary effects**

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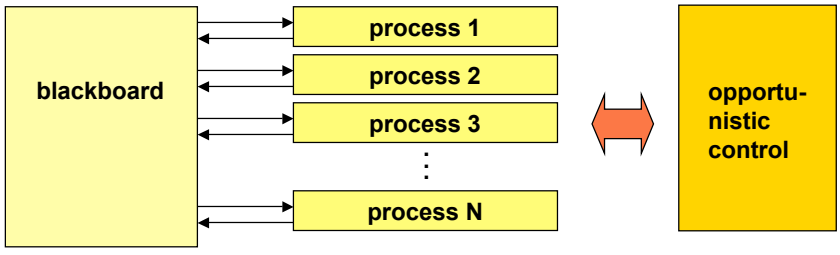
Blackboard Architecture

Independent processes communicate Prozesse via a common database ("blackboard")



Recognition process may be structured into processes dedicated to the recognition of individual components

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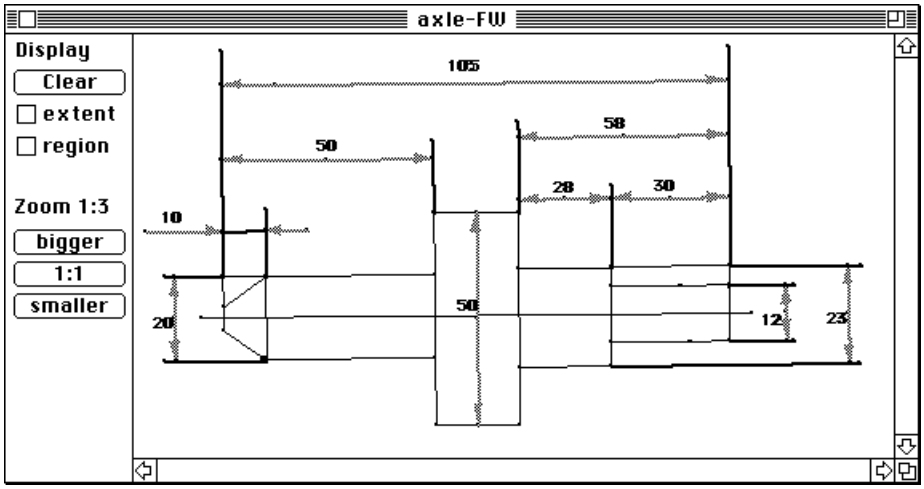
Analysis of a Machine Drawing

Recognition of dimensioning



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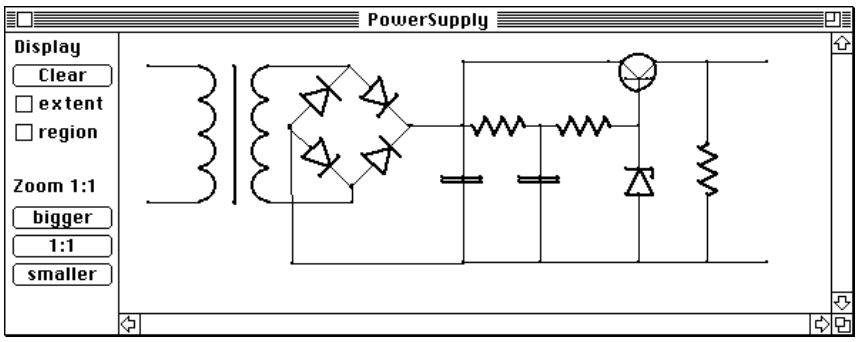
Analysis of an Electrical Circuit

Recognition of electrical components



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Qualitative Relations

Quantitative relations are characterized by a quantitative value, e.g.

$$D \subseteq O \times O \times R^{+}$$

with O = set of objects, R^{+} positive real numbers.

Qualitative relations may ...

-	**abstract from quantitative values**	"contains", "touches"
-	**express a range of values**	d10: 8 ≤ d < 12
-	**express fuzzy relations**	"left-of", "above"
-	**enable soft comparisons**	fuzzy-set theory

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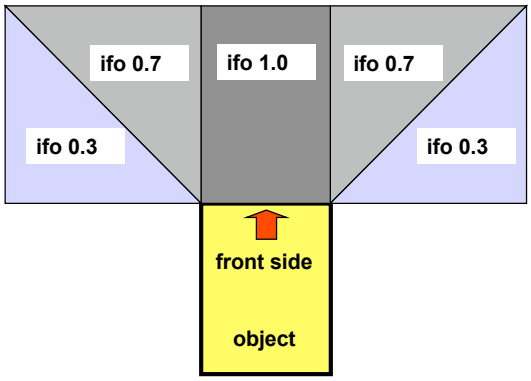
Qualitative spatial relations

Qualitative spatial relations are expressed by "linguistic variables" (fuzzy variables, symbols with fuzzy values)

Example: "in front of" (ifo)



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Combining Fuzzy Propositions

Example: Combining fuzzy spatial relations

"Look for a red light in front of a house and above the entrance"

(light1 in-front-of house1, 0.7) and (light1 above entrance1, 0.4)
(light2 in-front-of house2, 0.5) and (light2 above entrance2, 0.6)

Which light matches the description best?

Formal conjunction of fuzzy values:

$[x, \delta(x)]$, $[y, \delta(y)]$, $0 \le \delta() \le 1$ $\quad \delta(x \,\&\, y) = ?$

alternative 1:	$\delta(x \,\&\, y) = \delta(x) \cdot \delta(y)$	product of fuzzy values
alternative 2:	$\delta(x \,\&\, y) = \min \{\delta(x), \delta(y)\}$	minimum of fuzzy values

Probability theory provides a better foundation for uncertainty management

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Qualitative View Recognition

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Recognition of Views by Qualitative 2D-Spatial Relations

Development of "spectacles" for the blind in project MOVIS:

- spectacles contain 2 mini cameras
- blind person may store important views (view models are generated automatically)
- view model can be used to recognize a view during walking

Technical problem:

How can one determine the correspondence of a test view with a model view in spite of

- changed perspective
- changed illumination
- changed objects?

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Views of the Same Location from Different Perspectives




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Views of the Same Location under Different Illumination

12h

14h

16h

17h

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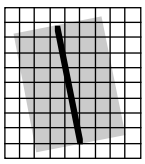
Relational Description of Views

Principle:

- description of views by "interesting" image elements and their spatial relations
- use of straight edges and their properties as "interesting" image elements

straight edge with left and right environment



properties of an edge
(I =intensity,
H = hue
S = saturation):

orientientation:	[..]
length:	[..]
I-mean/variance-left:	(,)
I-mean/variance-right:	(,)
H-mean/variance-left:	(,)
H-mean/variance-right:	(,)
S-mean/variance-left:	(,)
S-mean/variance-right:	(,)
I-contrast:	[-1 .. +1]
H-contrast:	[-1 .. +1]
S-contrast:	[-1 .. +1]
total contrast:	[-1 .. +1]
significance:	[0 .. 1]

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Location Relation between Edges

Possible relative locations of 2 edges are described by "offset regions"

For test views:

- uncertain reference points

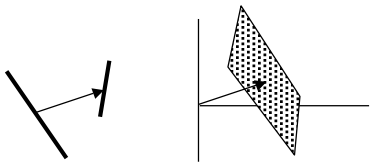

image elements offset region

For model views:

- uncertain reference points
- uncertain depth values
- uncertain perspective

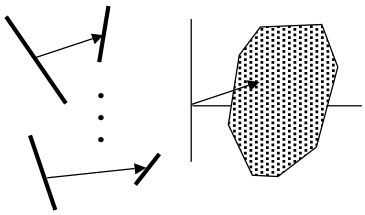

image elements offset region

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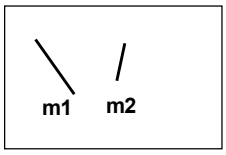
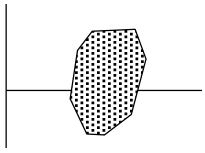
Compatibility Test for Location Relation

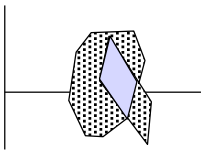
Is the spatial relation of a test pair of edges compatible with the spatial relation of a model pair of edges?



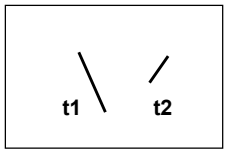
model view



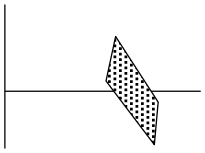
offset region for m1 and m2



compatibility test by intersecting the offset regions (empty = incompatible)



test view



offset region for t1 and t2

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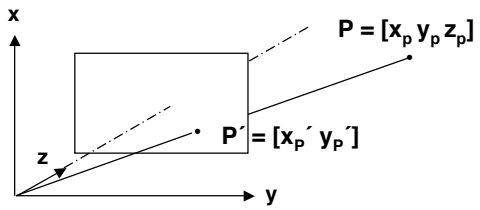
Determining Offset Regions



Determine the image of P, if

- **the camera is translated by $\Delta t = [\Delta x, \Delta y, \Delta z]$ and rotated by $[\Delta\alpha, \Delta\beta, \Delta\gamma]$,**
- **the depth of P is given by an uncertainty interval of $[z_{p\text{-}min}\ z_{p\text{-}max}]$**

Perspective projection applied to boundary values of uncertainty intervals provides corner points of offset region.

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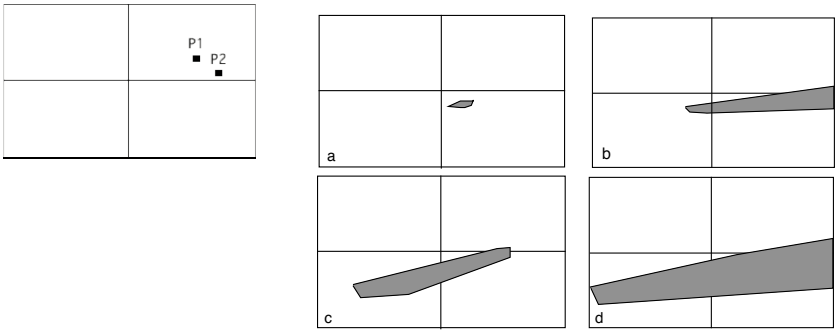
Offset Regions for Different Uncertainty Intervals

		a	b	c	d
$[\Delta x_{min}\ \Delta x_{max}]$	:	[-1m +1m]	[-1m +1m]	[-1m +1m]	[-1m +1m]
$[z1_{min}\ z1_{max}]$	:	[19m 21m]	[19m 21m]	[9m 51m]	[9m 51m]
$[z2_{min}\ z2_{max}]$	:	[29m 31m]	[9m 51m]	[29m 31m]	[9m 51m]
$[\Delta\gamma_{min}\ \Delta\gamma_{max}]$	:	[-5° +5°]	[-5° +5°]	[-5° +5°]	[-5° +5°]



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