E M E R G E N C E
as Creative Design Process

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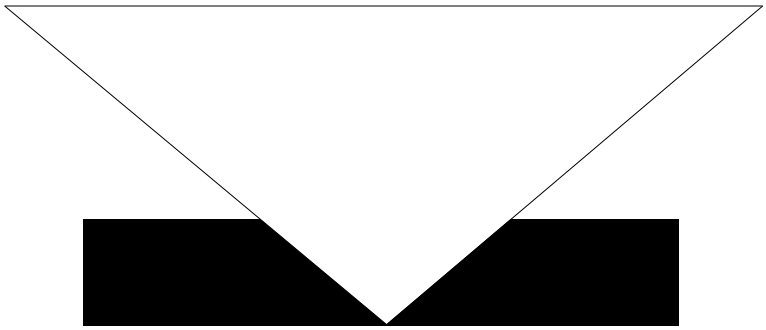
Visual emergence



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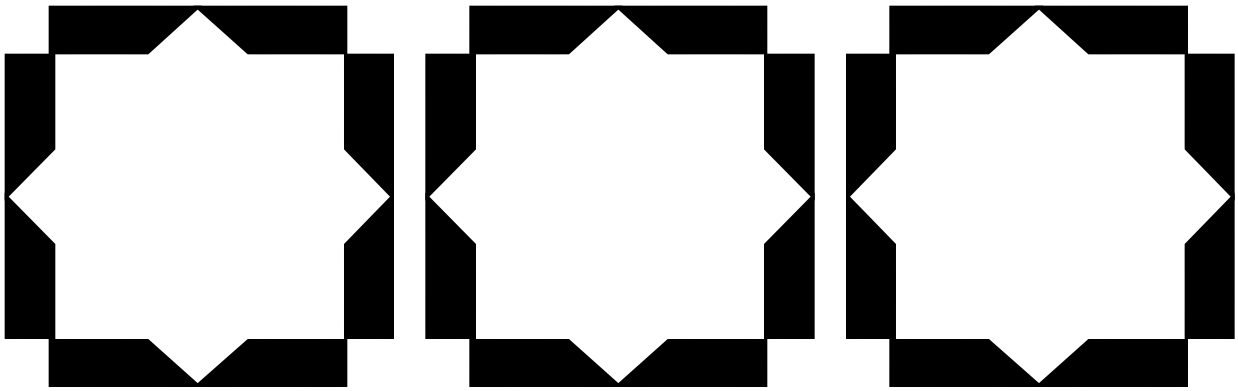

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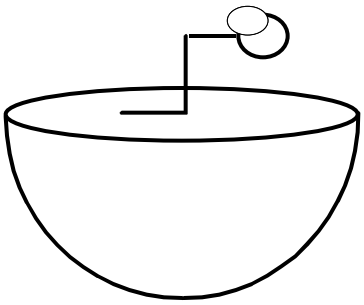
Functional emergence



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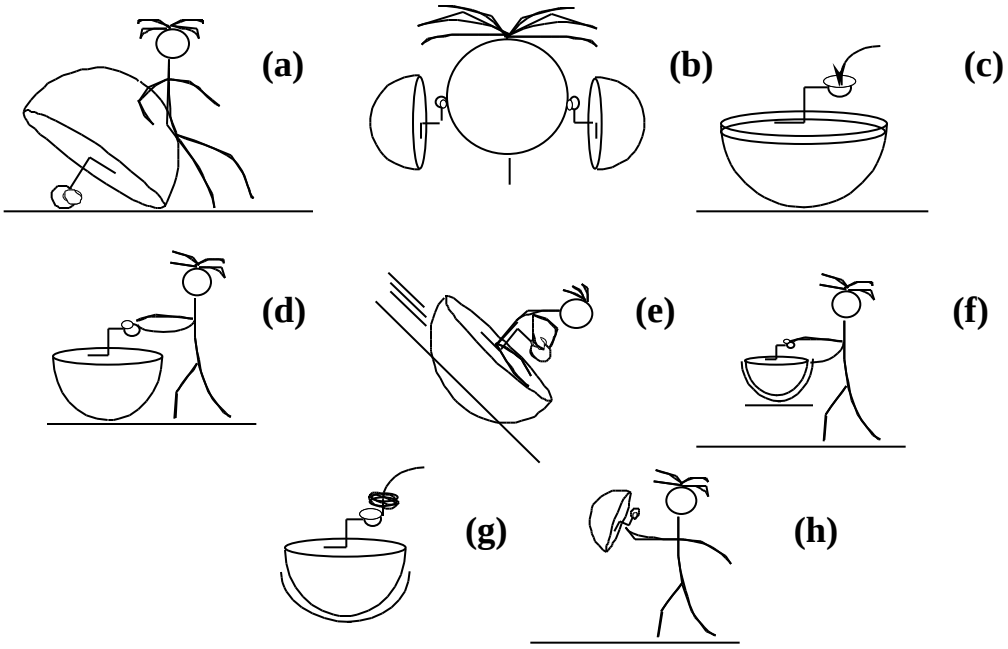
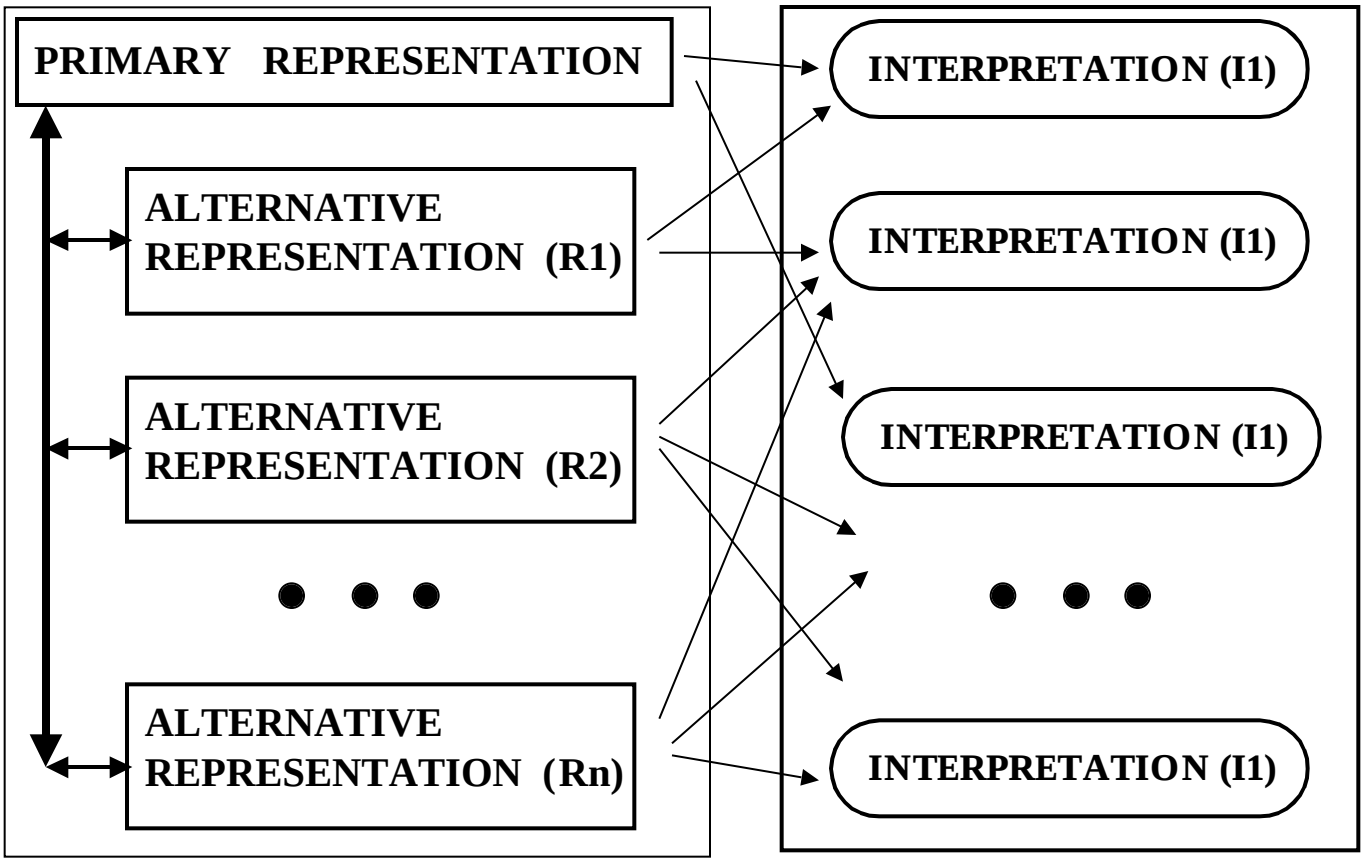

(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)

Emergence in design

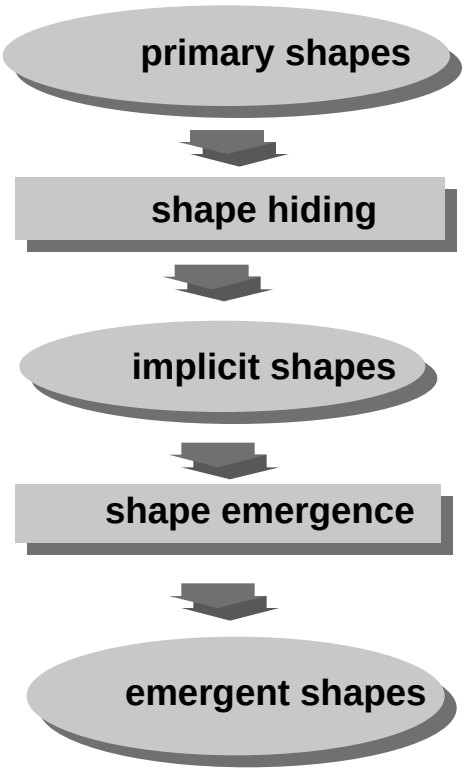
A property that is not represented explicitly is said to be an emergent property if it can be made explicit and is unexpected.

In searching for a new solution, Leonardo projected new meanings into forms he saw in his old discarded sketches (Gombrich, 1966)

Multiple Representations



Model of visual emergence



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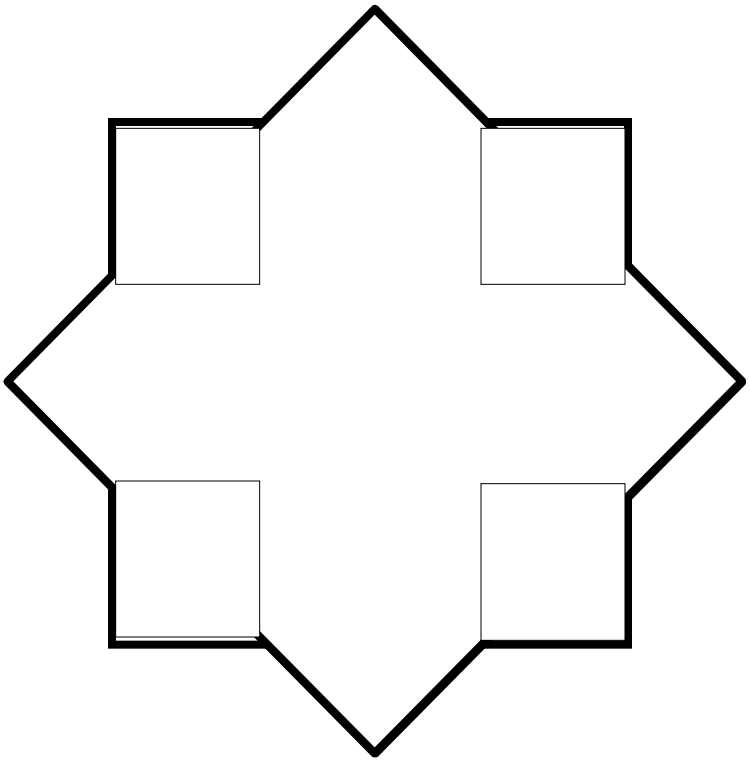

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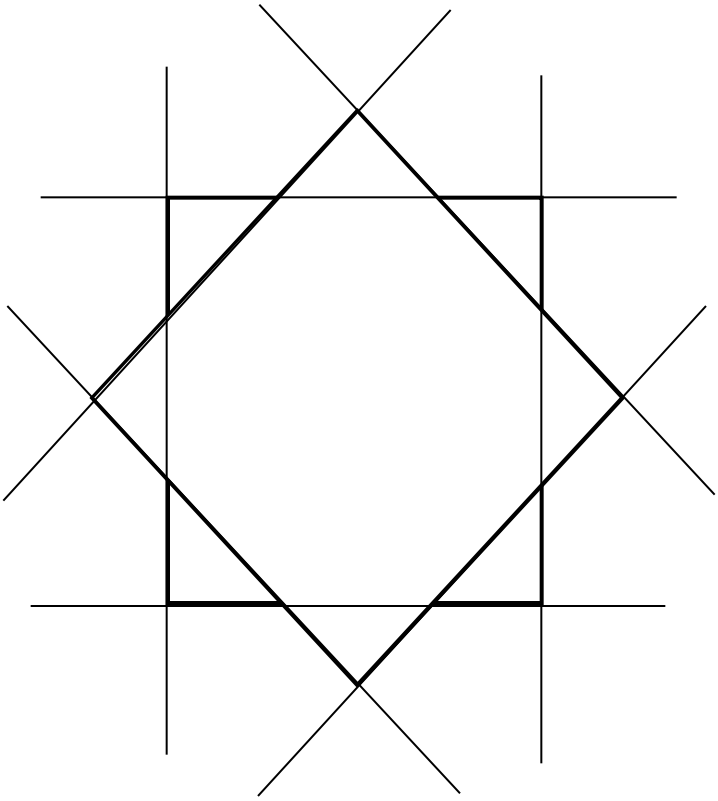

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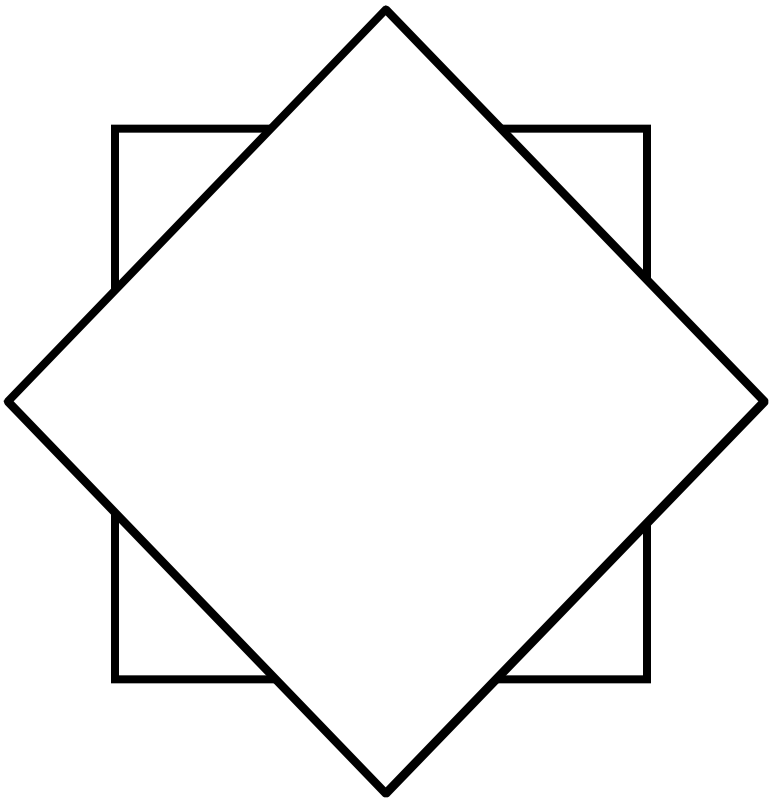

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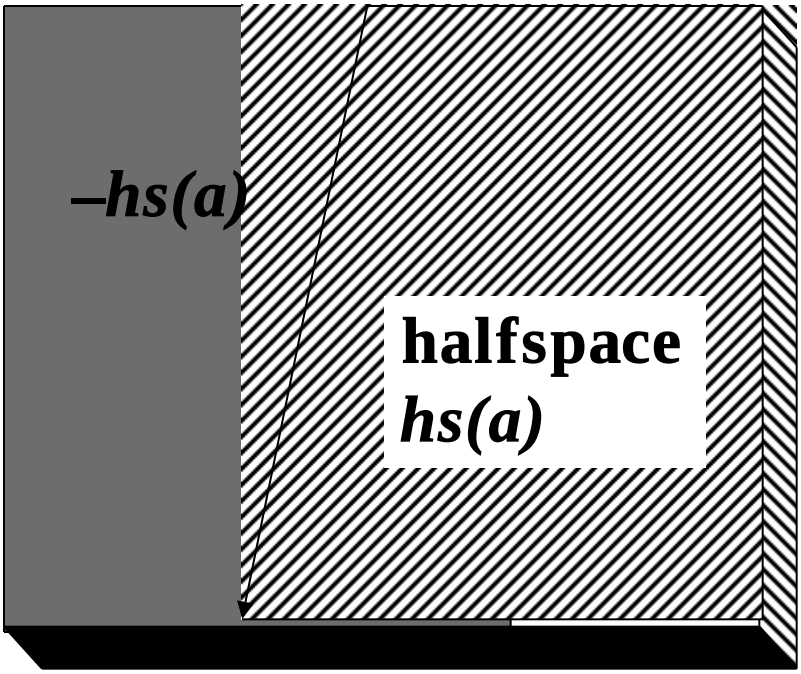
Logic Representation of Objects

Universe of discourse *U*



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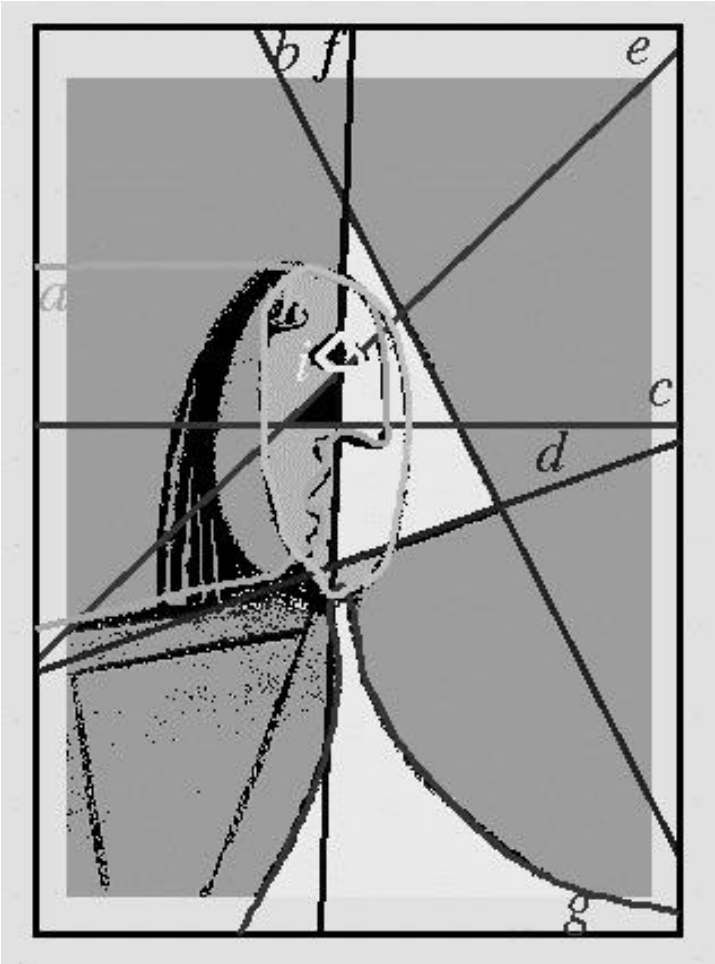
Axioms and definitions

- **universe of discourse *U* is a set of points *p(x,y,z)*.**
- **halfspace *H* is a non-empty set of points *p(x,y,z)*, *H = {p(x,y,z):f(x,y,z) > 0}* where *p(x,y,z)* $\in$ *U***
- **given a halfspace *a* there is another halfspace *a'* which is a set of points *p(x,y,z)* which belongs to *U* and does not belong to *a***
- **a predicate *hs(a)* is defined for the halfspace *a* and *–hs(a)* for the halfspace *a'*, *hs(a)* is defined as True and *–hs(a)* as False**
- **a volume *V* is $hs(a_1) \wedge hs(a_2) \wedge \ldots\ldots hs(a_n)$**
- **an object O is $V_1 \vee V_2 \vee V_3 \vee \ldots\ldots \vee V_m$**


b
f
e
a
c
d
g

The face's silhouette is represented by:

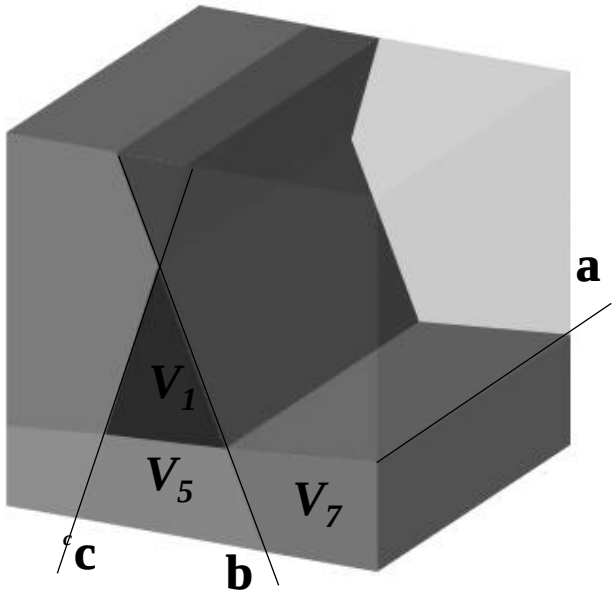
$$hp(a) \quad \neg hp(b) \quad hp(d) \quad \neg hp(g) \quad hp(h)$$

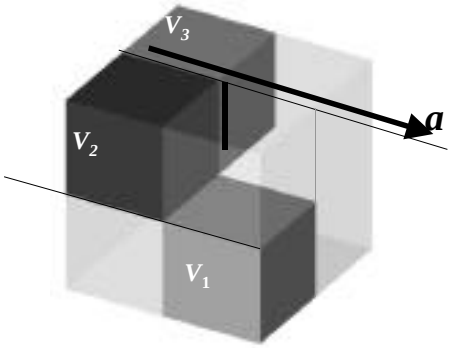
The region inside the eye is:

$$hp(a) \quad \neg hp(b) \quad hp(c) \quad hp(d) \quad \neg hp(g) \quad hp(h)$$

Volume representation

Volume V_1 is $hs(a) \wedge hs(b) \wedge hs(c)$





Face adjacency

Face adjacency to V_2 iif Vj differs in only one literal $hs(x_i)$:

- V_2 is $hs(a) \wedge \neg hs(b) \wedge hs(c)$
- $V'2_{\text{fadj}}$ (V_3) is $\neg hs(a)$ $\neg hs(b)$ $hs(c)$

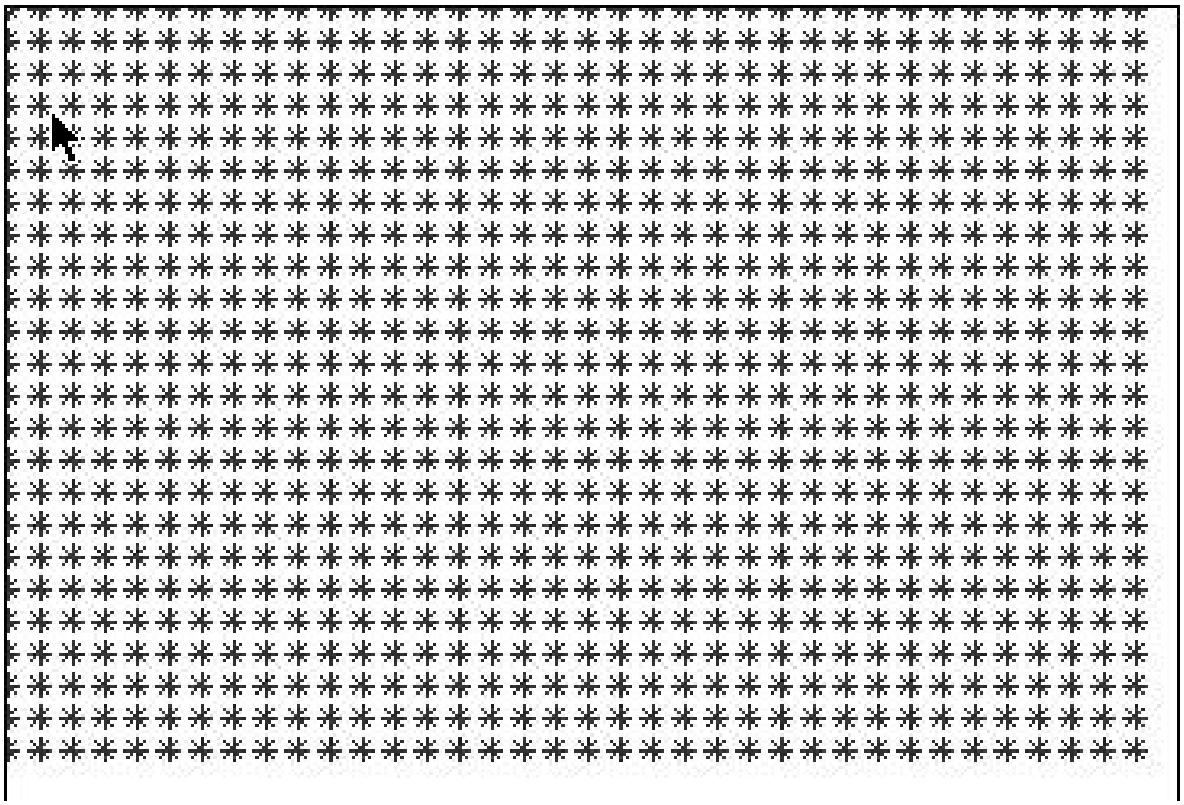
Boundary Contour System

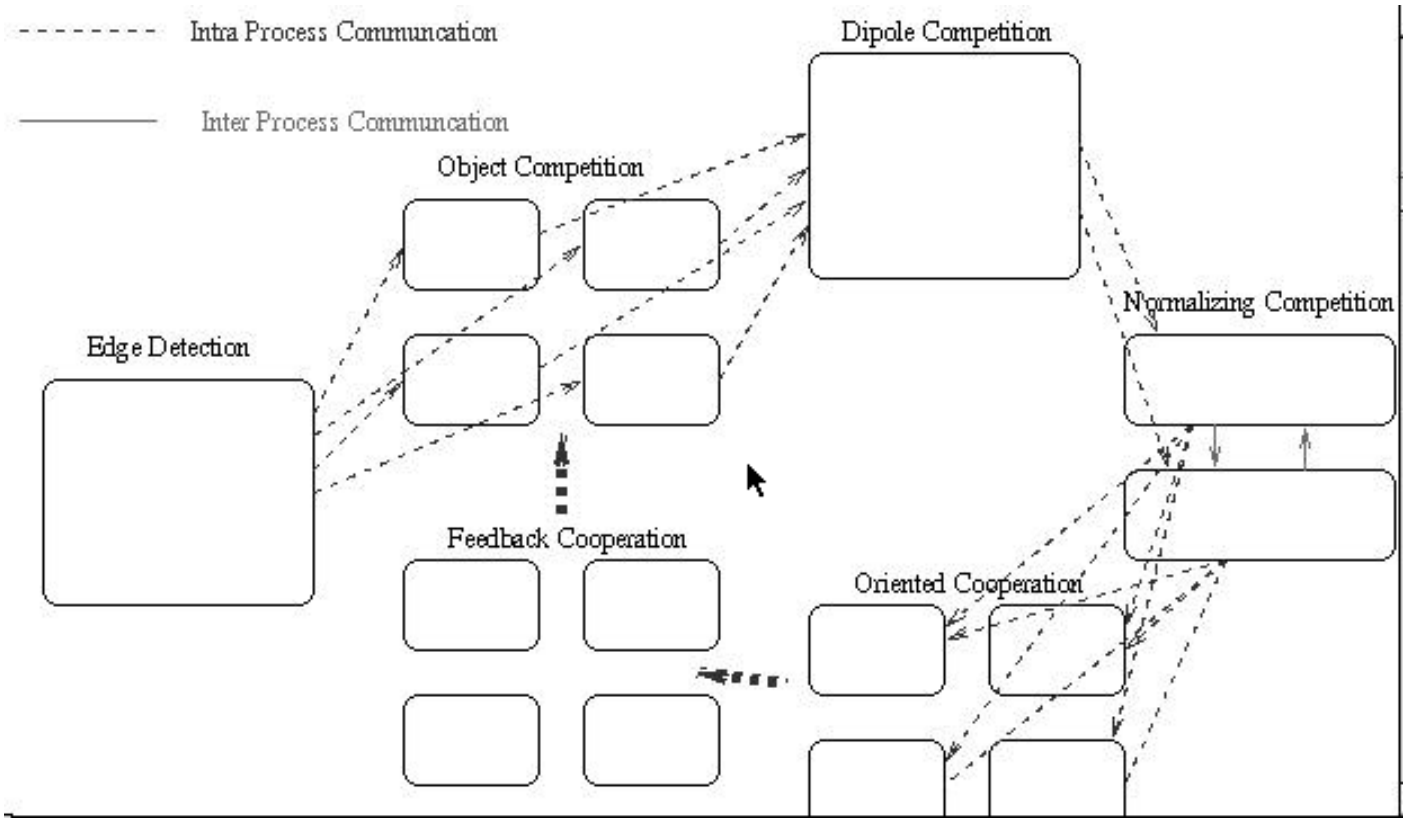
based on human vision perception

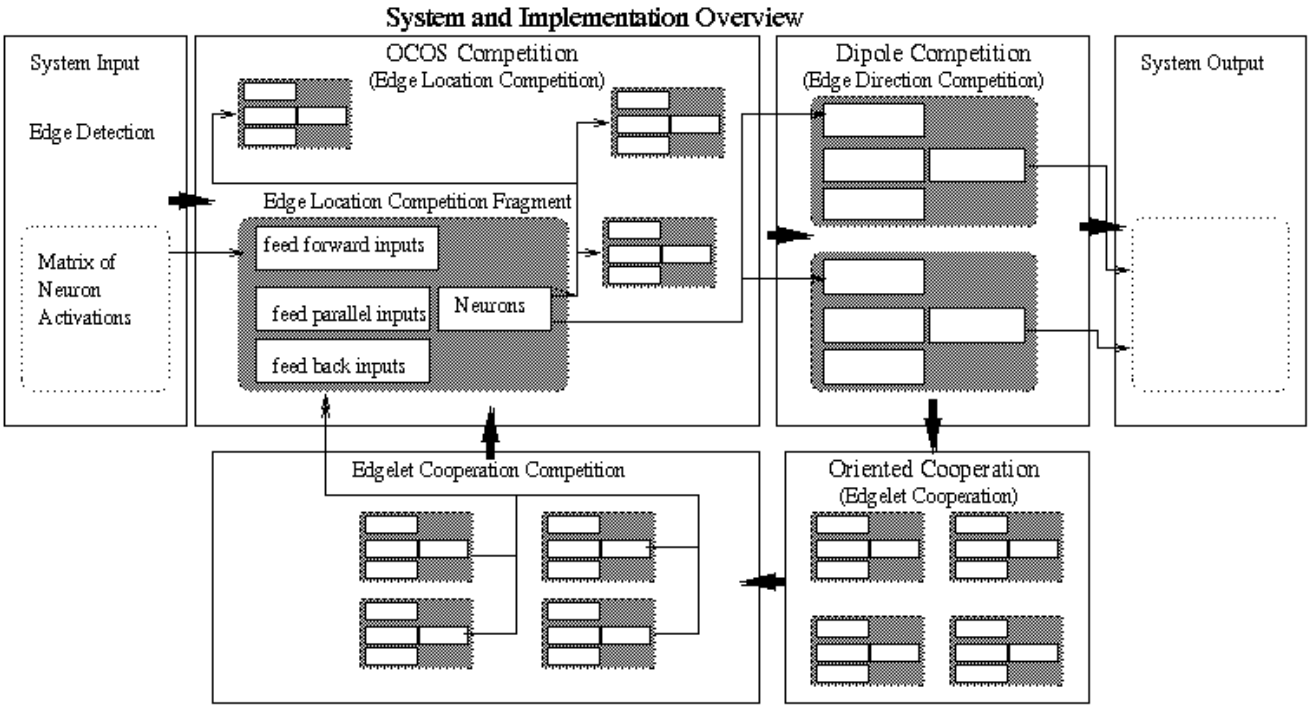
- non-schema based
- illusory cognition
- preattentive
- selective

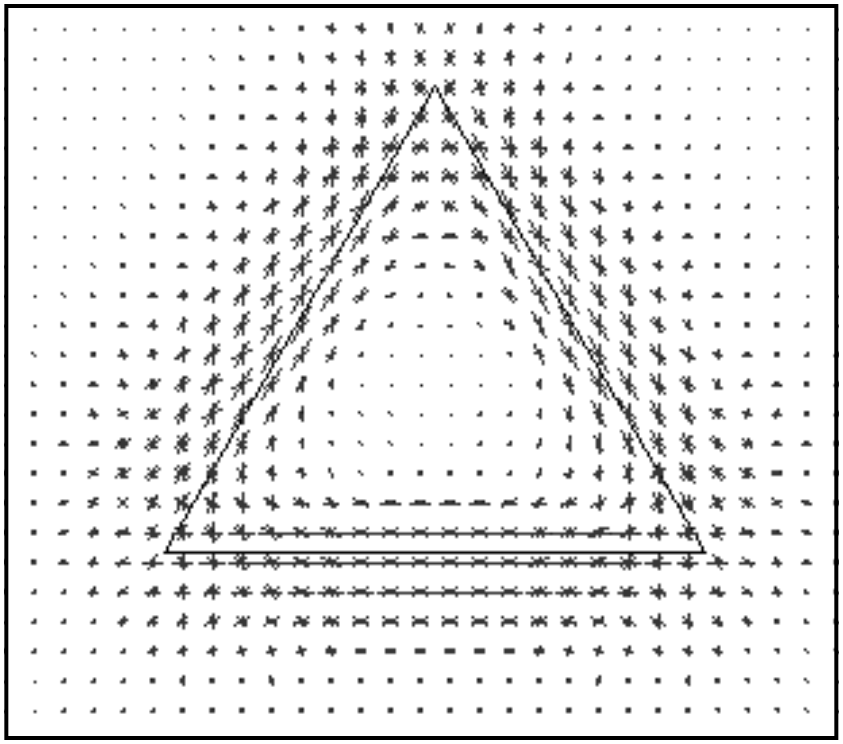
Heuristic rules

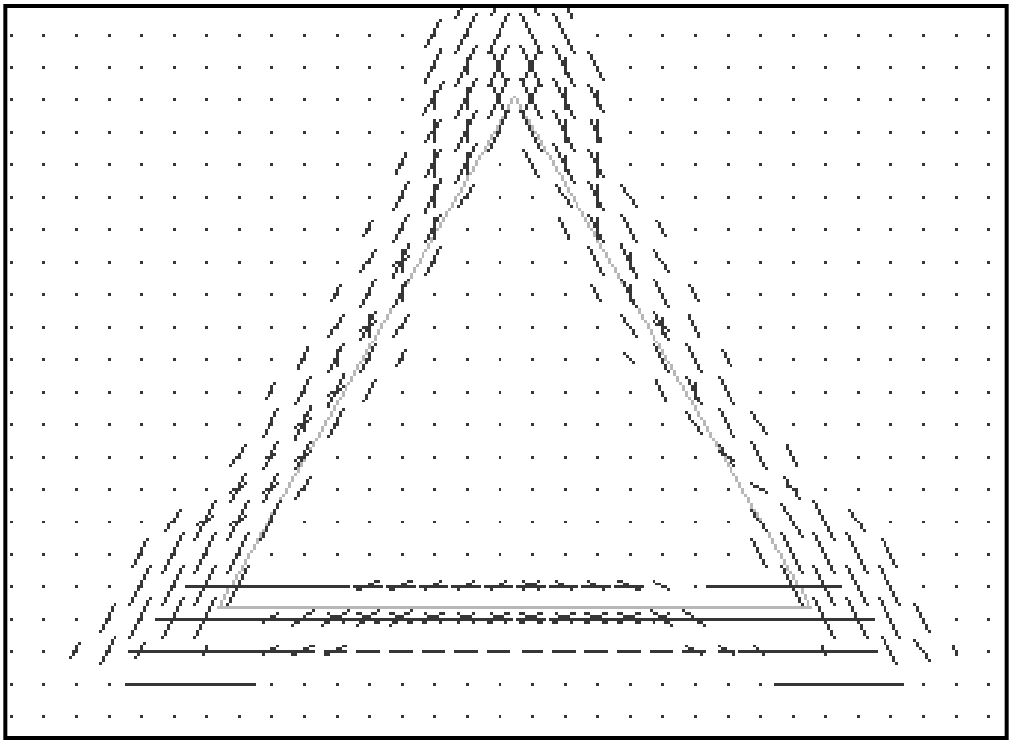
- **edge location rule**: cannot exist in a direction and orientation in two close locations
- **edge direction rule**: edge cannot go in two directions as the same location
- **edge as edgelets rule**: edgelet cannot remain active without feedback from other edgelets on same edge




Intra Process Communication
Inter Process Communication
Dipole Competition
Object Competition
Normalizing Competition
Edge Detection
Feedback Cooperation
Oriented Cooperation


System and Implementation Overview
System Input
Edge Detection
Matrix of Neuron Activations
OCOS Competition
(Edge Location Competition)
Edge Location Competition Fragment
feed forward inputs
feed parallel inputs
feed back inputs
Neurons
Dipole Competition
(Edge Direction Competition)
System Output
Edgelet Cooperation Competition
Oriented Cooperation
(Edgelet Cooperation)





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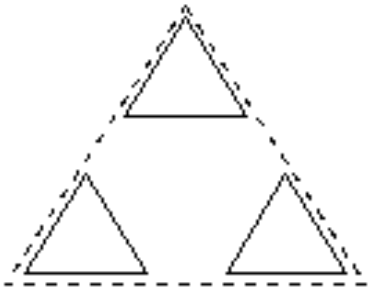
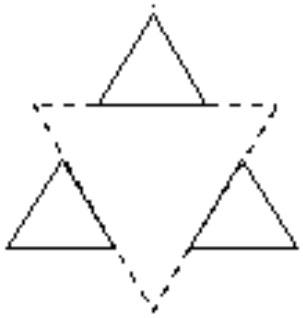
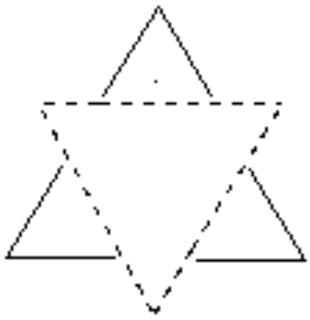
Continuous Illusory

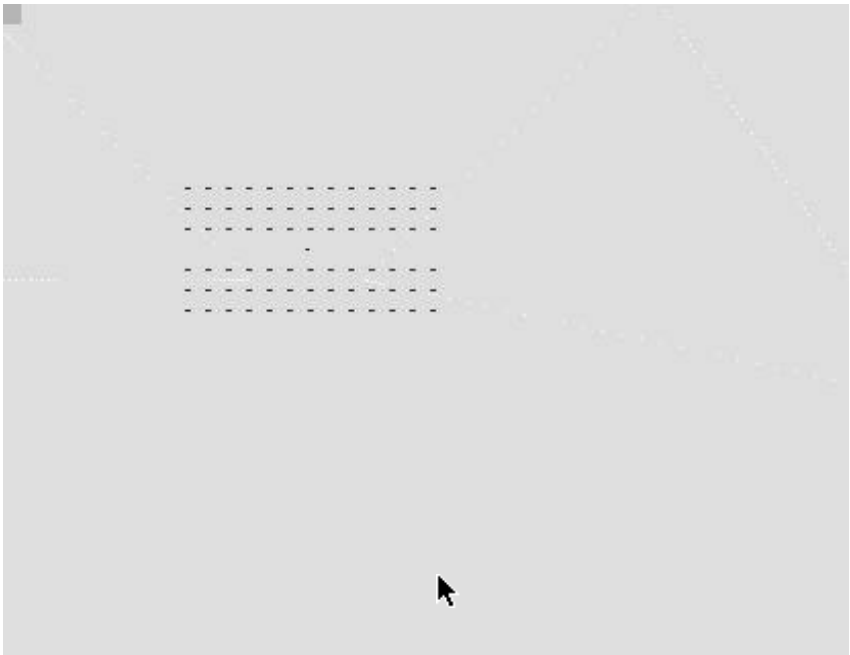


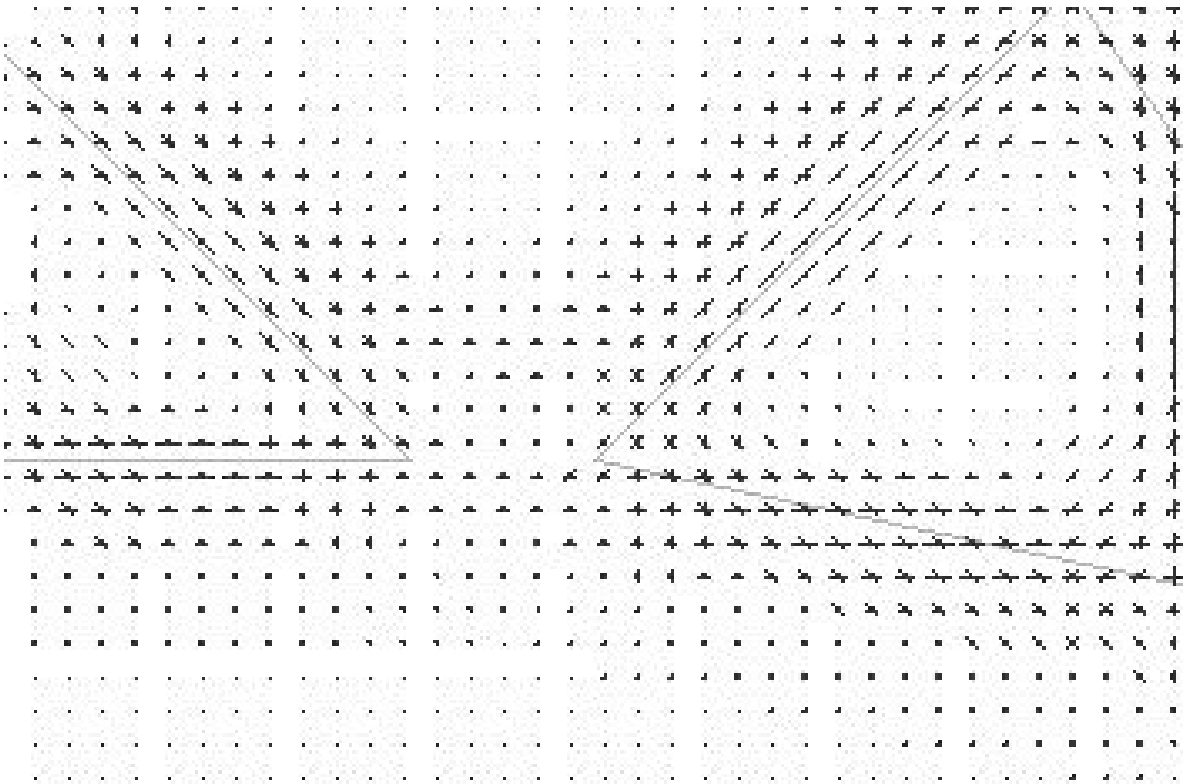
Corner Extension Illusory



End Cut Illusory







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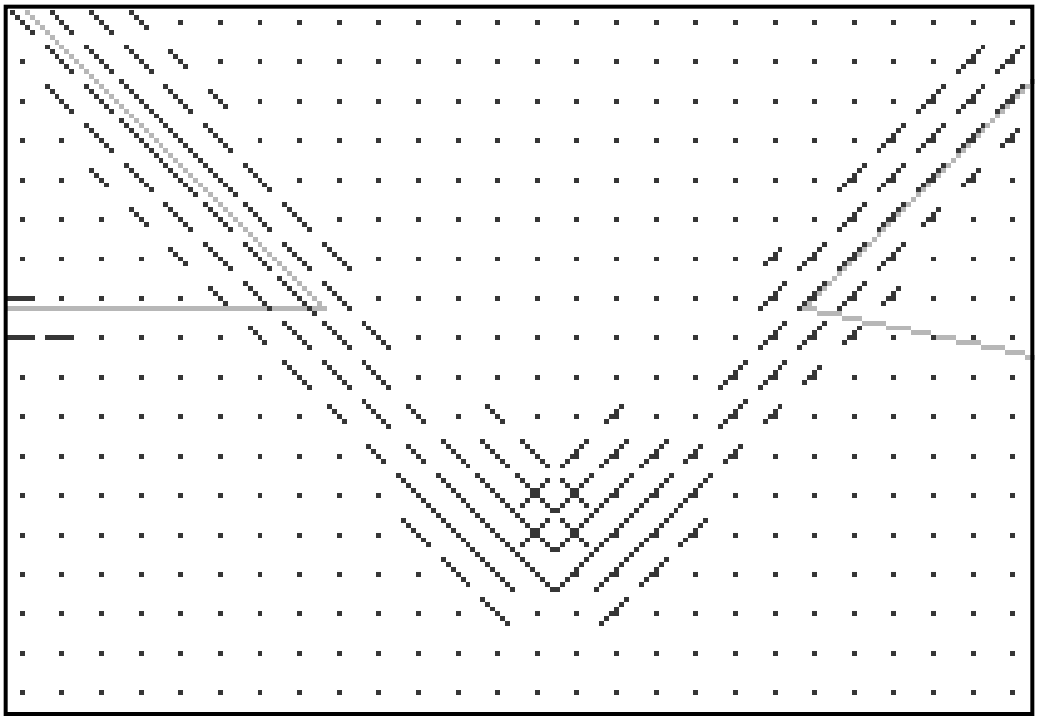

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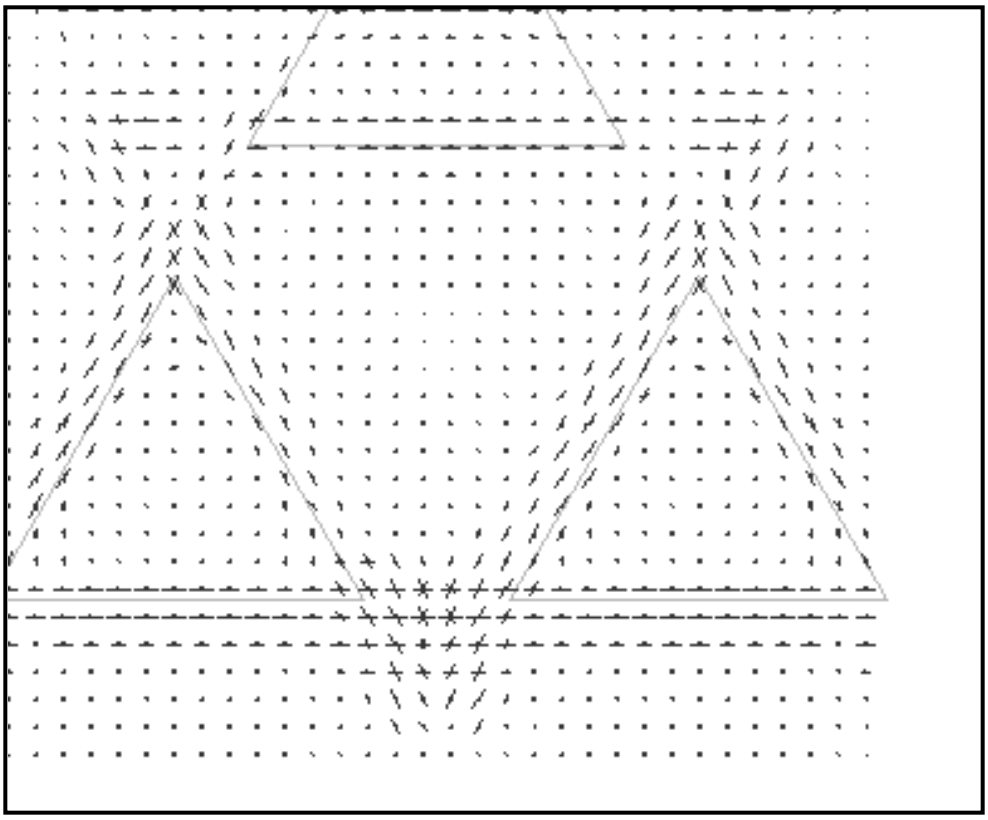

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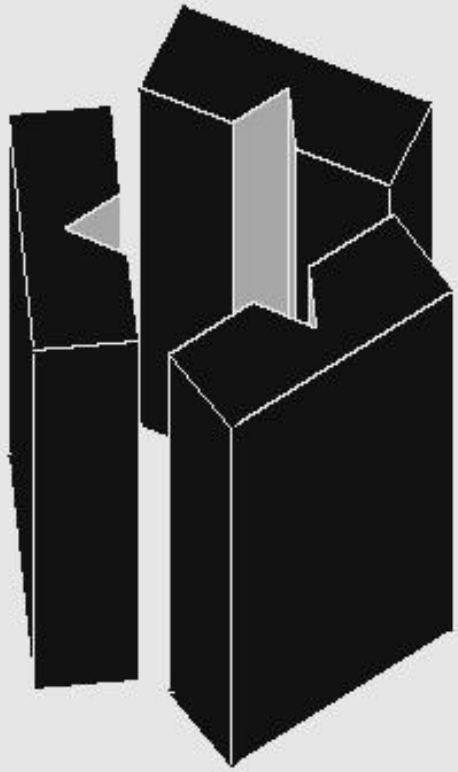
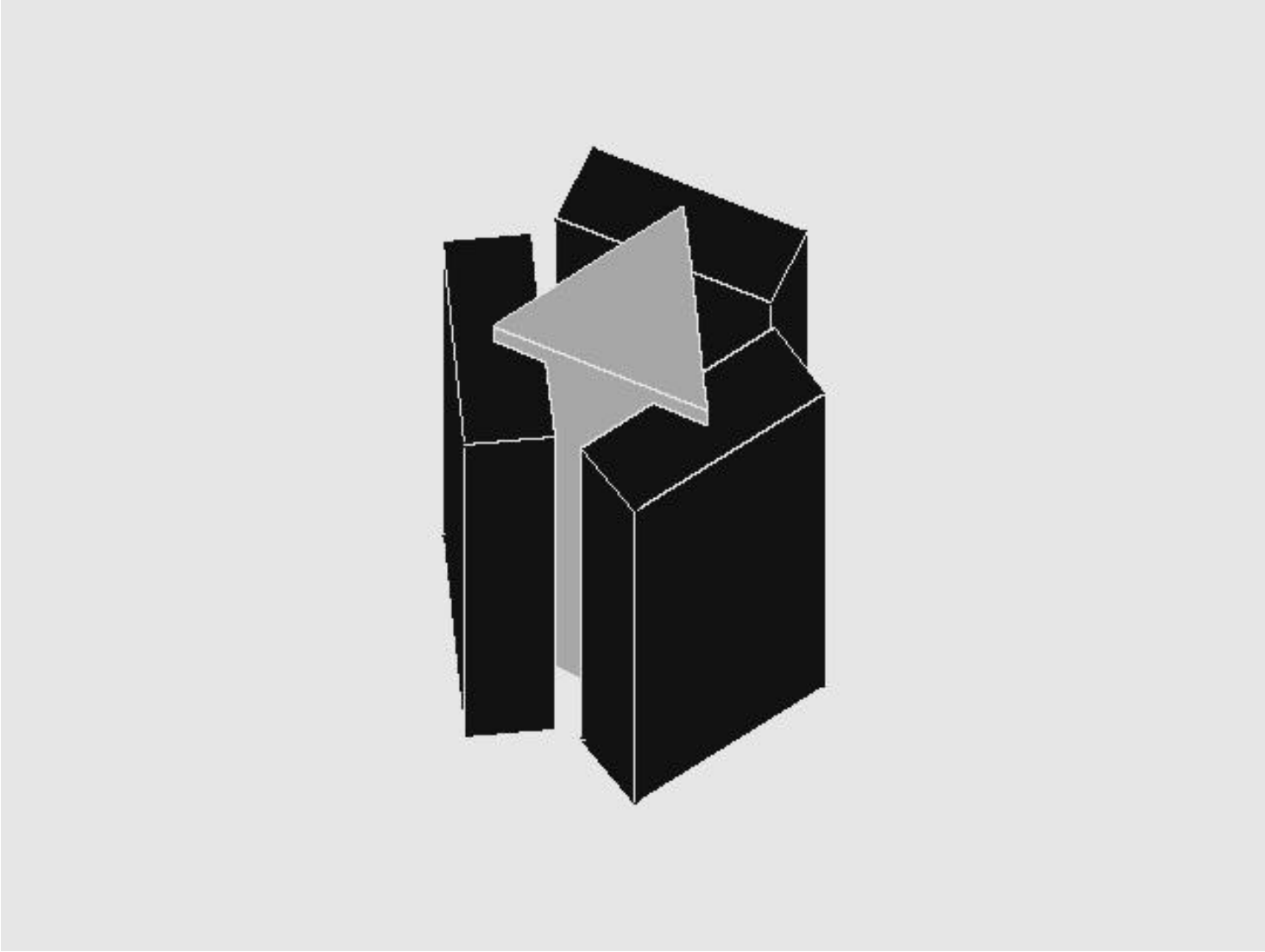
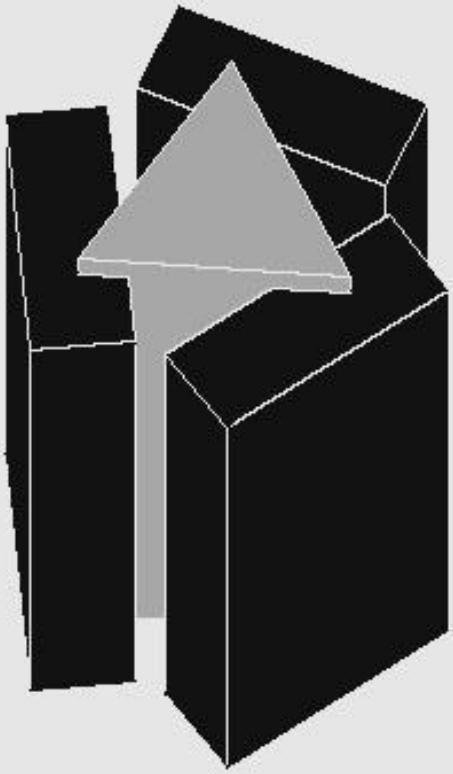
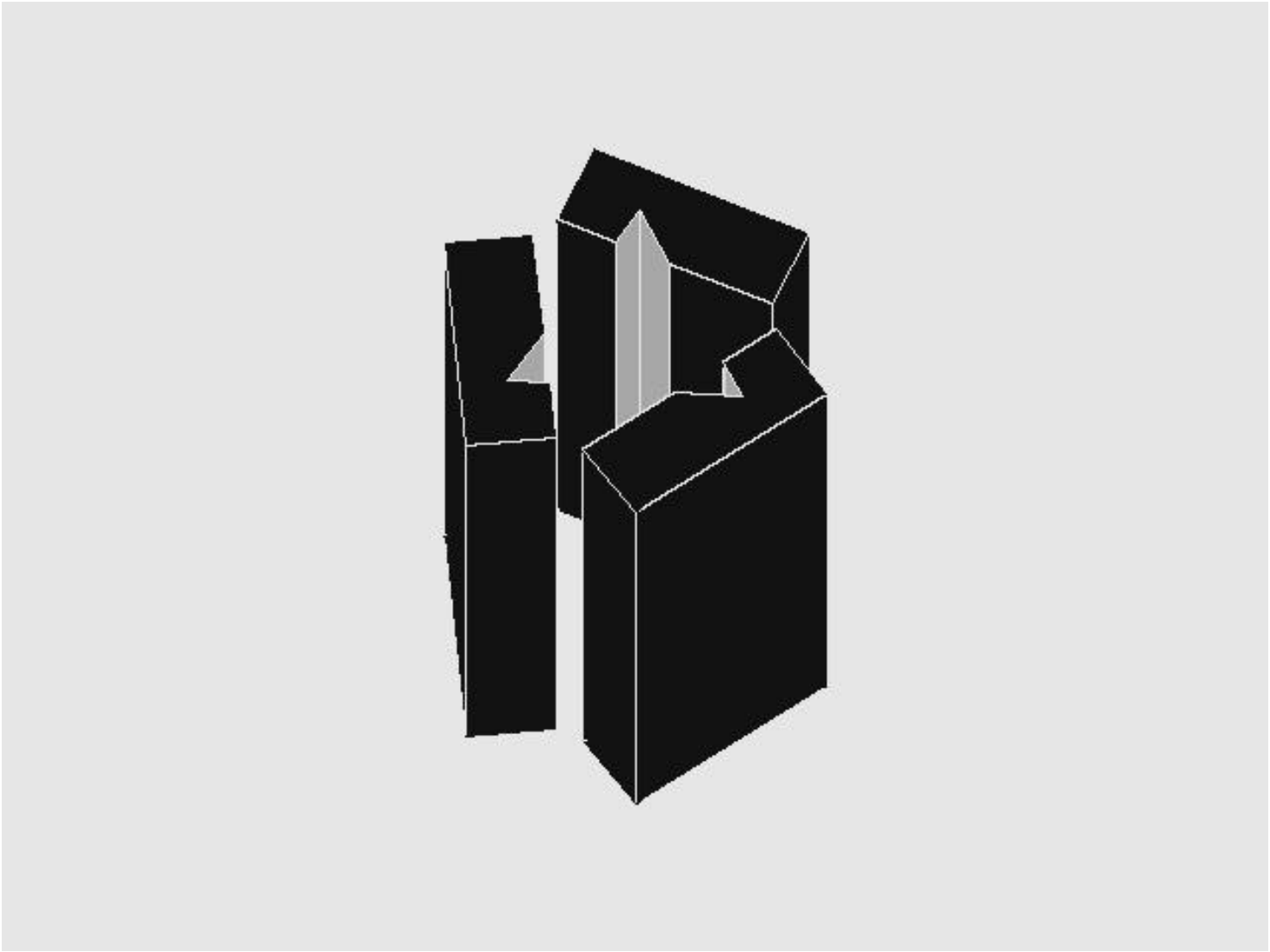








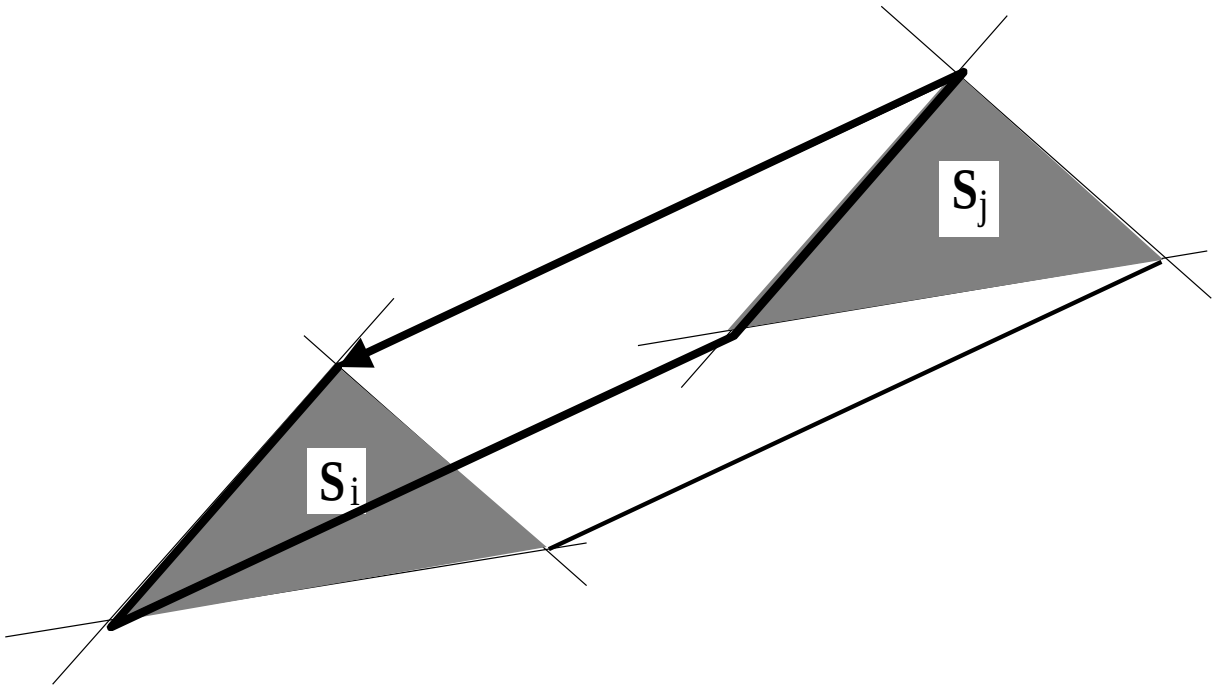
Shape Semantics Emergence

- Visual symmetry
- Visual rhythm
- Visual movement
- Visual balance

Symmetry emergence

- Translational symmetry
- Reflectional symmetry
- Rotational symmetry
- Glide reflectional symmetry

Translational symmetry



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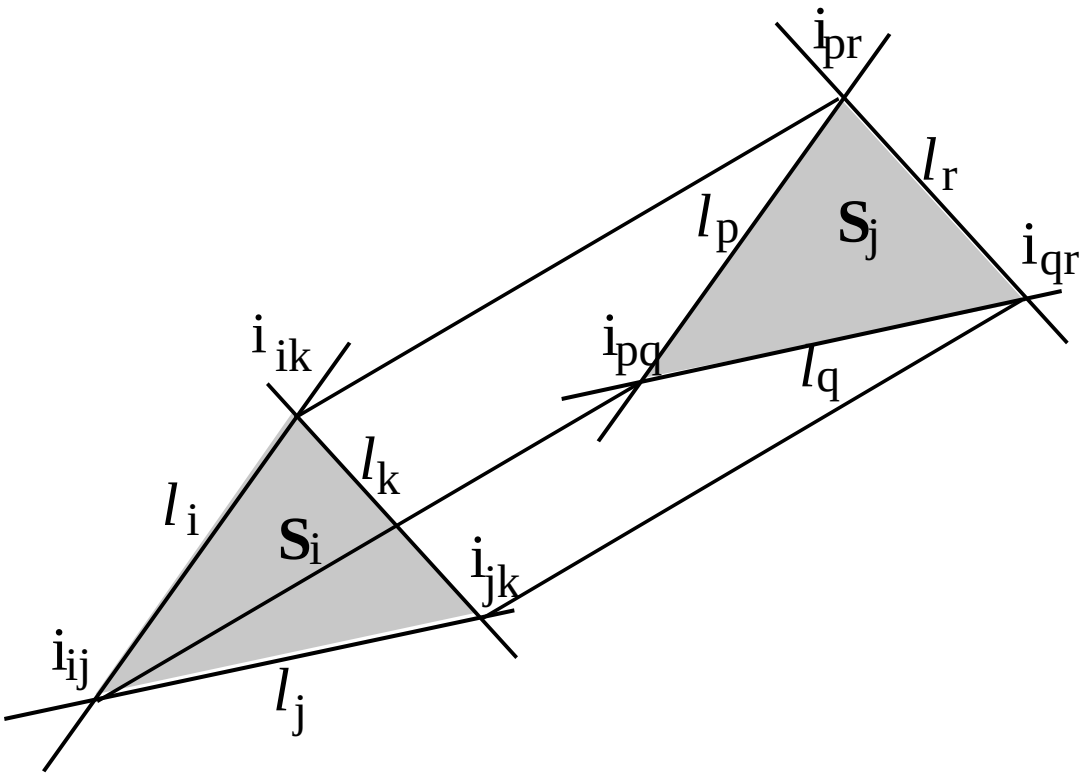
i pr
l r
l p
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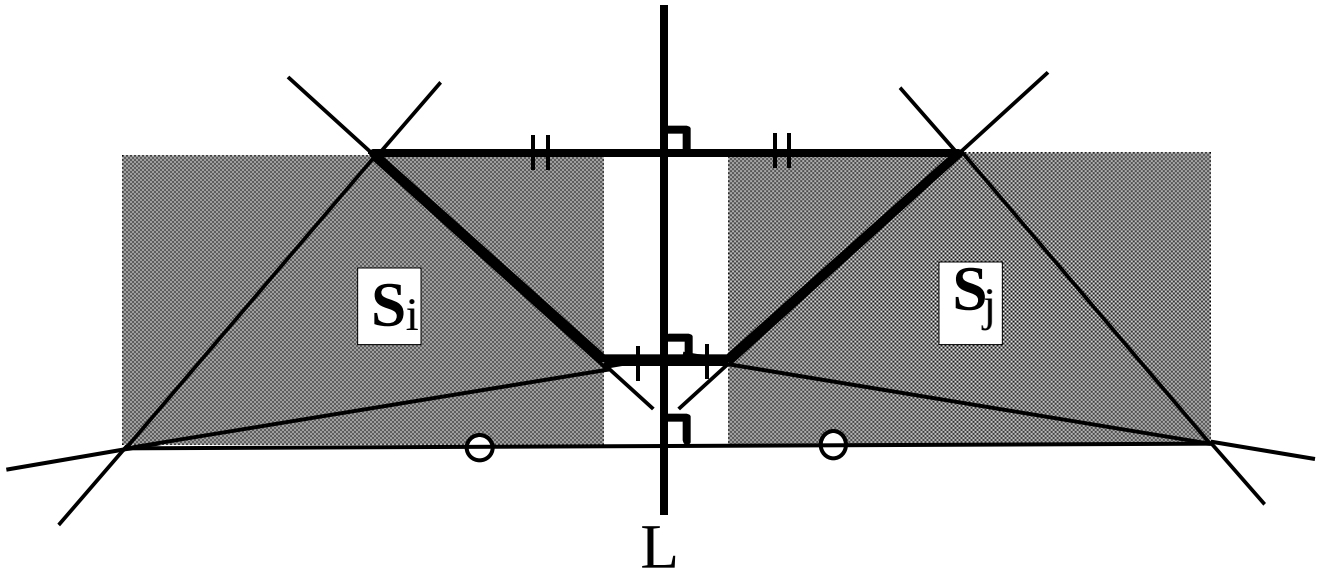
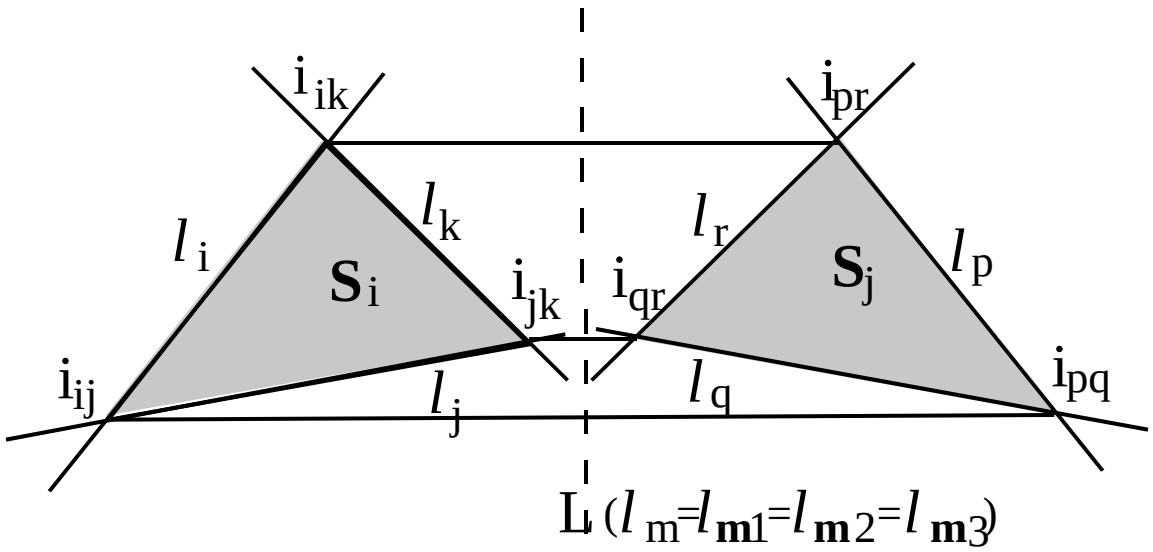
i qr
i ik
i pq
l q
l k
l i
S i
i jk
i ij
l j

Reflectional symmetry




i ik
ipr
l i
l k
l r
l p
S i
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l j
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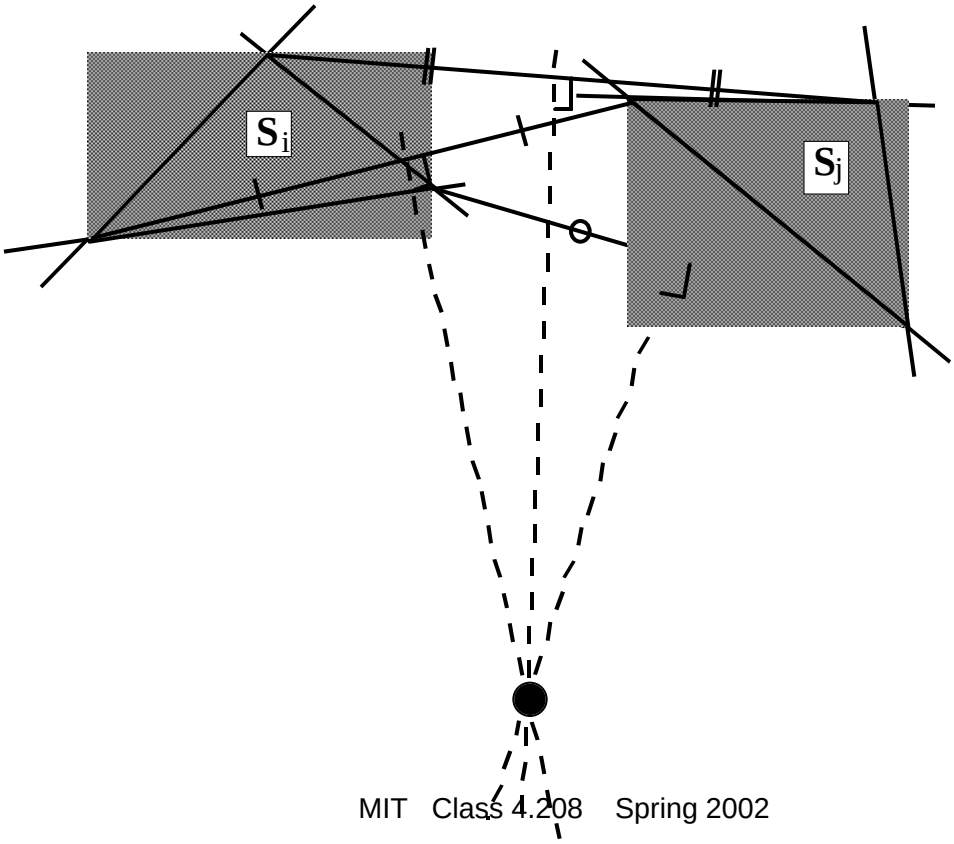
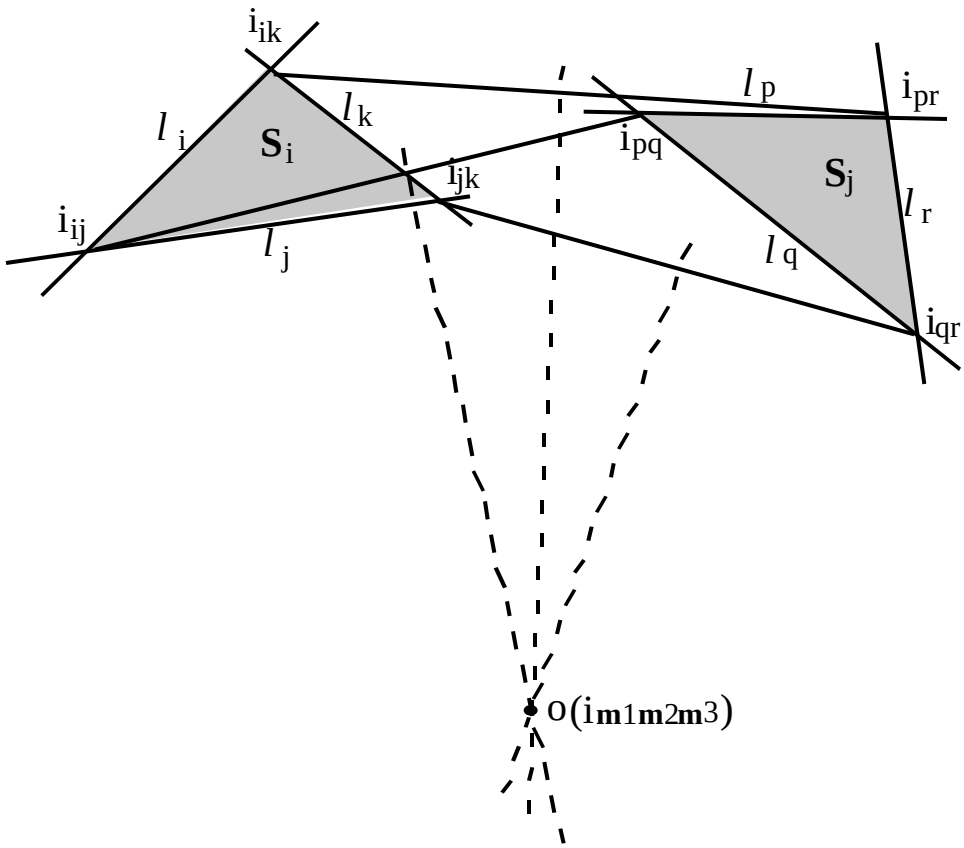
L (l m=l m1=l m2=l m3)

Rotational symmetry




i_{ik}
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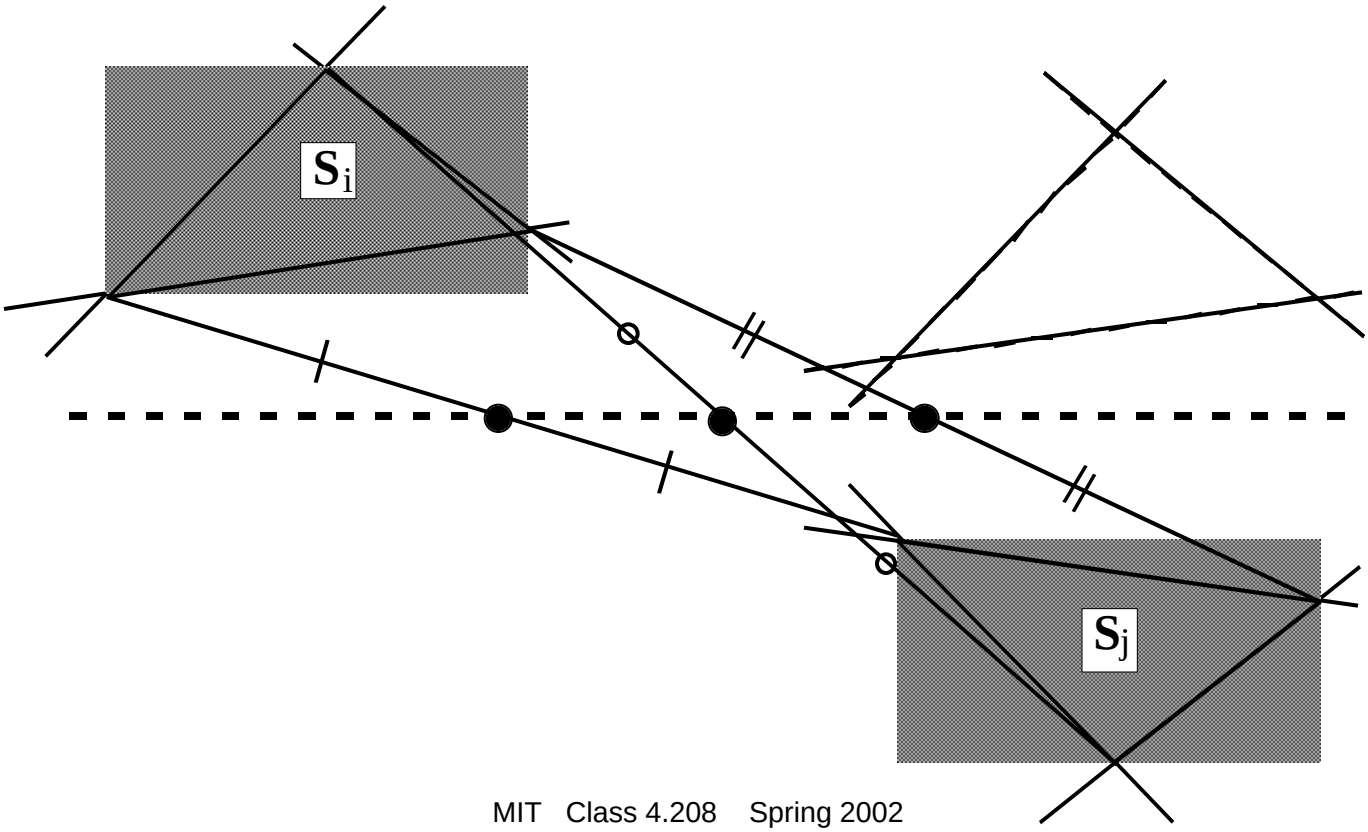
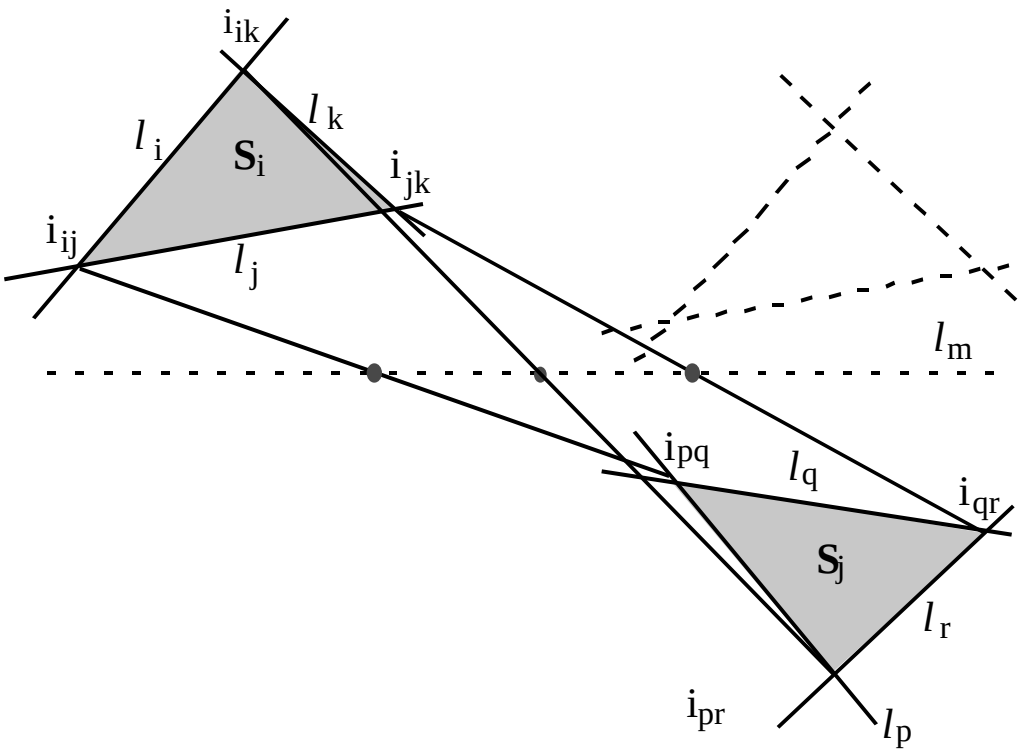
S_i
l_k
i_{jk}
i_{ij}
l_j
l_p
i_{pr}
i_{pq}
S_j
l_r
l_q
i_{qr}
$O(i_{m1}m_2m_3)$

Glide reflectional symmetry




i_{ik}
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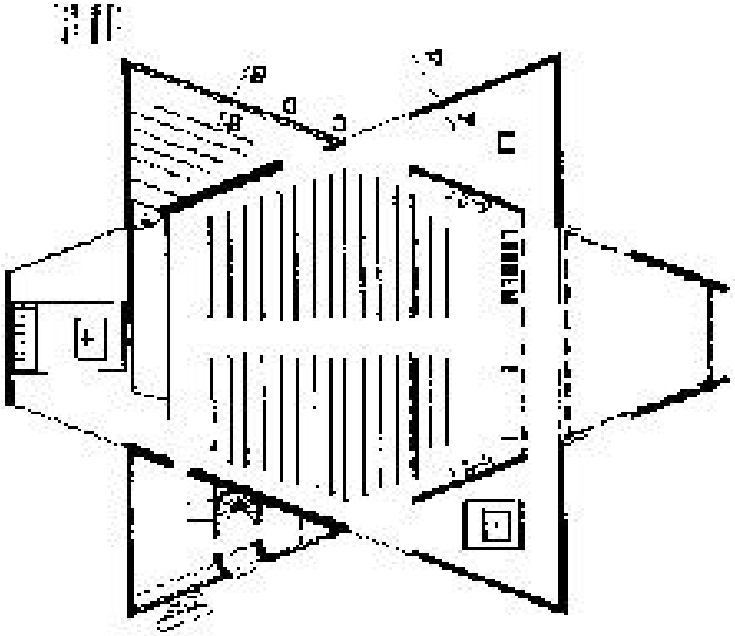
i_{pr}
l_p

Application of shape emergence in CAAD



Church in Crailsheim - Fritz Vogt

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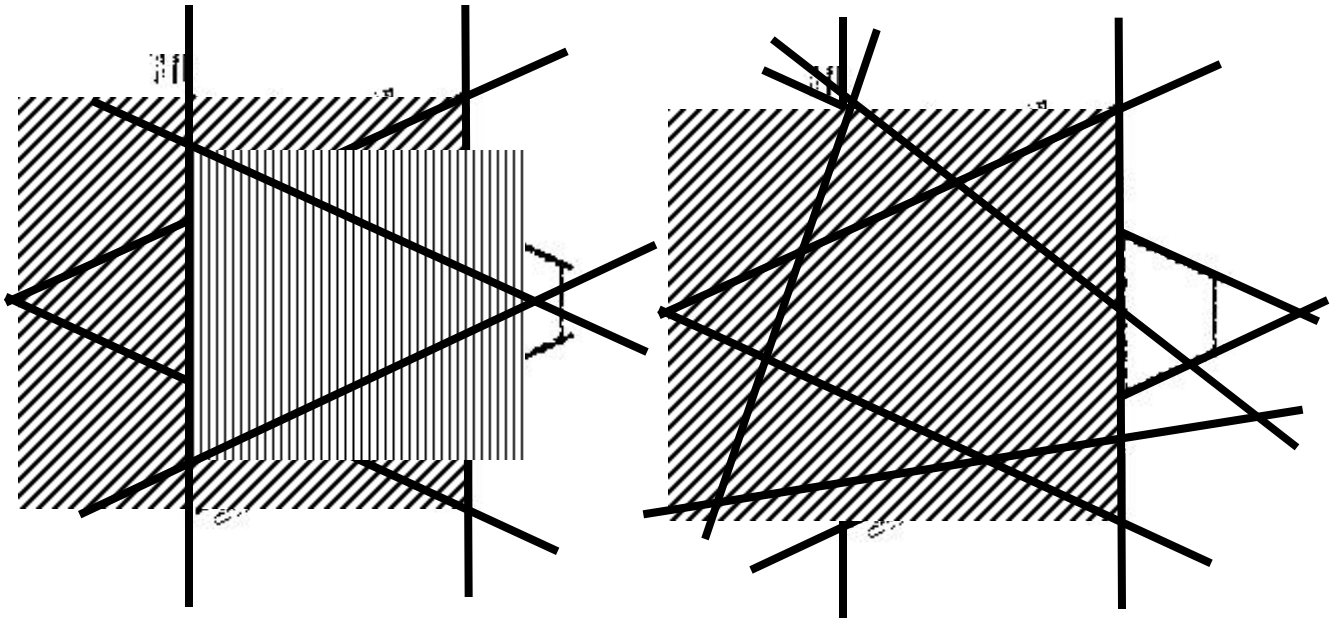

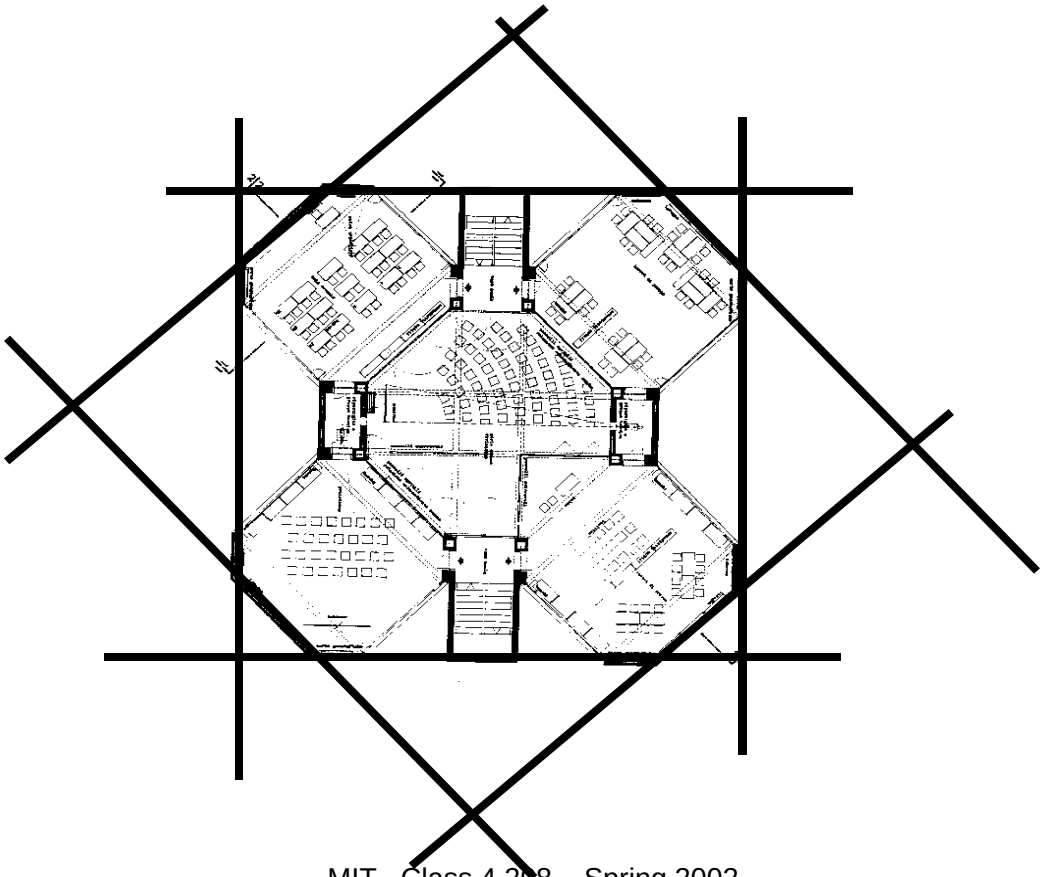

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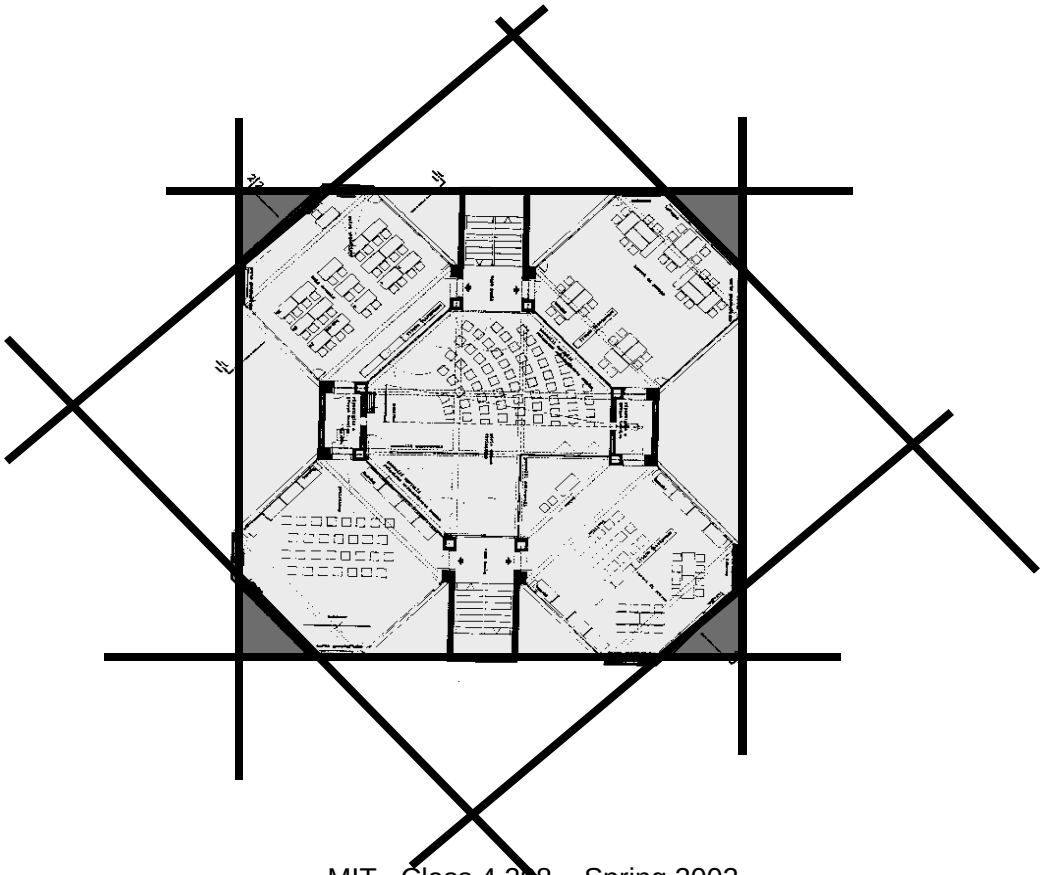

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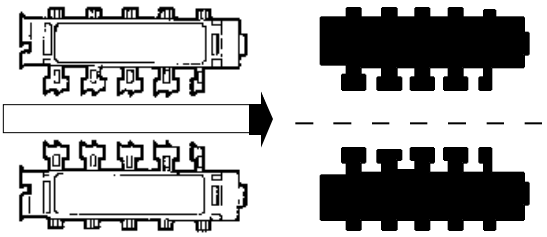

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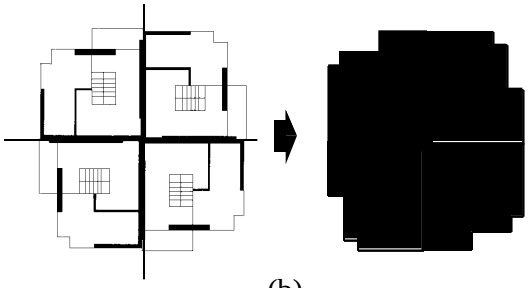

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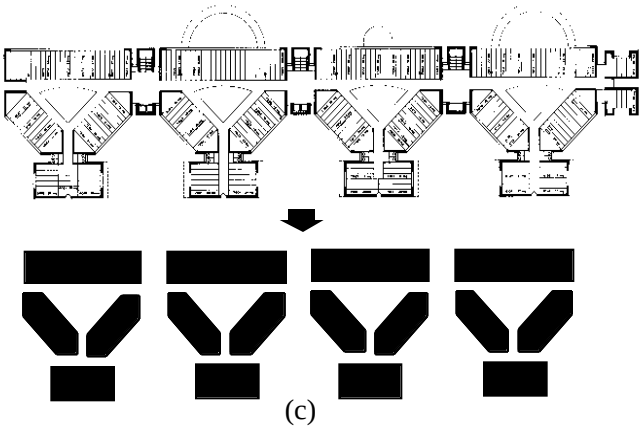
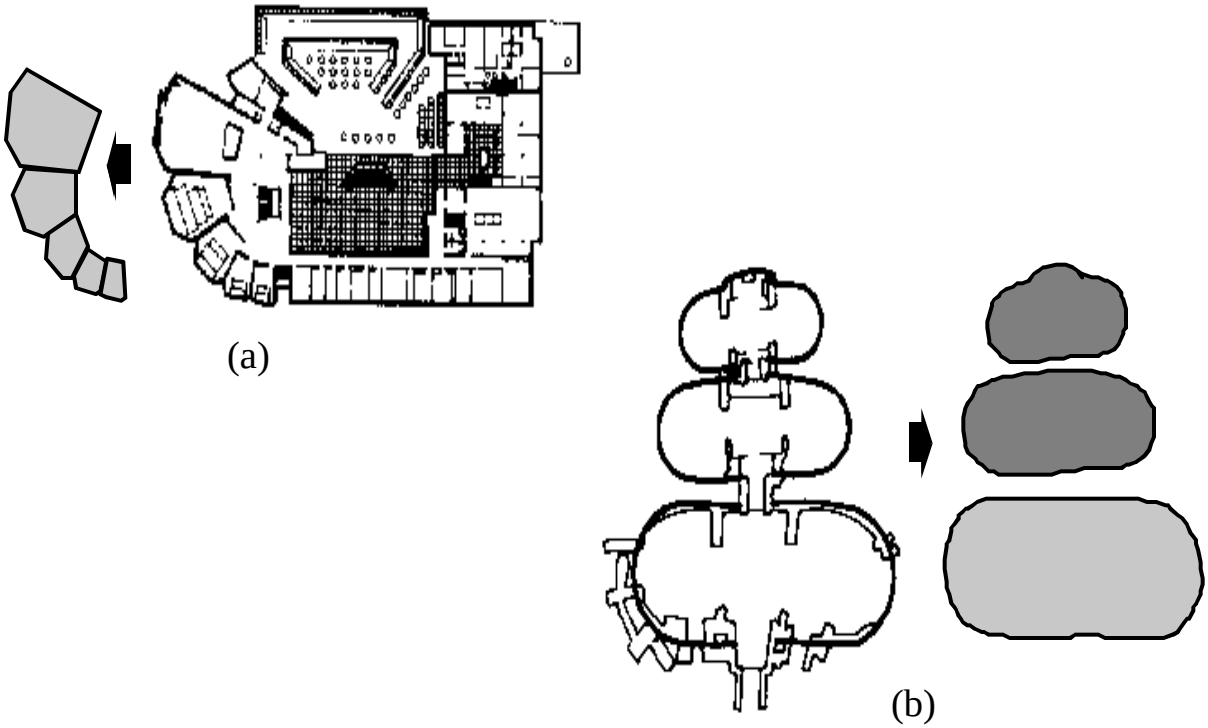
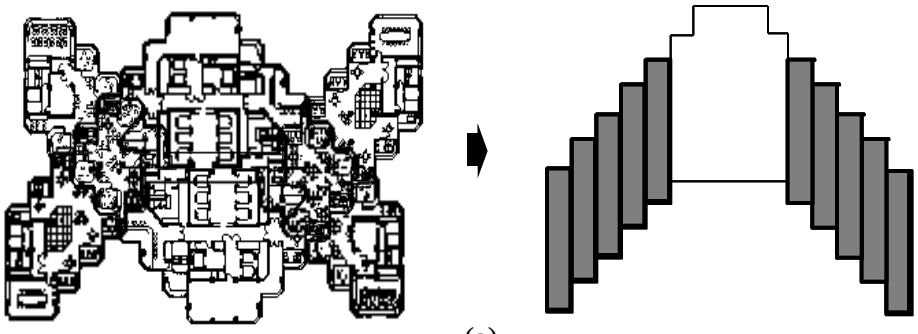
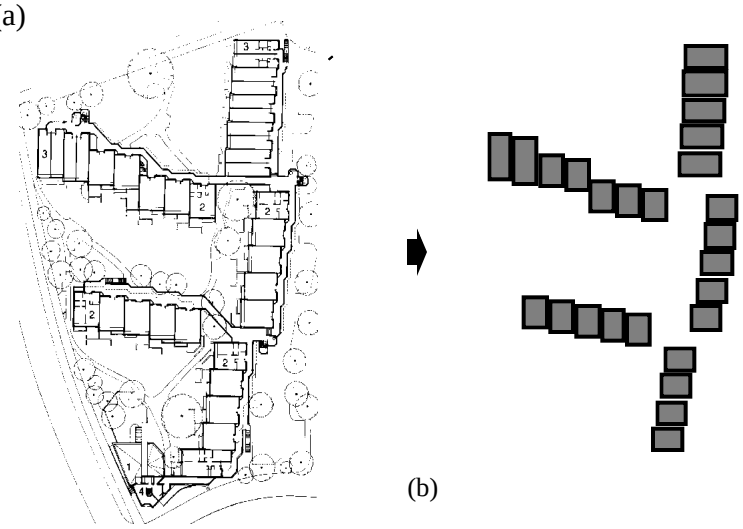


(c)

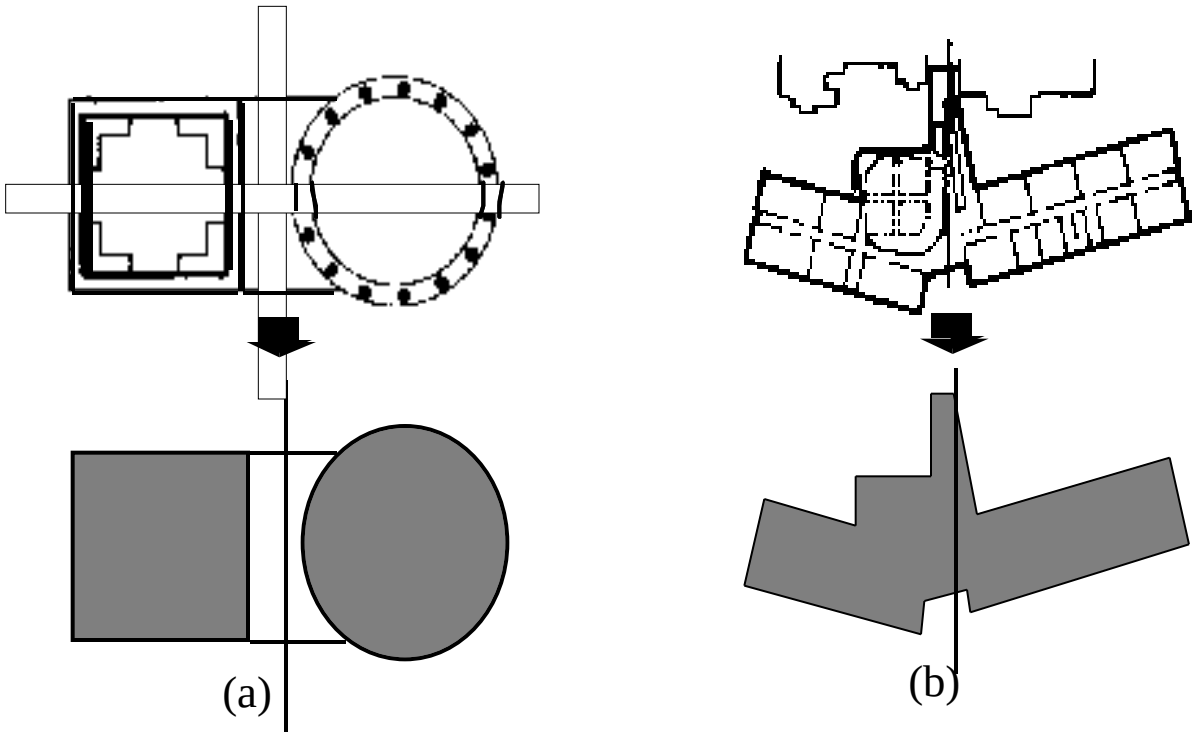

(a)
(b)



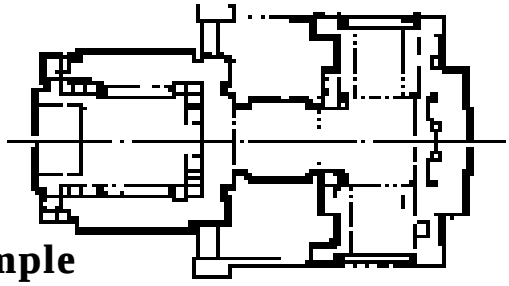
(a)



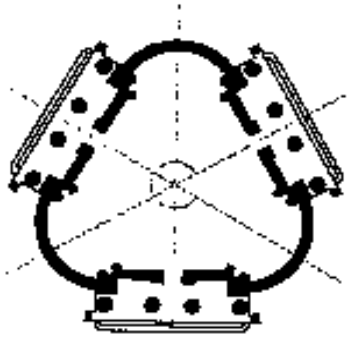
(b)


(a)
(b)

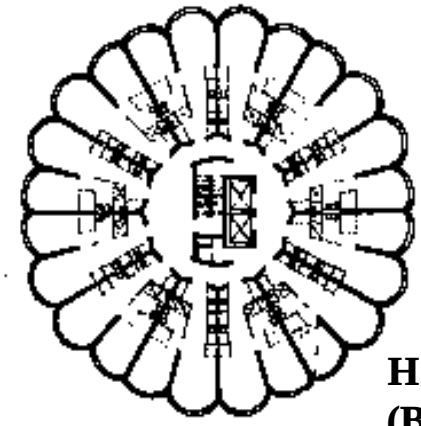
Visual symmetry



Unity Temple
(Frank Lloyd Wright)

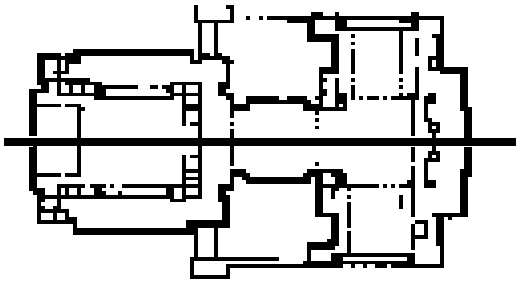


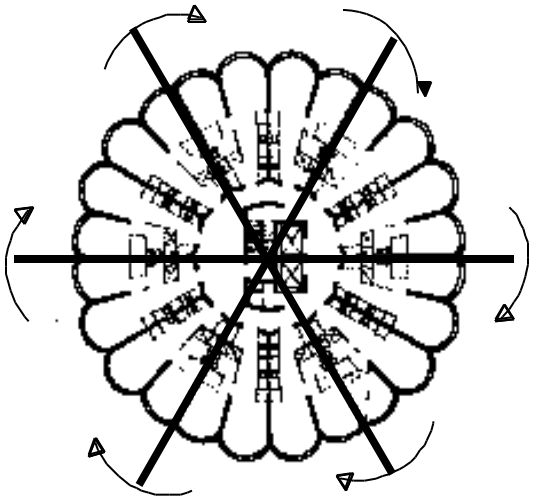
Sepulchral Church
(Sir John Soane)

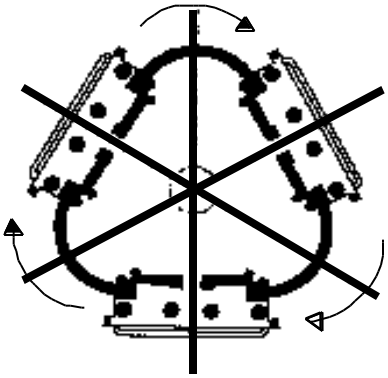


High rise flats in Chicago
(Betrand Goldberg Associates)

Visual symmetry







Visual rhythm

College Life Insurance Company of America Headquarters
(Kevin Roche)

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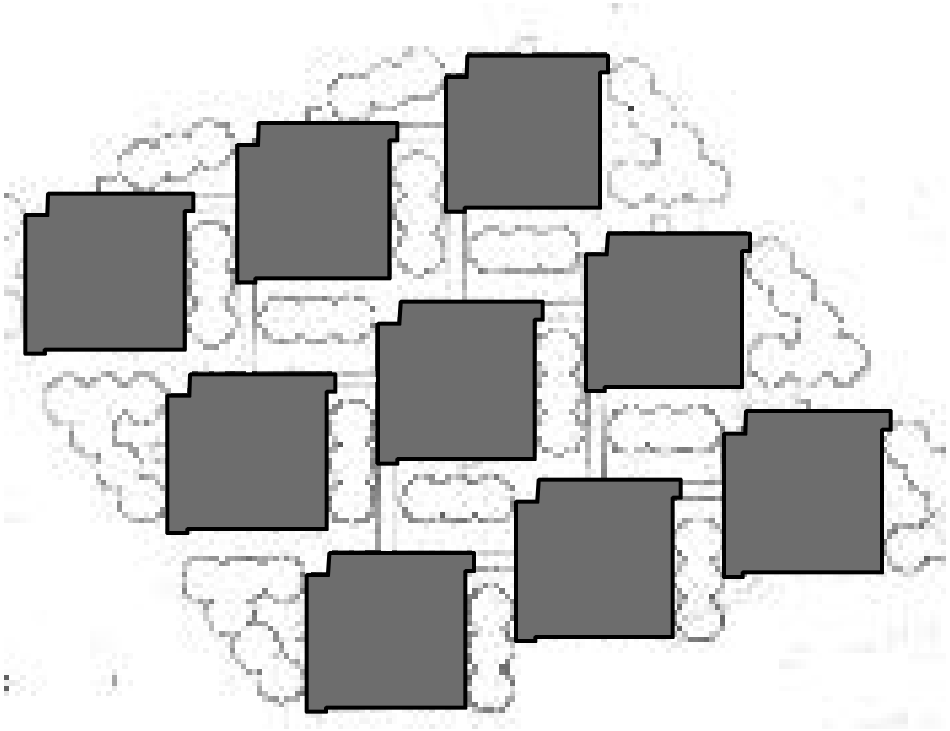
Visual rhythm



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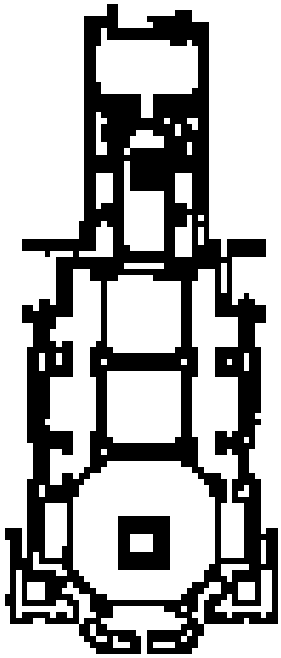
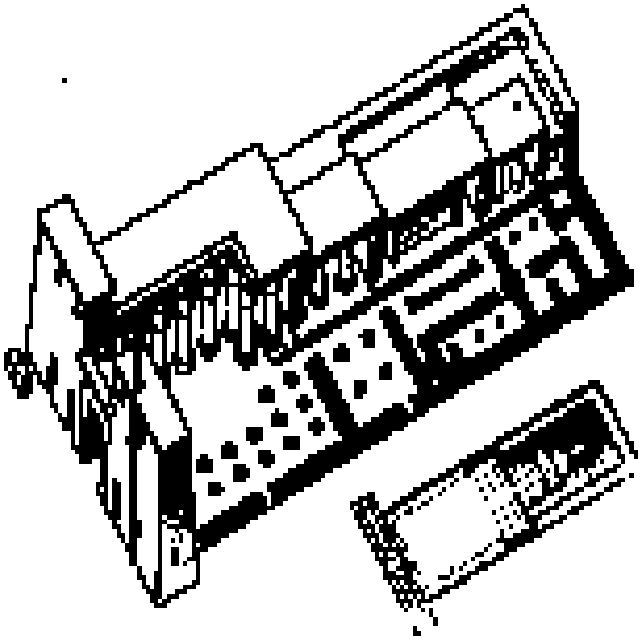
Visual movement

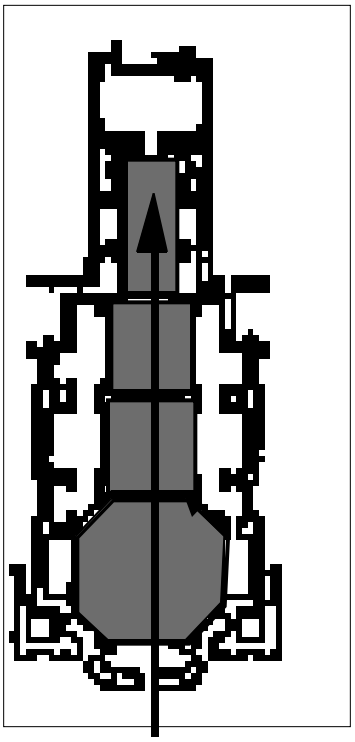
- **Einsiedeln Abbey**
- **(Kaspar Moosbrugger)**

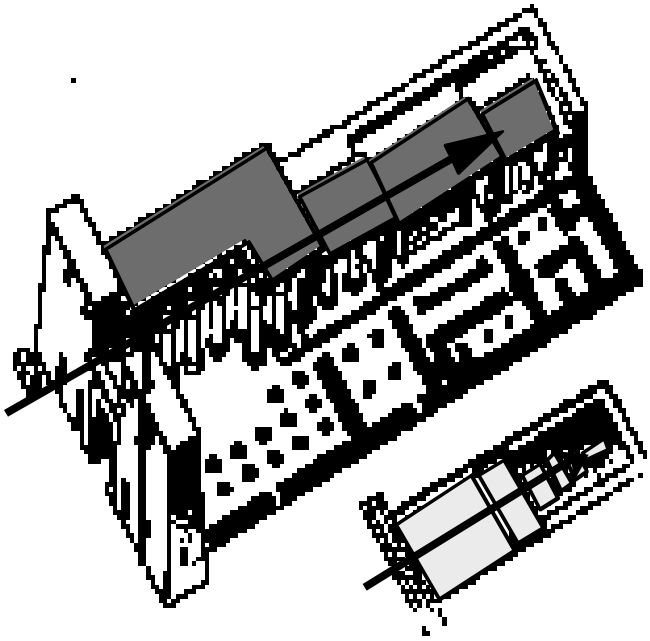




Temple of Thebes

Visual movement





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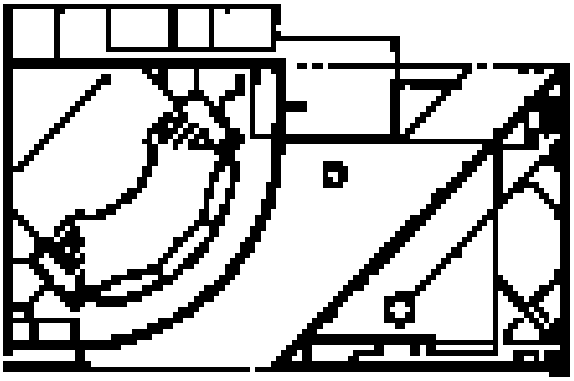
Visual balance



Paul Mellon Art Centre
(I. M. Pei)

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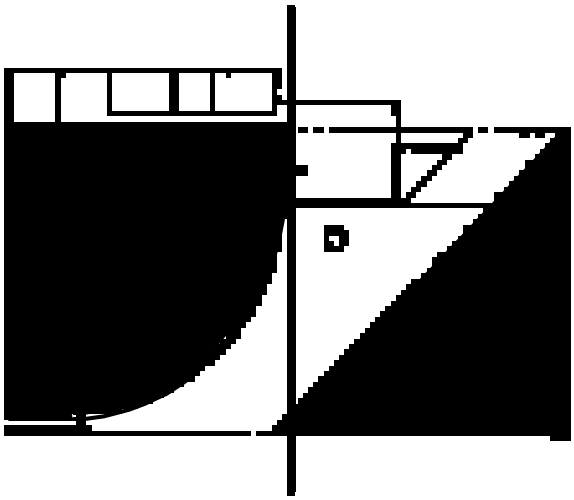
Visual balance



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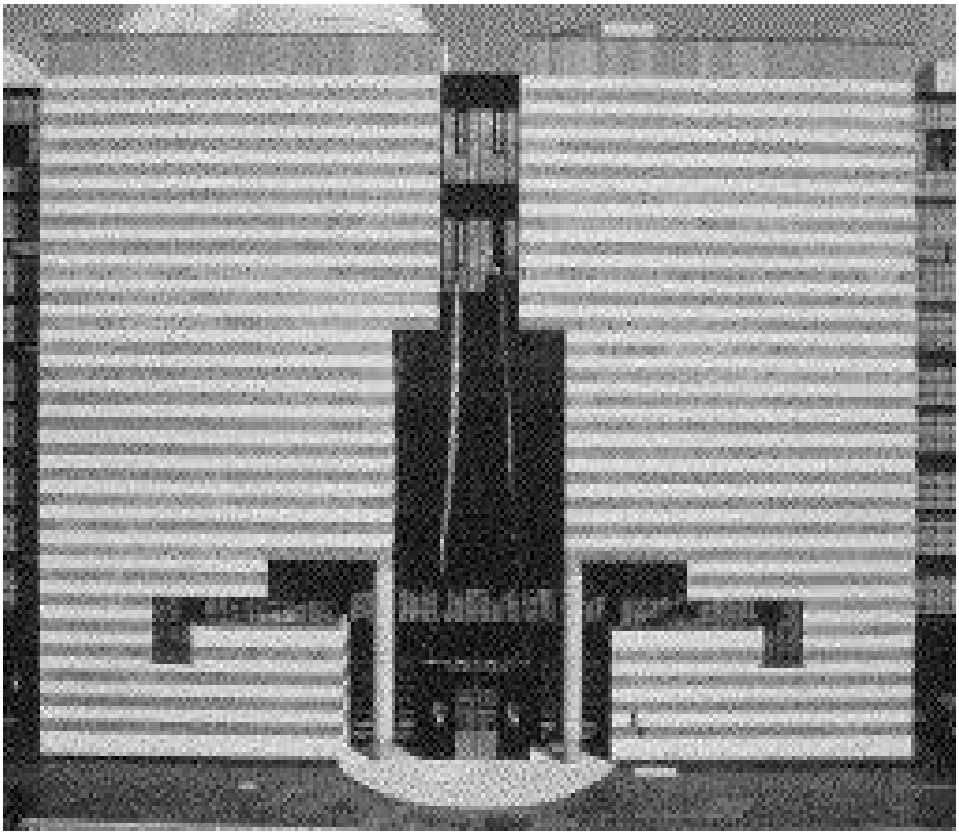
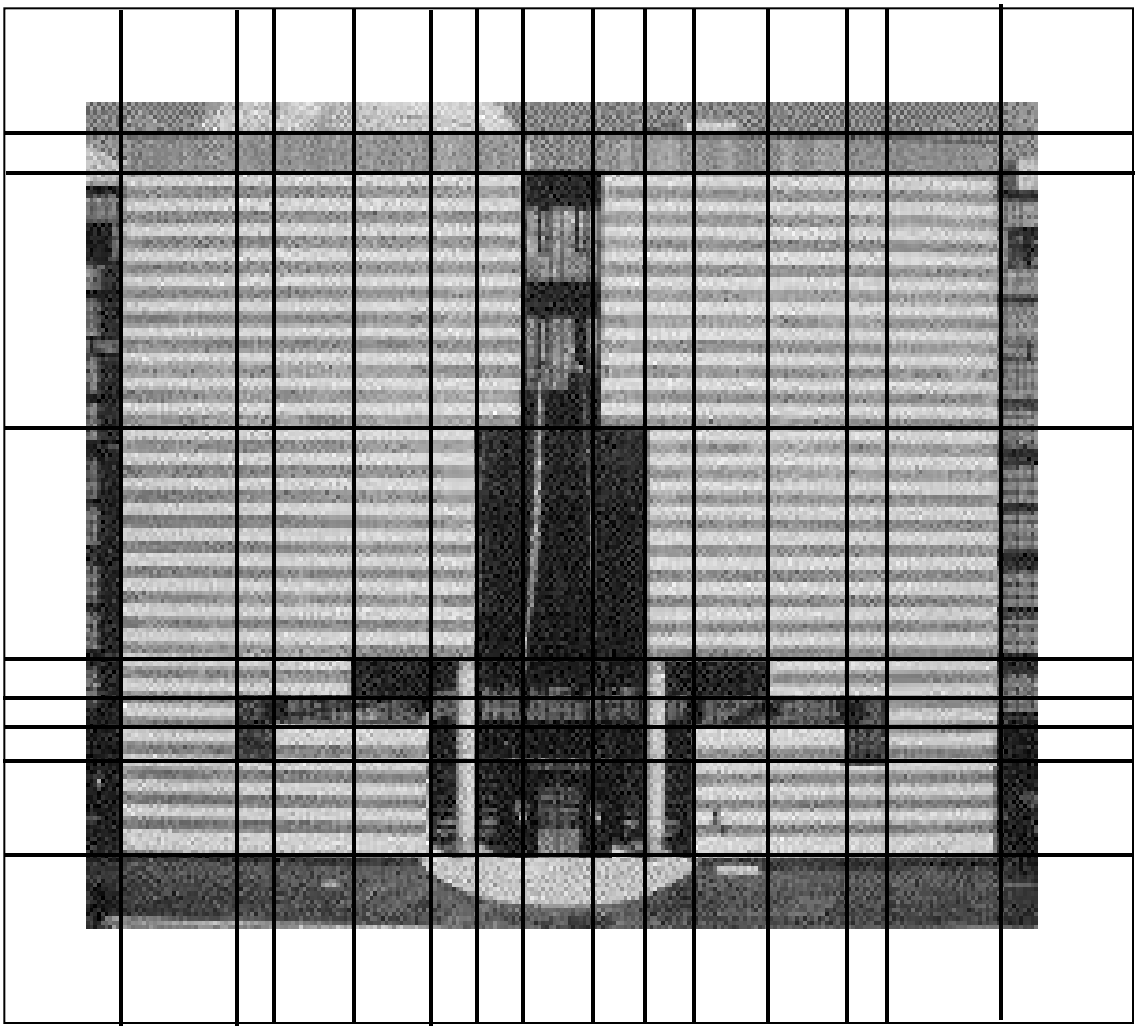
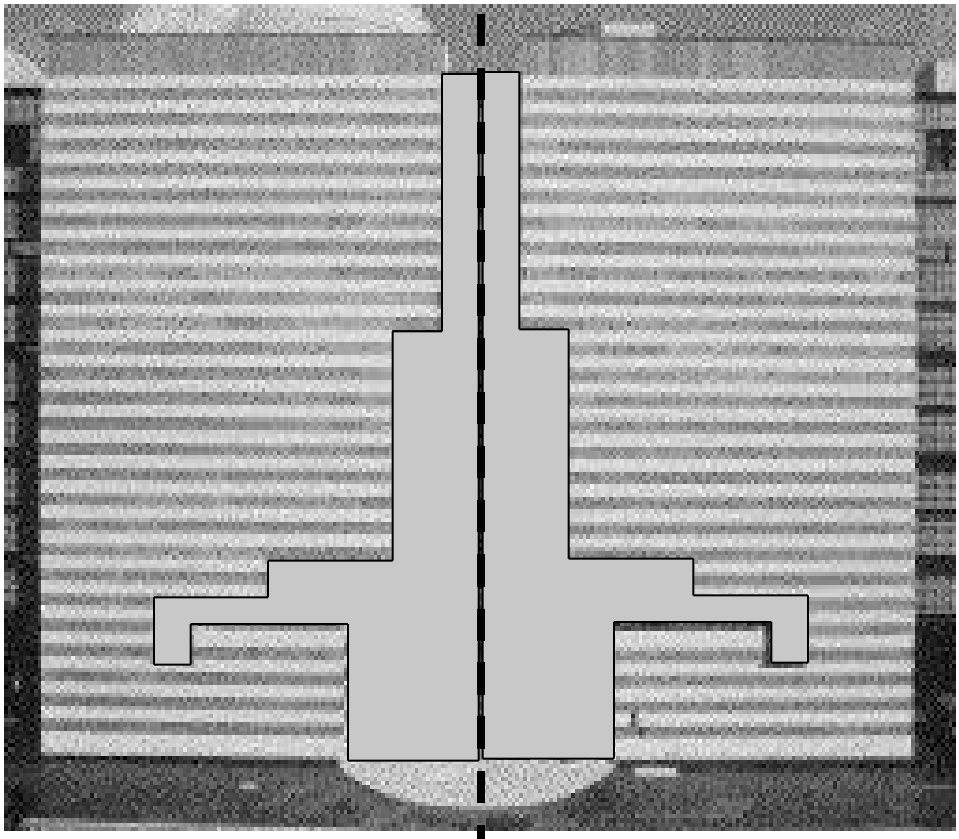


Mediatheque in Villeurbanne (Mario Bota)



QUT DESIGN KEY CENTRE



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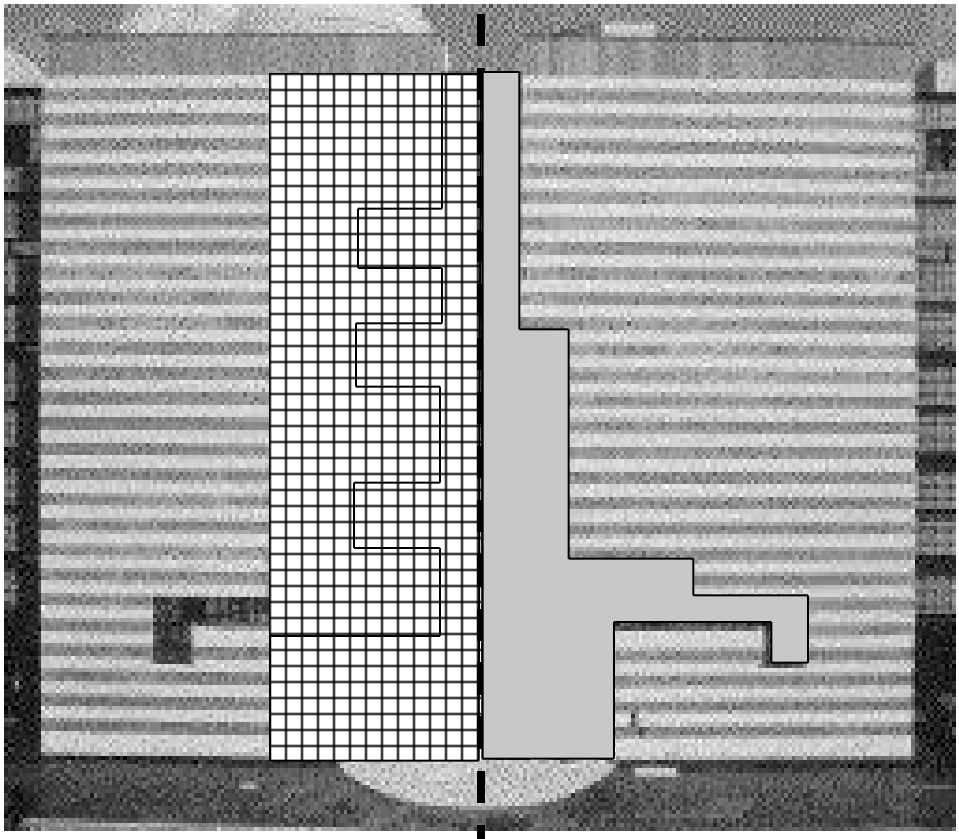
KEY CENTRE



DESIGN
KEY CENTRE

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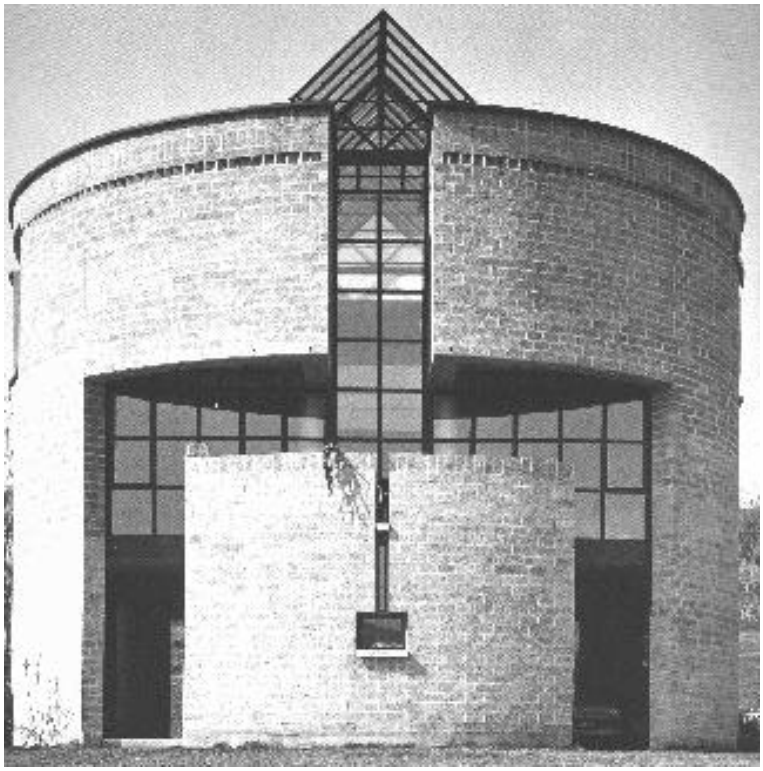

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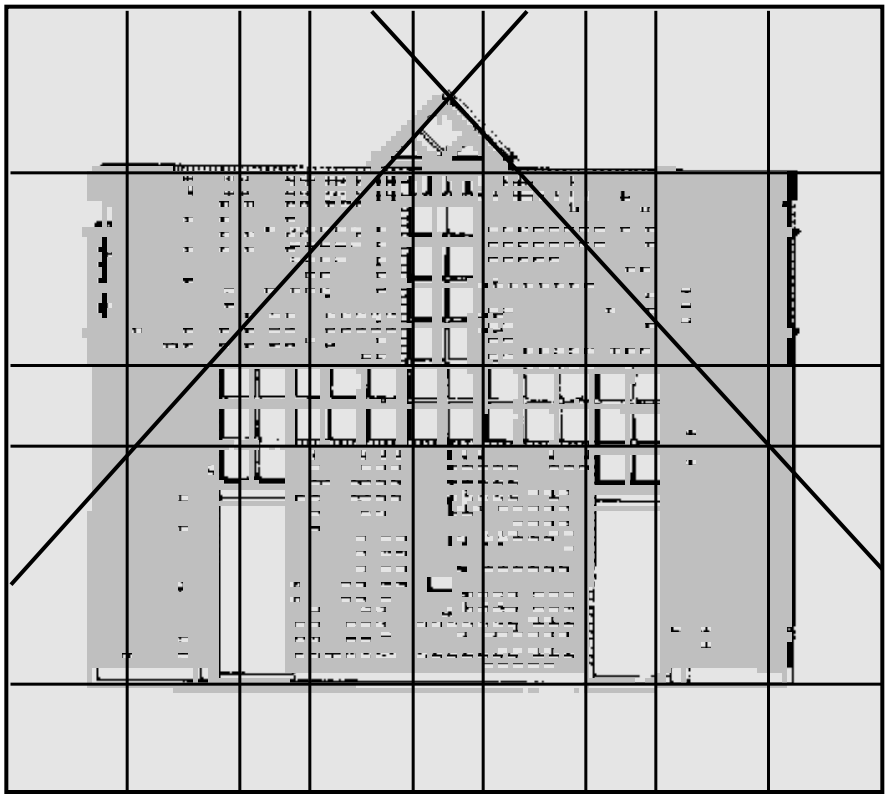

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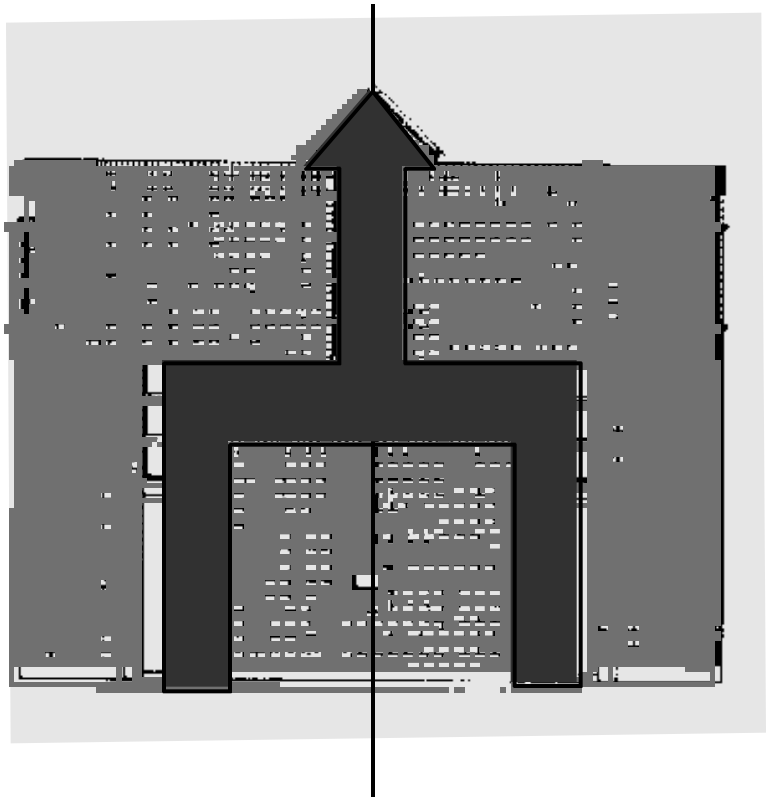

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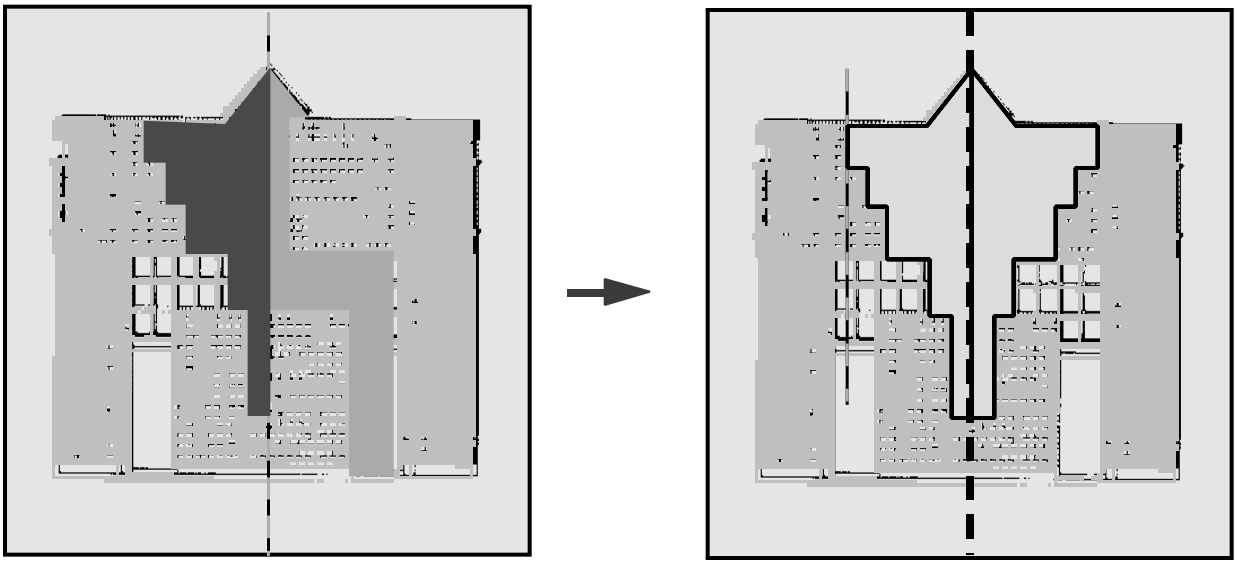
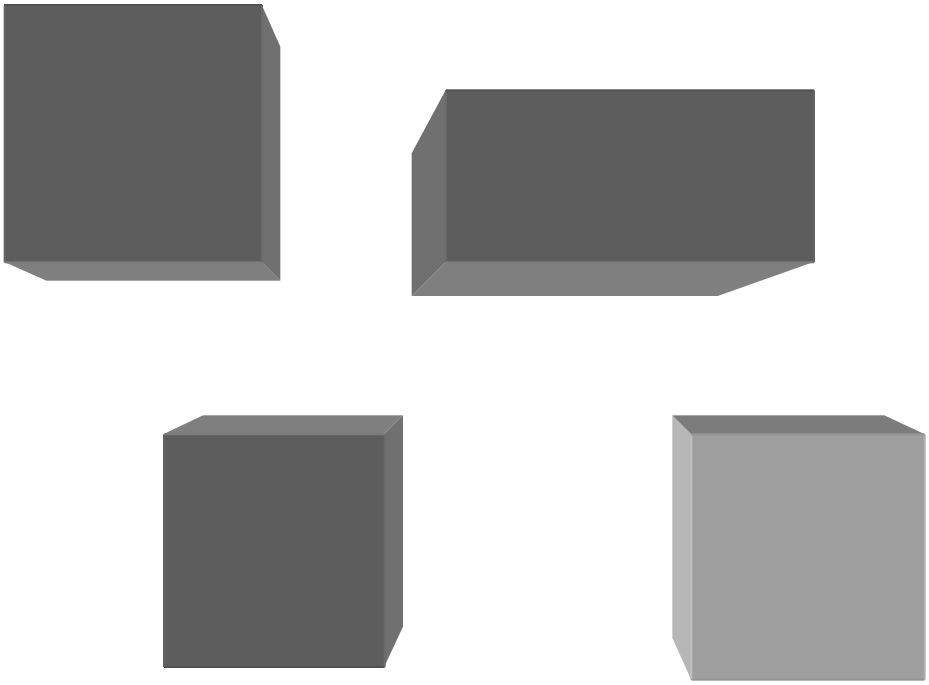
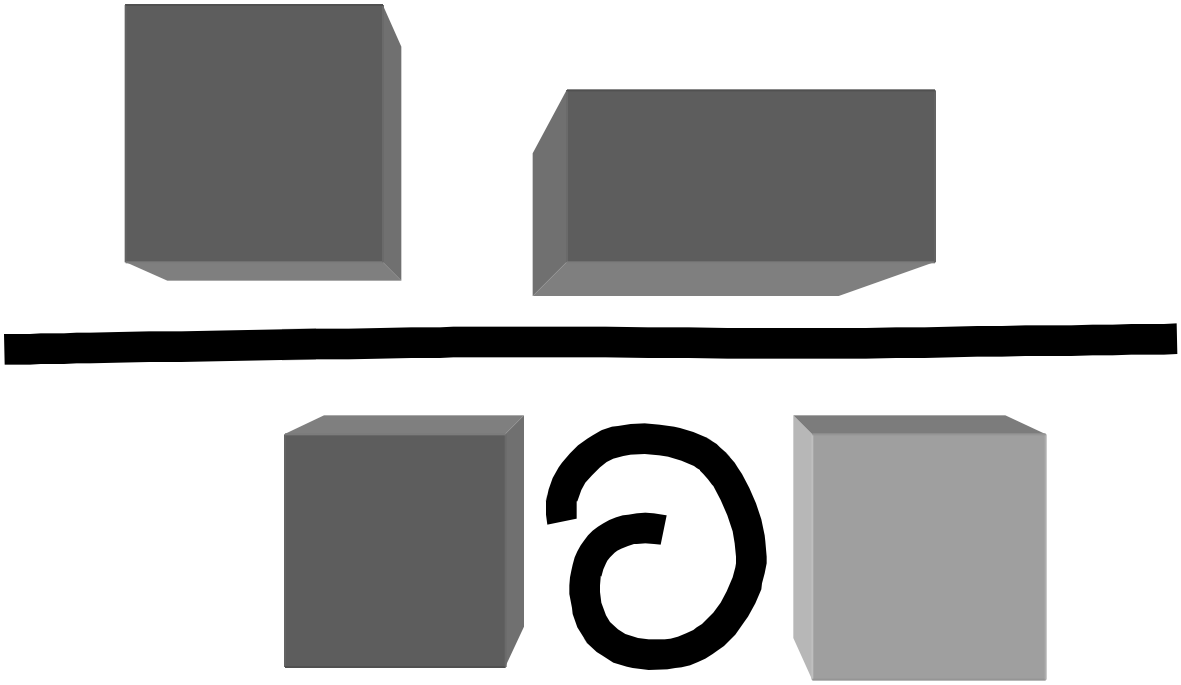




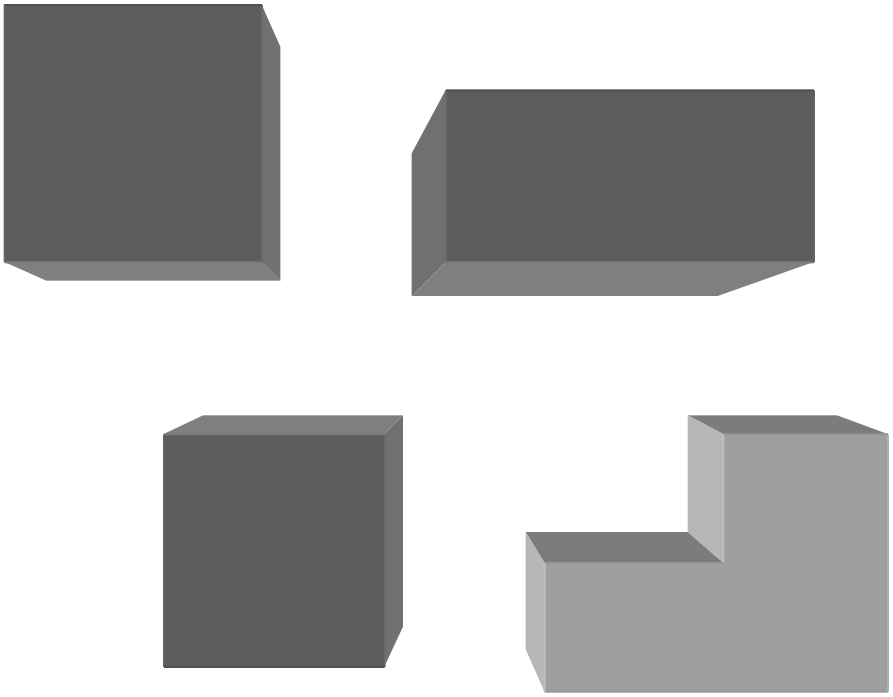
Provide space ← Area measure ← Shape



Provide space ← Area measure

Organize environment ← Compositional elements

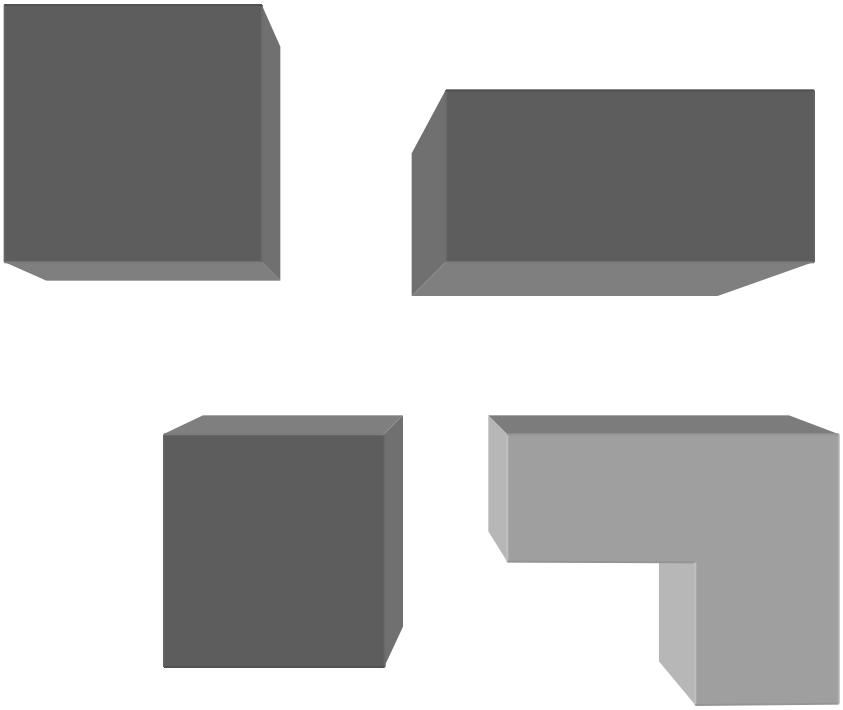
Area measure, Compositional elements → Shape



Provide space ← Area measure

Organize environment ← Compositional elements

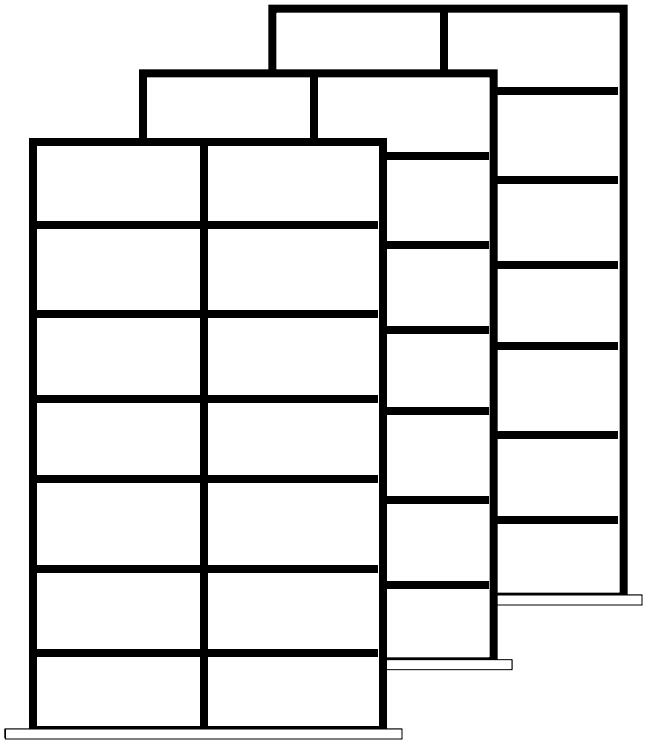
Area measure, Compositional elements → Shape



Provide space ← Area measure

Organize environment ← Compositional reinforcements

Shape



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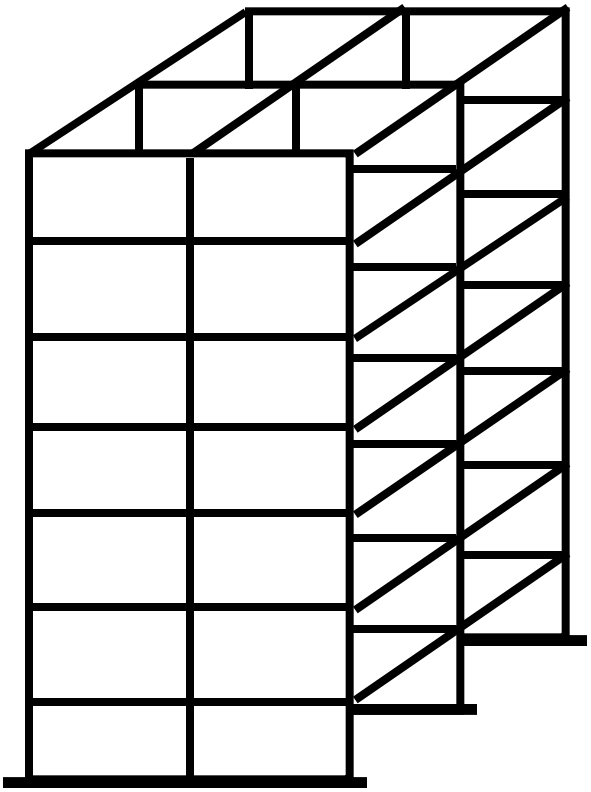

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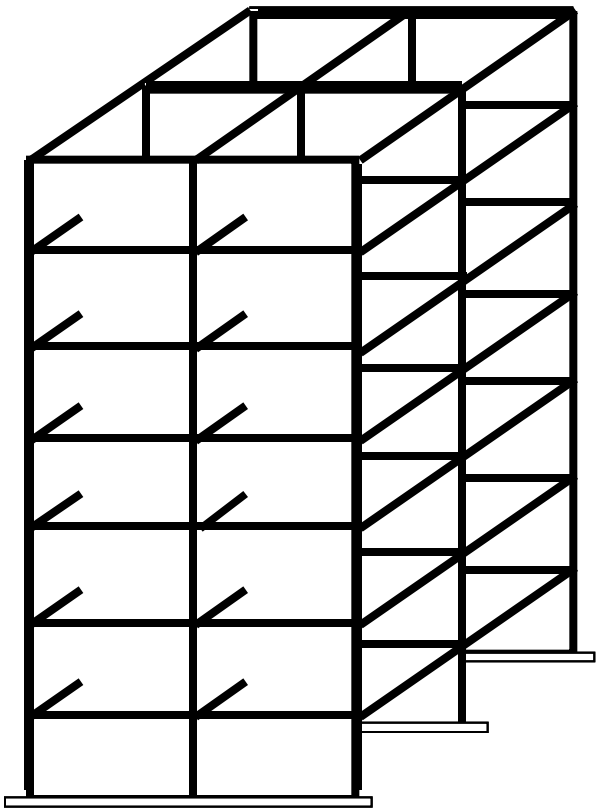

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