The Importance of A Good Representation

“You can’t learn what you can’t represent.”

--- G. Sussman

Properties of a good representation:

- Reveals important features
- Hides irrelevant detail
- Exposes useful constraints
- Makes frequent operations easy-to-do
- Supports local inferences from local features
  - Called the “soda straw” principle or “locality” principle
  - Inference from features “through a soda straw”
- Rapidly or efficiently computable
  - It’s nice to be fast

Reveals important features / Hides irrelevant detail

- **In search:**

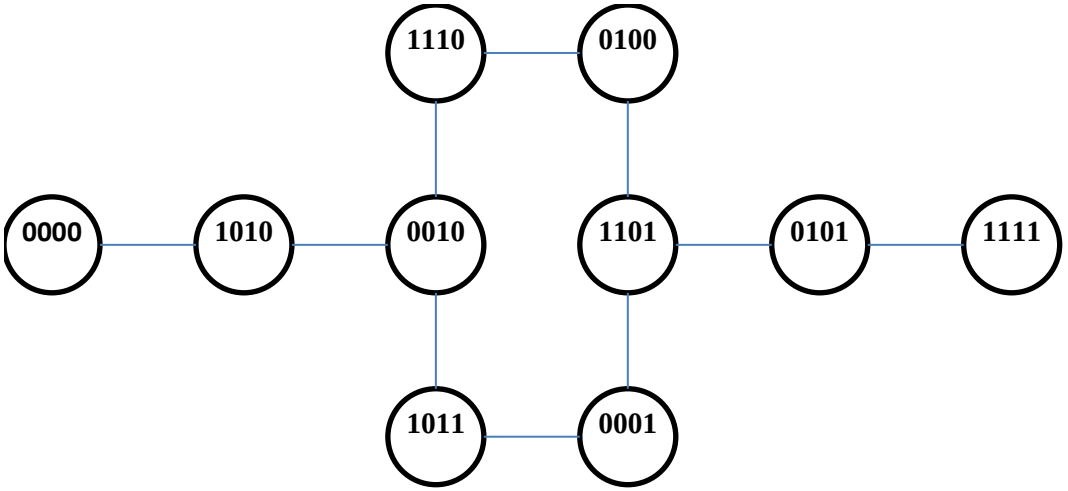
A man is traveling to market with a fox, a goose, and a bag of oats. He comes to a river. The only way across the river is a boat that can hold the man and exactly one of the fox, goose or bag of oats. The fox will eat the goose if left alone with it, and the goose will eat the oats if left alone with it.

How can the man get all his possessions safely across the river?

Reveals important features / Hides irrelevant detail

- **In search:** *A man is traveling to market with a fox, a goose, and a bag of oats. He comes to a river. The only way across the river is a boat that can hold the man and exactly one of the fox, goose or bag of oats. The fox will eat the goose if left alone with it, and the goose will eat the oats if left alone with it.*

  How can the man get all his possessions safely across the river?
- **A good representation makes this problem easy:**



MFGO

M = man
F = fox
G = goose
O = oats
0 = starting side
1 = ending side

Exposes useful constraints

- **In logic:**

If the unicorn is mythical, then it is immortal, but if it is not mythical, then it is a mortal mammal. If the unicorn is either immortal or a mammal, then it is horned. The unicorn is magical if it is horned.

Prove that the unicorn is both magical and horned.

Exposes useful constraints

- **In logic:** *If the unicorn is mythical, then it is immortal, but if it is not mythical, then it is a mortal mammal. If the unicorn is either immortal or a mammal, then it is horned. The unicorn is magical if it is horned.*

  Prove that the unicorn is both magical and horned.

- **A good representation makes this problem easy (as we'll see when we do our unit on logic):**

$$(\neg Y \vee \neg R) \wedge (Y \vee R) \wedge (Y \vee M) \wedge (R \vee H) \wedge (\neg M \vee H) \wedge (\neg H \vee G)$$

Makes frequent operations easy-to-do

- **Roman numerals**
  - M=1000, D=500, C=100, L=50, X=10, V=5, I=1
  - 2000 = MM; 1776 = MDCCLXXVI

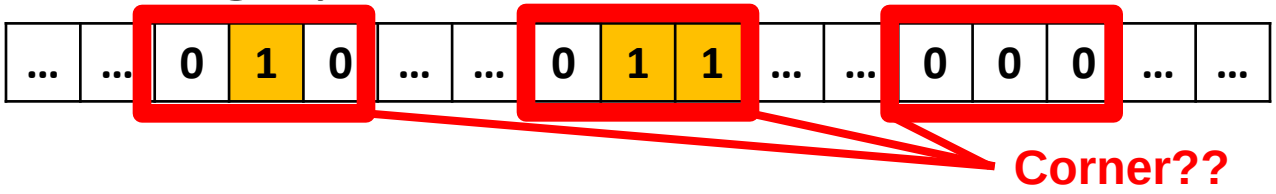
- Long division is **very tedious** (try MDCCLXXVI / XVI)
- Testing for N < 1000 is very easy (first letter is not “M”)

- **Arabic numerals**
  - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, “.”

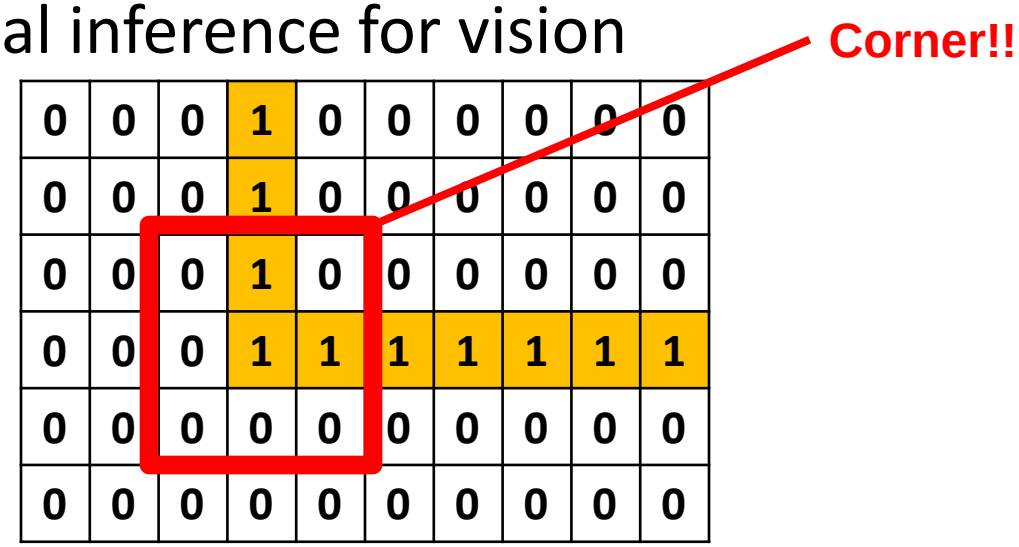
- Long division is **much easier** (try 1776 / 16)
- Testing for N < 1000 is slightly harder (have to scan the string)

Local inferences from local features

- Linear vector of pixels
  = highly non-local inference for vision



- Rectangular array of pixels
  = local inference for vision



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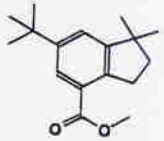

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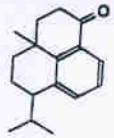

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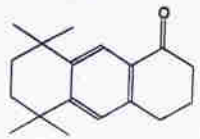

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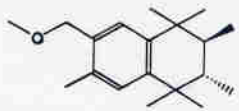

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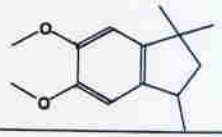

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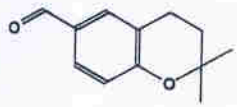

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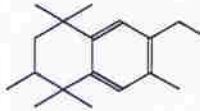

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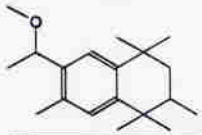

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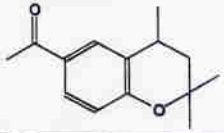

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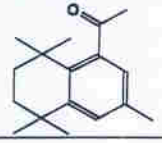

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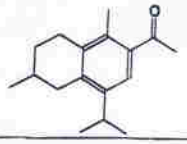

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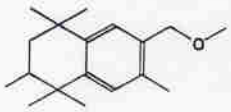

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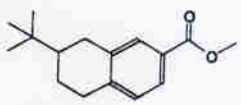

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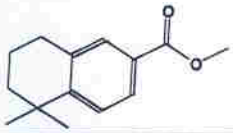

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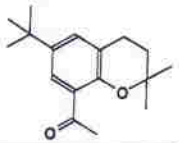

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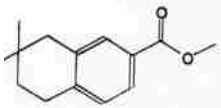

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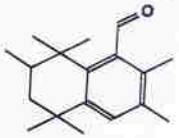

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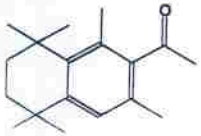

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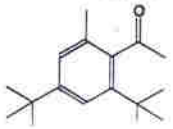

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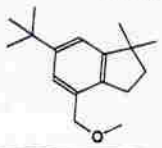

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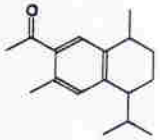

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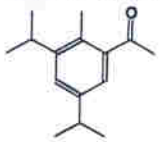

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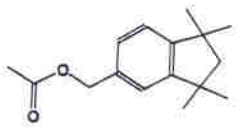

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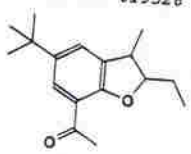

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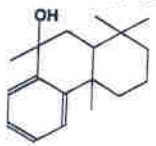

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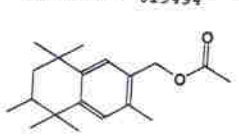
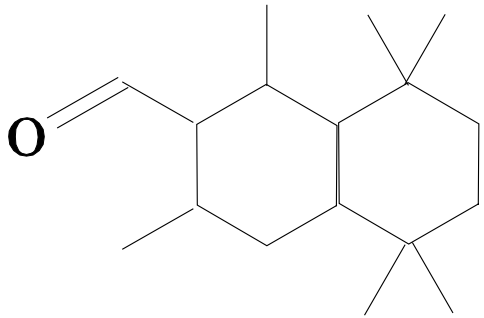
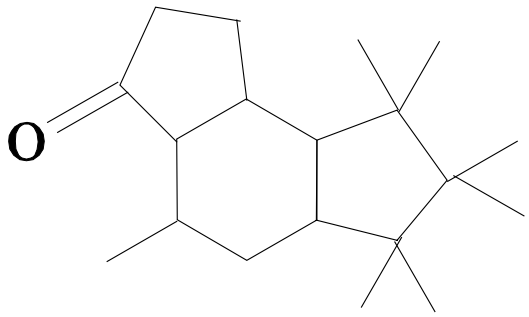
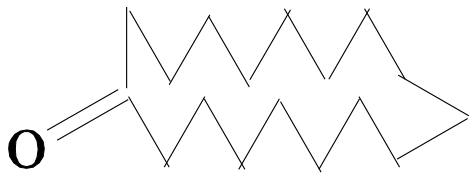
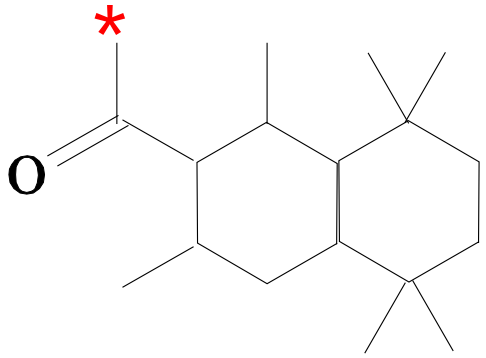


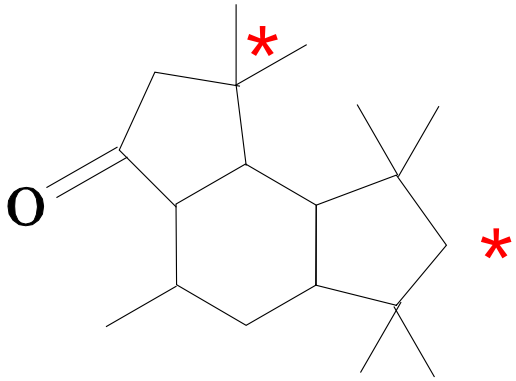
Positive Examples | Negative Examples



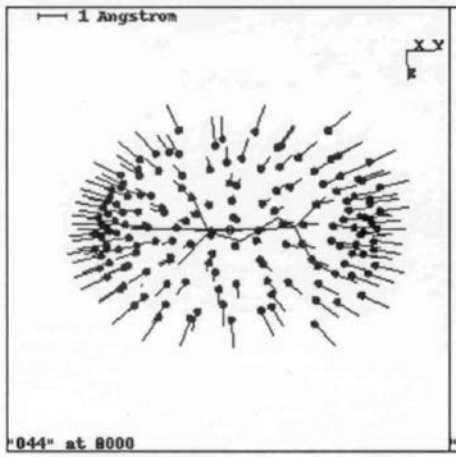


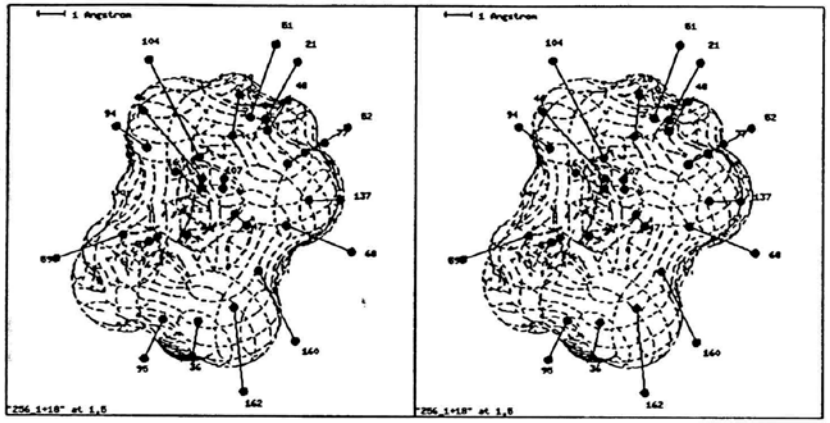


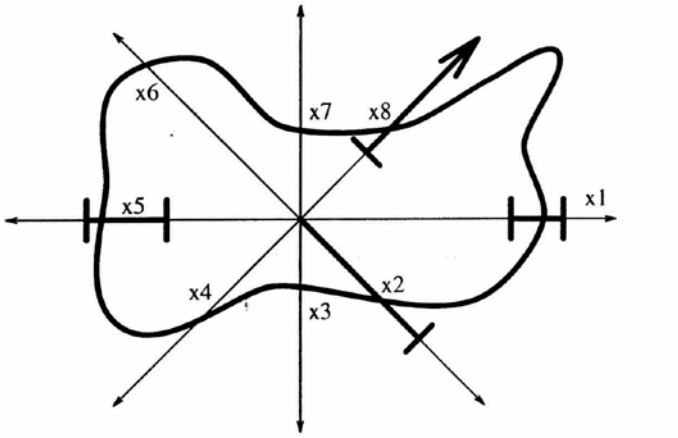


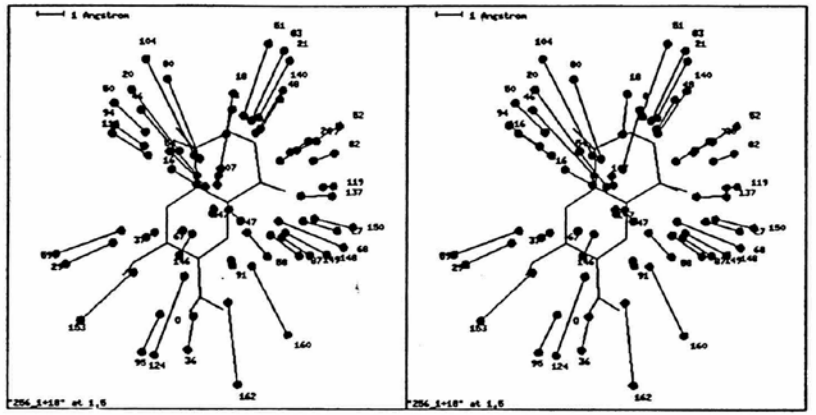


Digital 3D Shape Representation

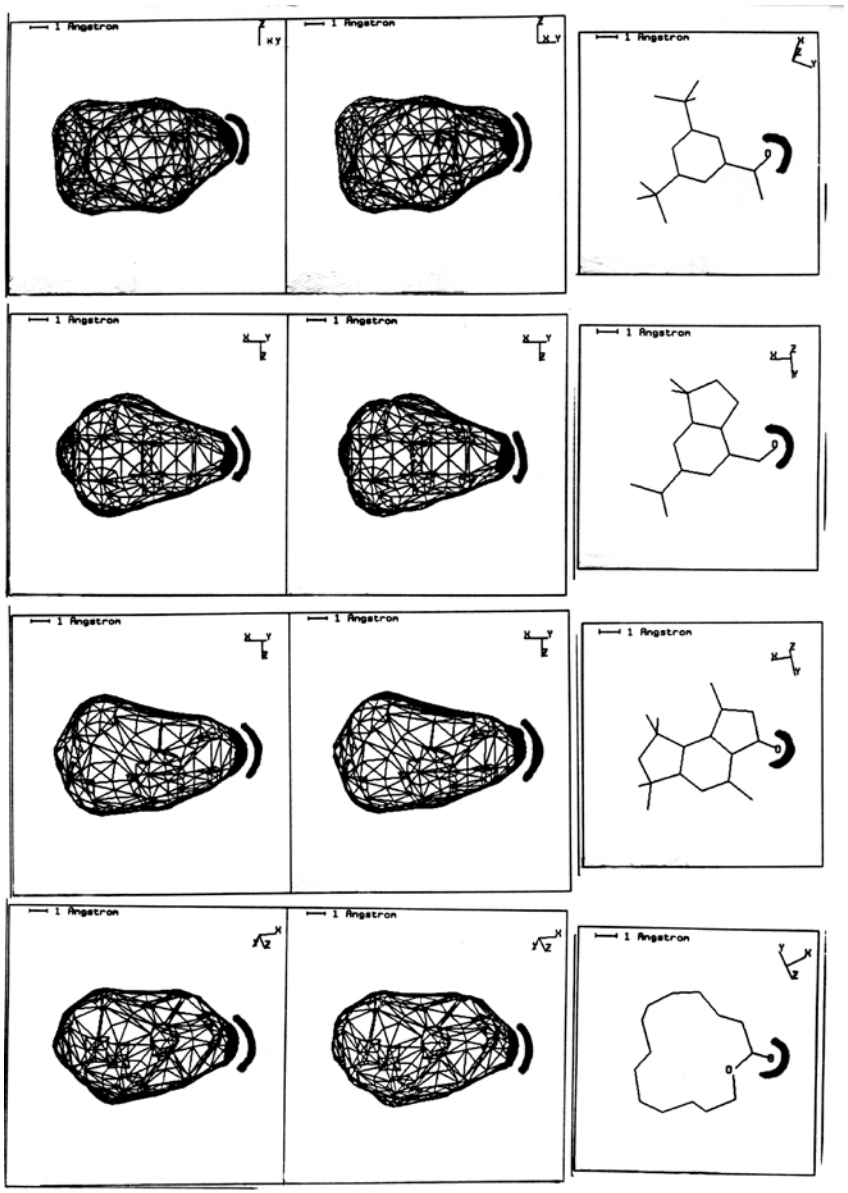




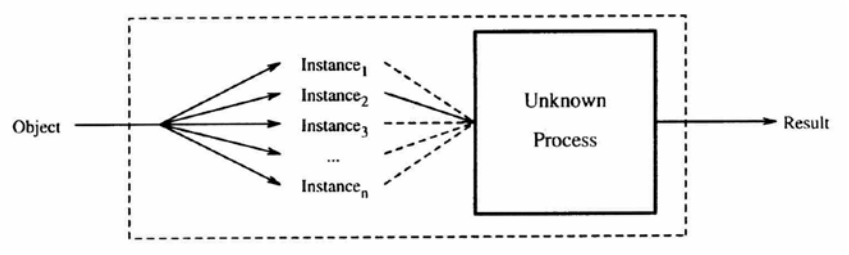


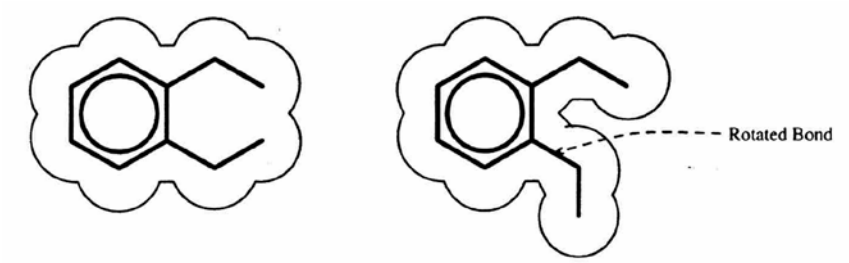


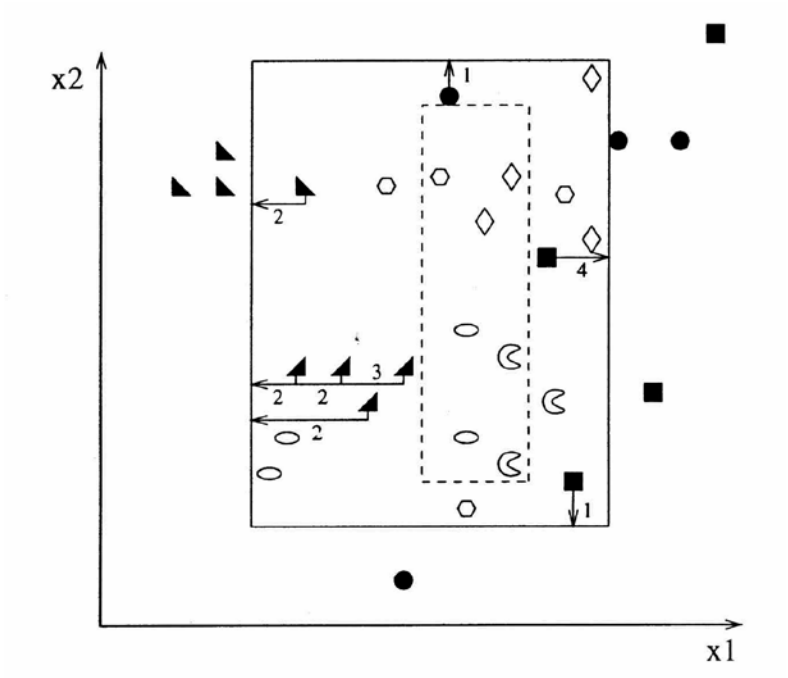
The Power of a Good Representation



Learning the “Multiple Instance” Problem







“Solving the multiple instance problem with axis-parallel rectangles”

Dietterich, Lathrop, Lozano-Perez, Artificial Intelligence 89(1997) 31-71

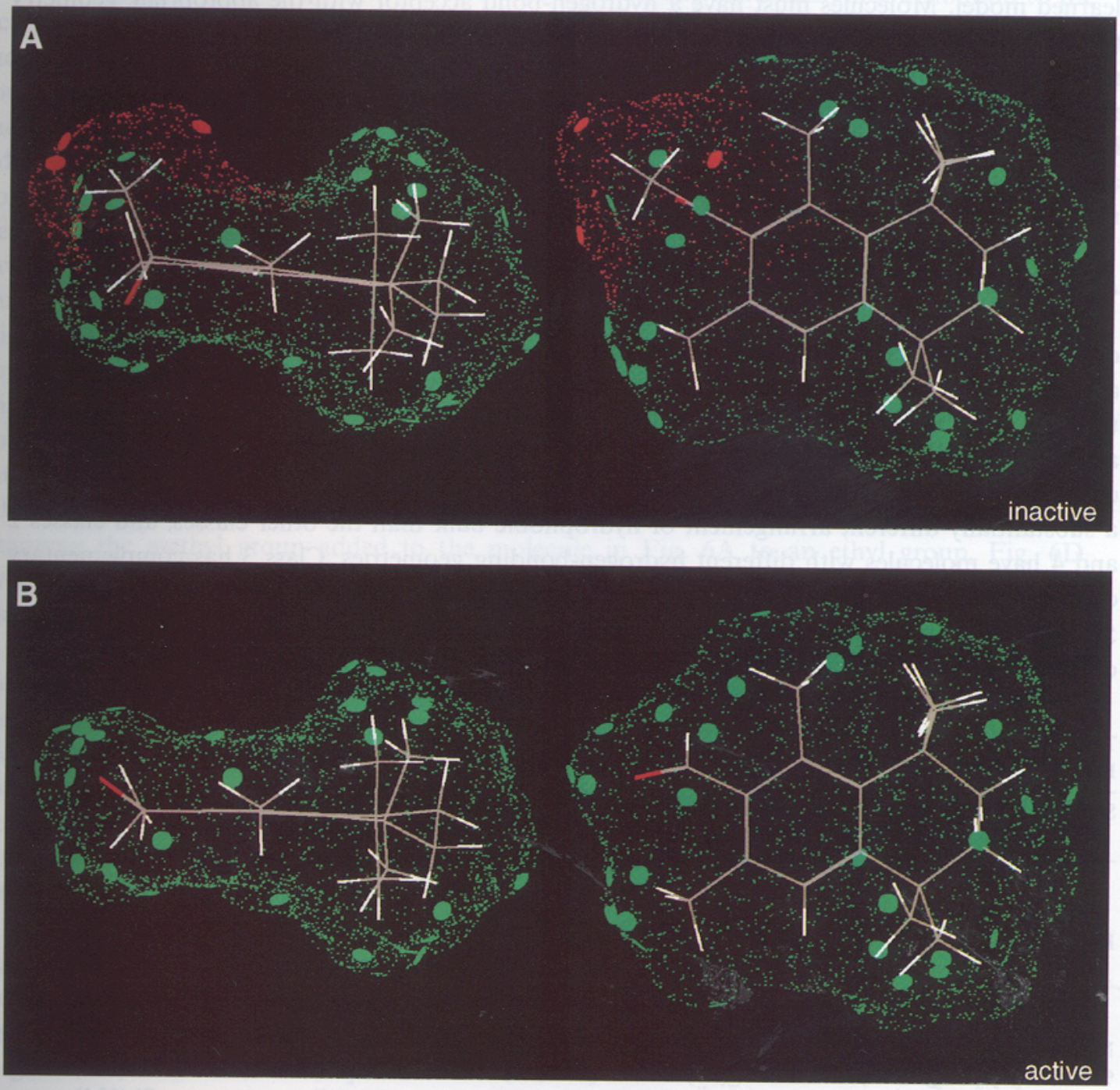


Fig. 7. Remediation of unfavorable steric interaction. (A) Non-zwuk with

"Compass: A shape-based machine learning tool for drug design," Jain, Dietterich, Lathrop, Chapman, Critchlow, Bauer, Webster, Lozano-Perez,

J. Of Computer-Aided Molecular Design, 8(1994) 635-652