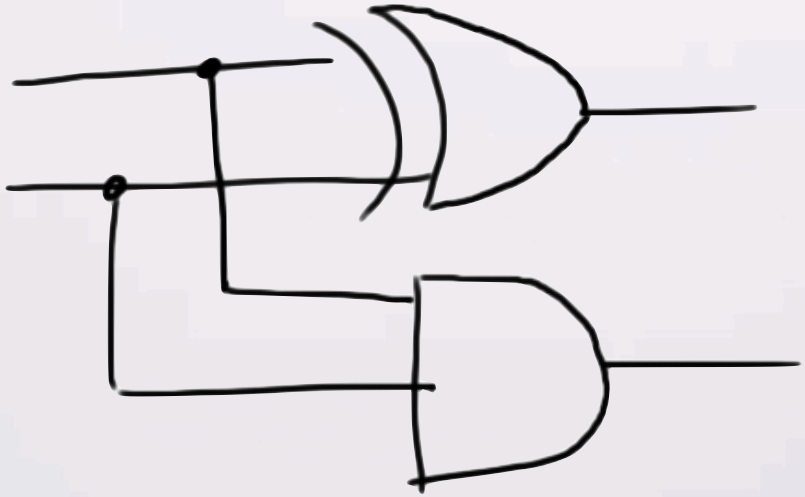
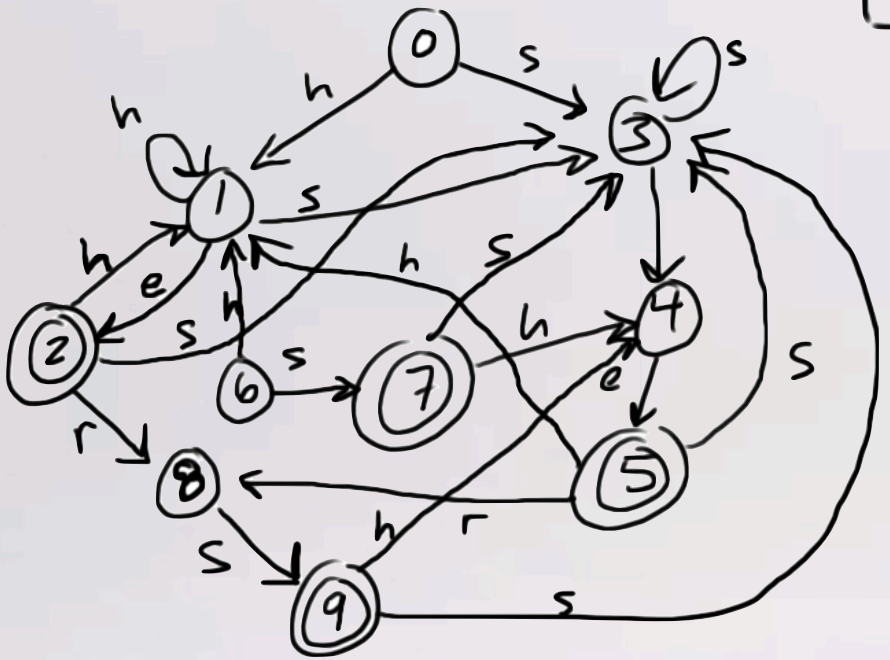
Whiteboards that Compute:

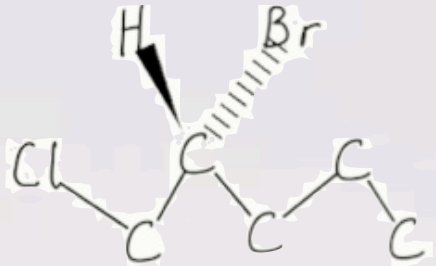
Goals and Challenges for System Designers

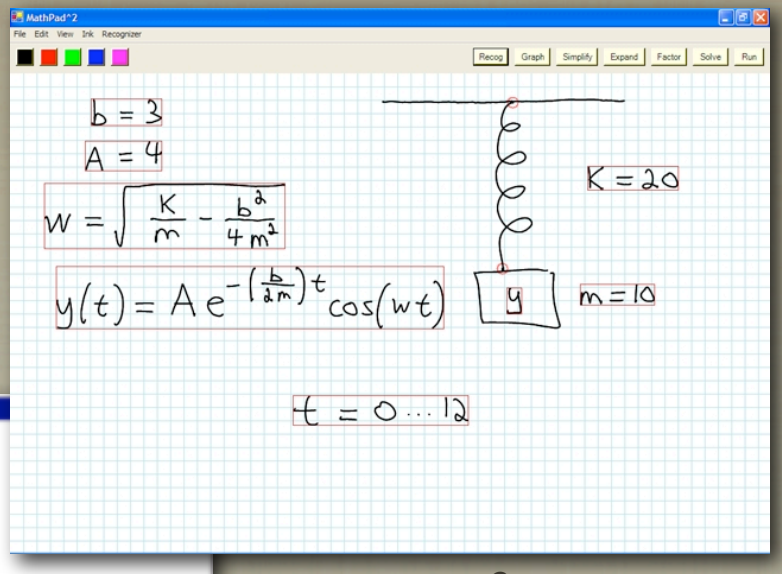
Ryan Dixon & Timothy Sherwood
UC Santa Barbara

$$y = mx + b$$

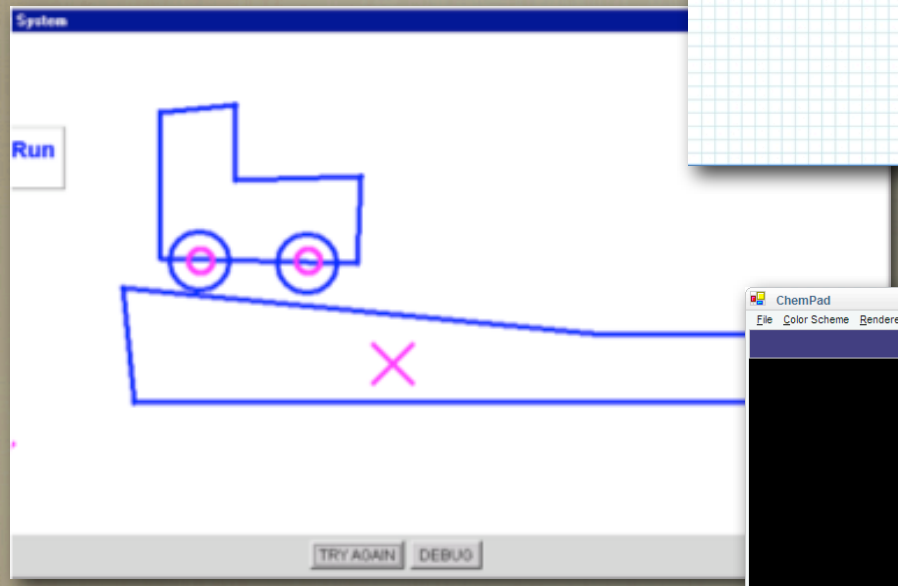




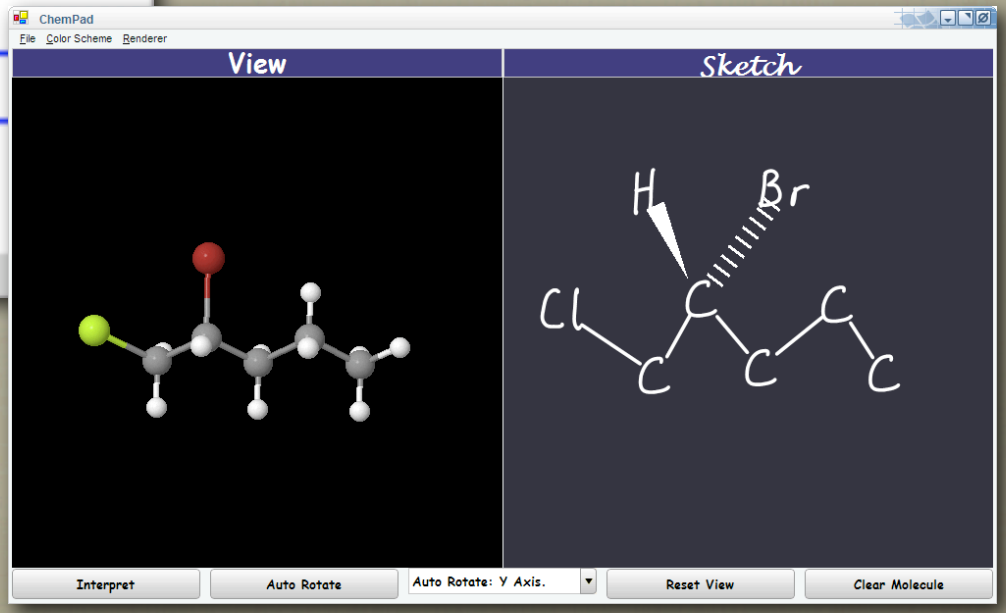




MathPad²

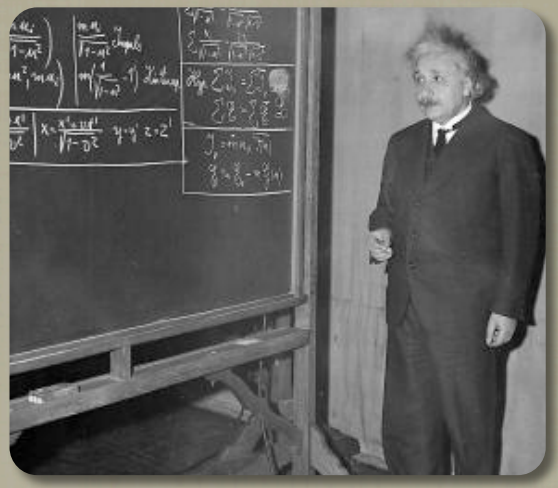


ASSIST



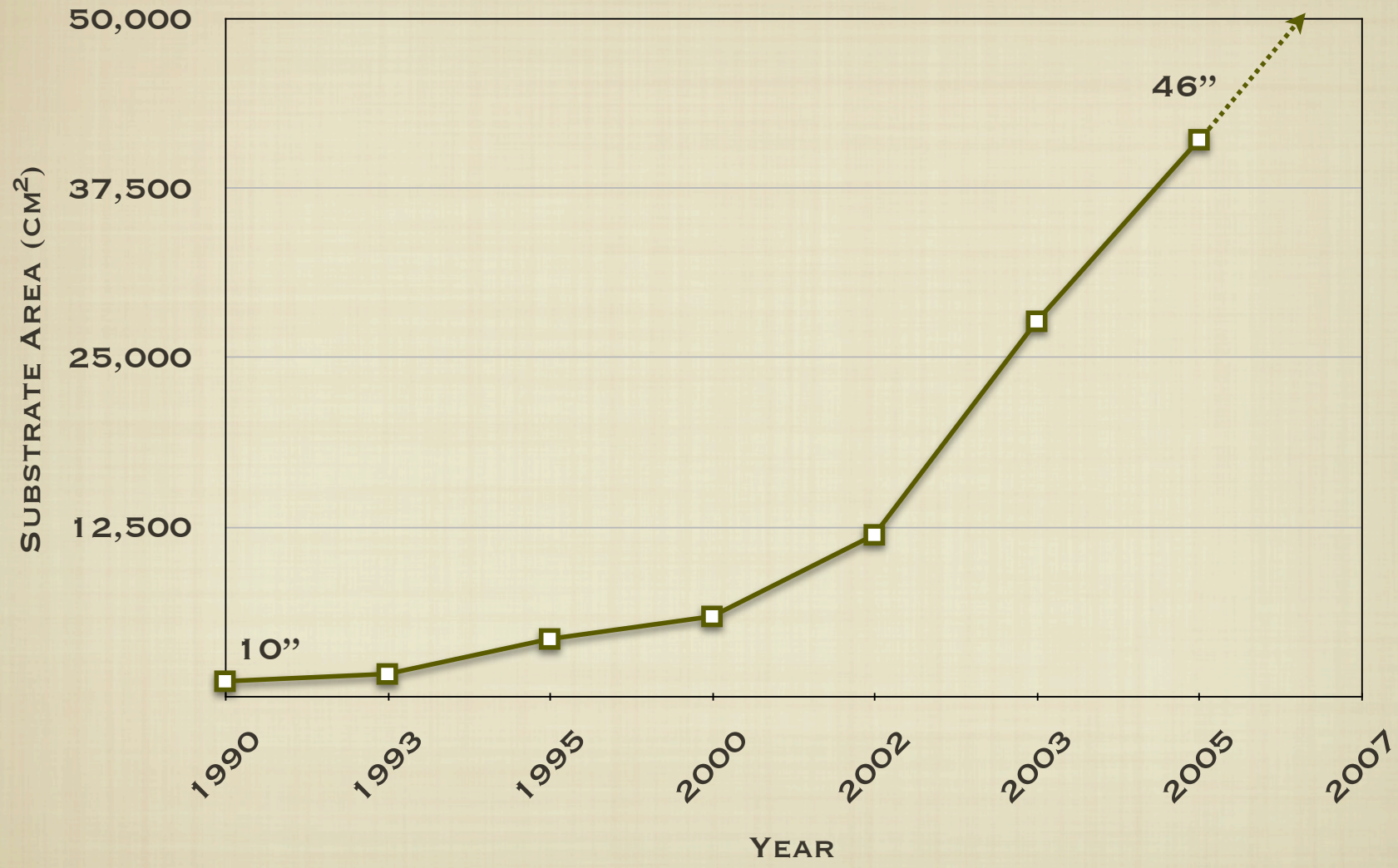
ChemPad

50,000 YEARS AGO



50 YEARS AGO

Flat Panel Display Growth



Applied Materials **AKT Large Area PECVD Capability**

Projecting Flat Panel Display Growth

Today

Systems Challenges

- General purpose recognition framework
- Programming language-level support
- Efficient hypothesize-model-measure loop[1]
- Board management

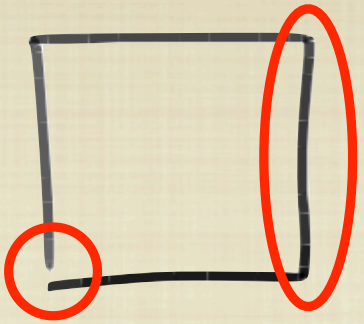
1. Alvarado **Dynamically constructed bayes nets**

Why is This Hard?

- Handwritten input is noisy[1]
- Even when input is perfect, we still face a combinatorial problem[2]
- a single drawing can be interpreted differently as more domains are considered[3]

1 Mahoney Three main concerns in sketch recognition
2 Alvarado A Framework for multi-domain sketch recognition
3 gross Ambiguous Intentions: A Paper-like Interface for creative design

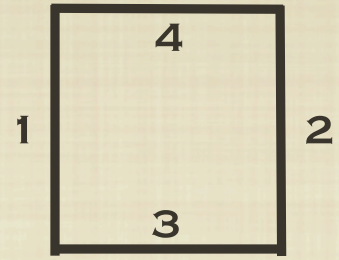
Why is This Hard?



- Handwritten input is noisy[1]
- Even when input is perfect, we still face a combinatorial problem[2]
- a single drawing can be interpreted differently as more domains are considered[3]

1 Mahoney Three main concerns in sketch recognition
2 Alvarado A Framework for multi-domain sketch recognition
3 Gross Ambiguous Intentions: A Paper-like Interface for creative design

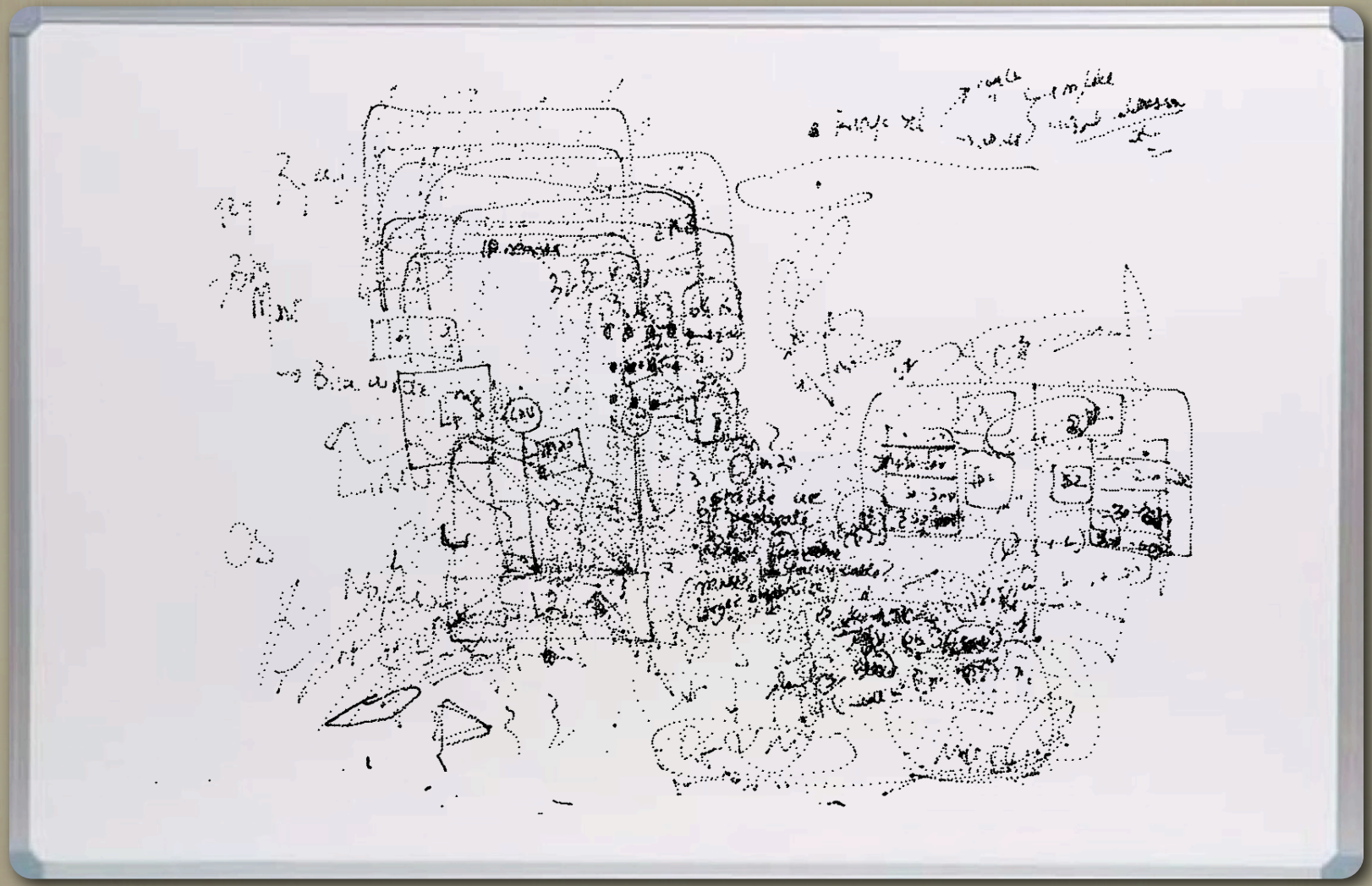
Why is This Hard?



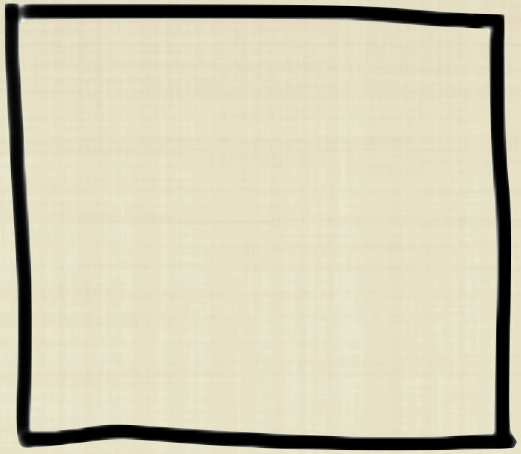
- Handwritten input is noisy[1]
- Even when input is perfect, we still face a combinatorial problem[2]
- a single drawing can be interpreted differently as more domains are considered[3]

1 Mahoney Three main concerns in sketch recognition
2 Alvarado A Framework for multi-domain sketch recognition
3 Gross Ambiguous Intentions: A Paper-like Interface for creative design

The Challenge



Ideal Recognition



User Drawing

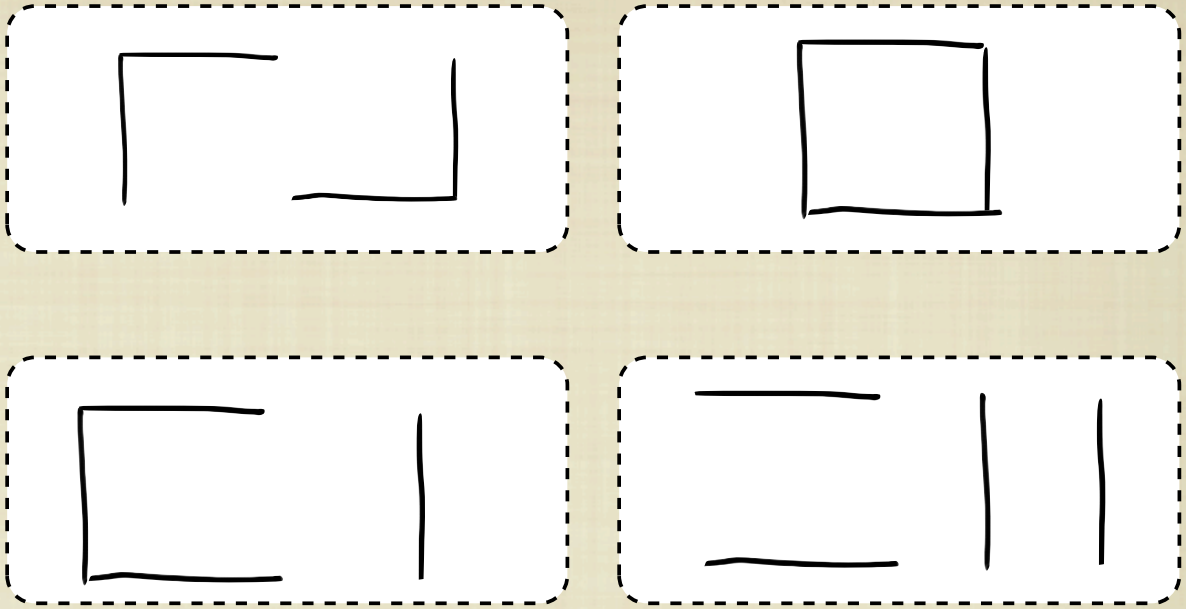
Potential Groupings

Potential model matches

Conclusions

Final Output

Ideal Recognition



User Drawing

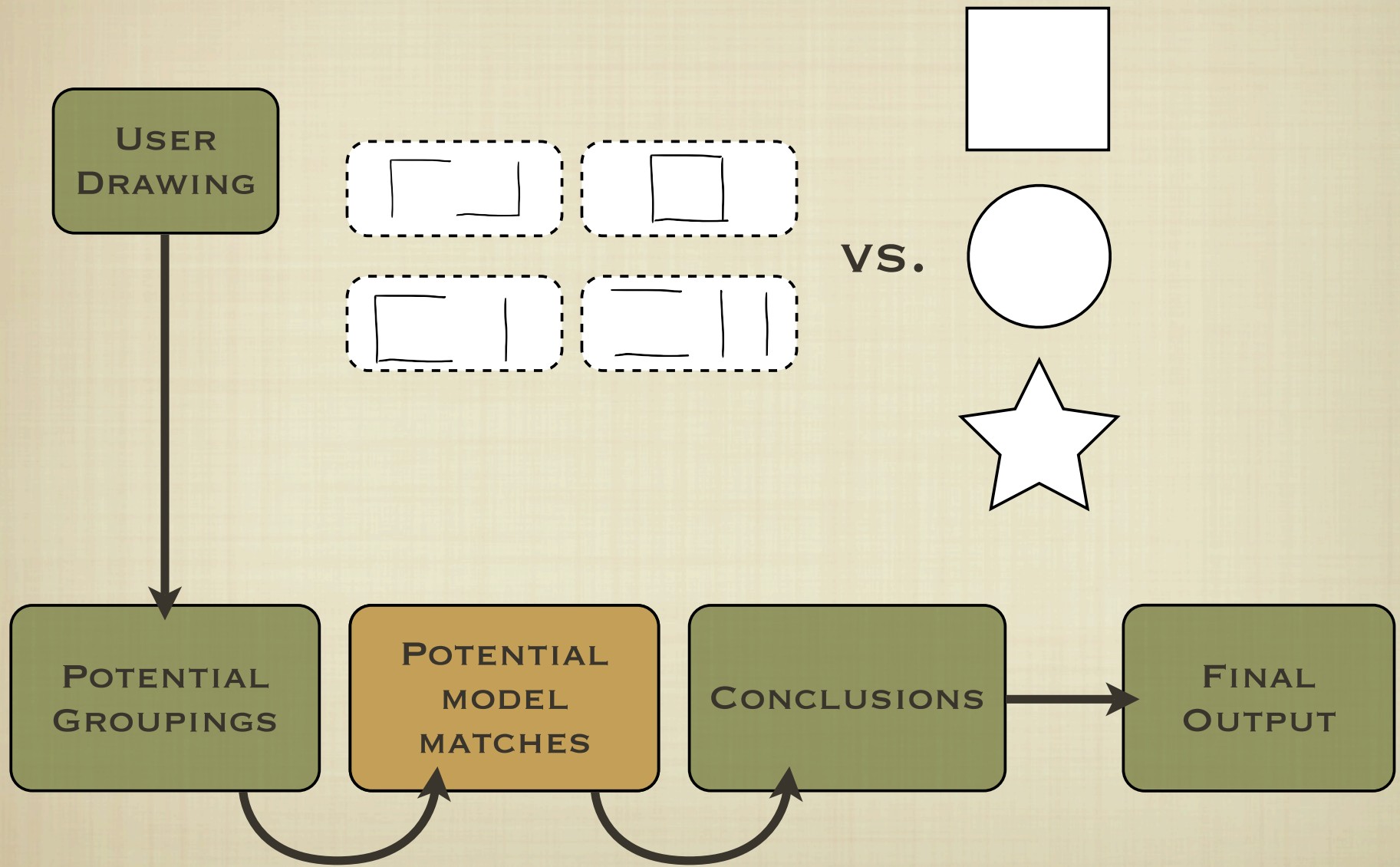
Potential Groupings

Potential model matches

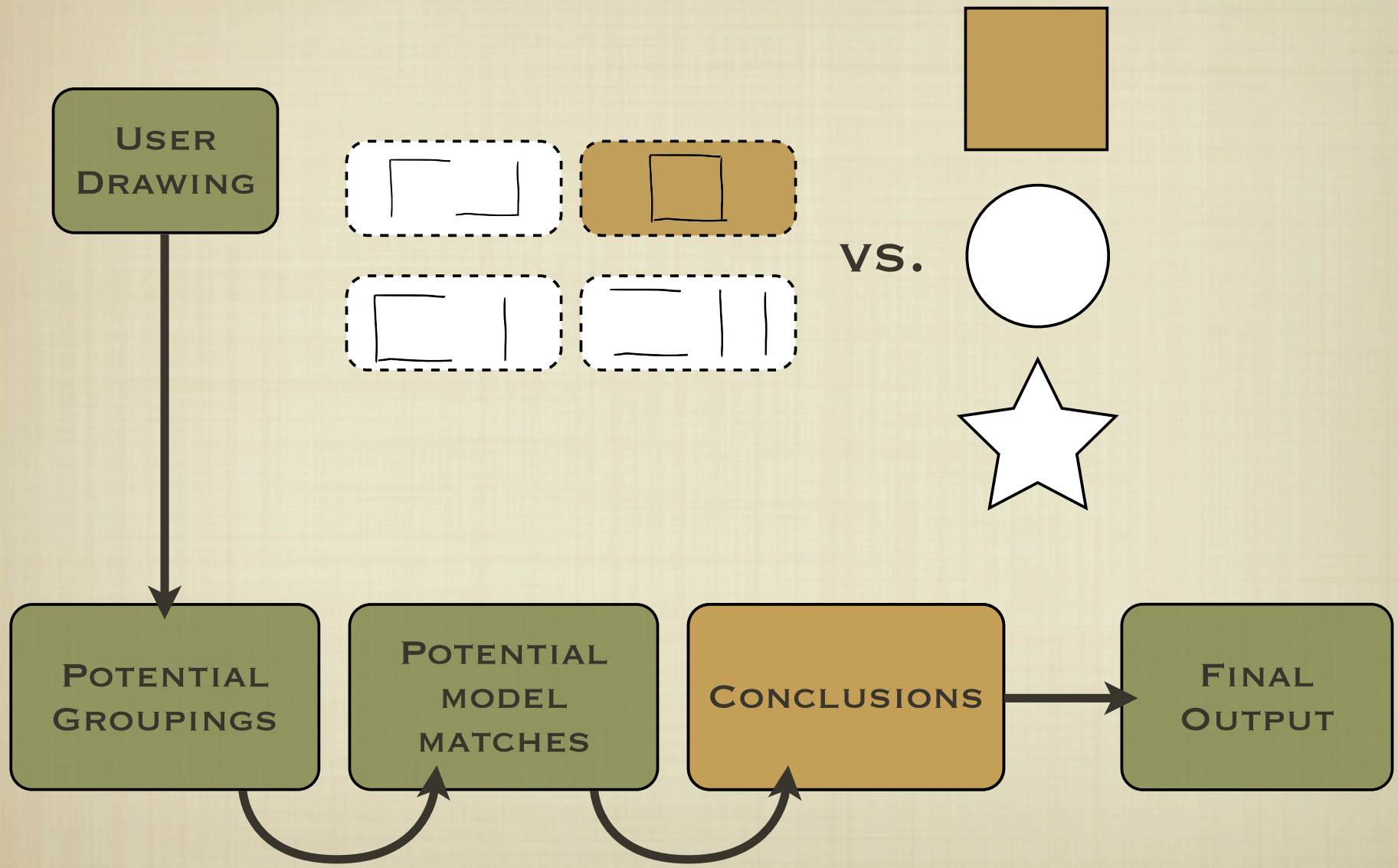
Conclusions

Final Output

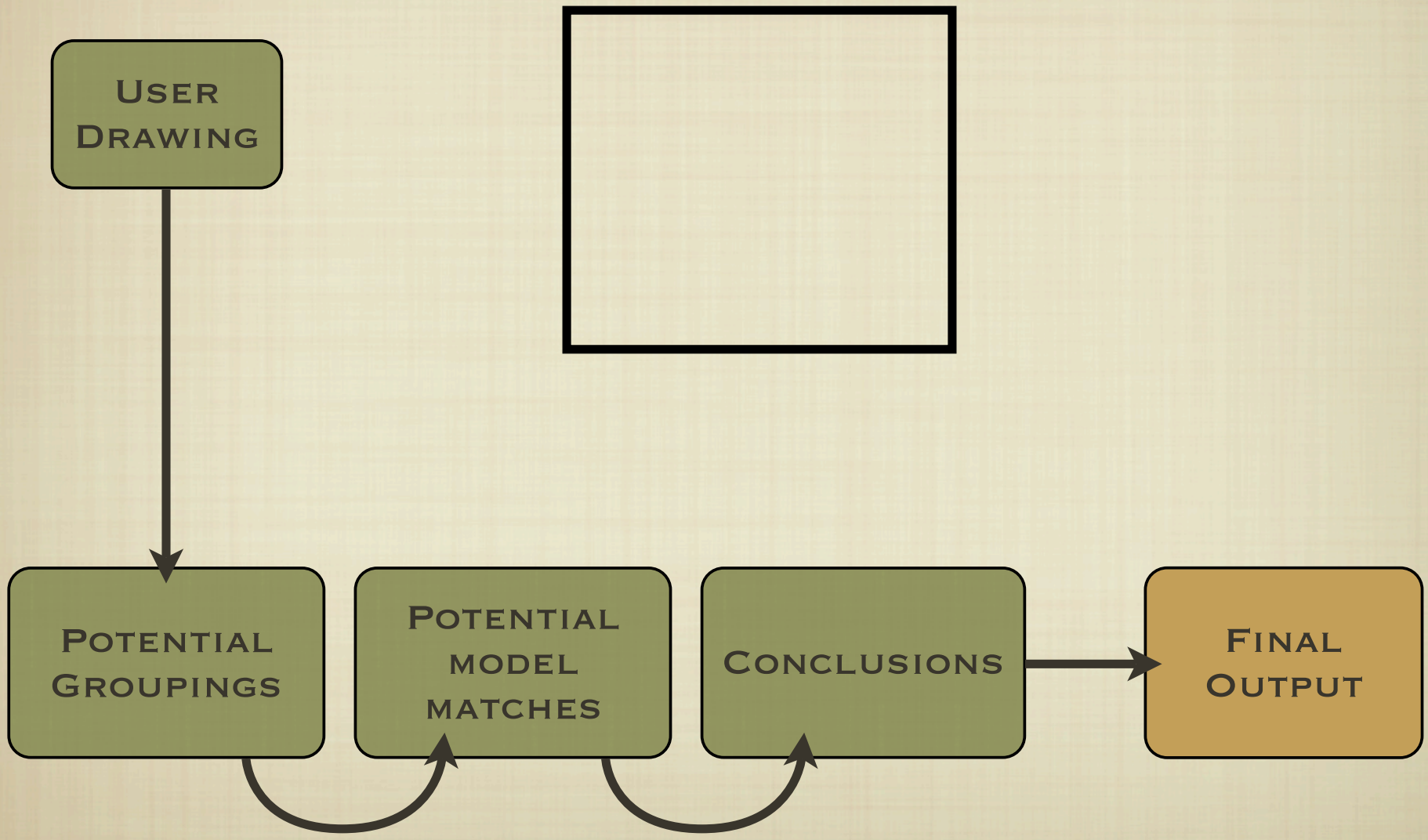
Ideal Recognition



Ideal Recognition



Ideal Recognition



Recognition Loop

User Drawing

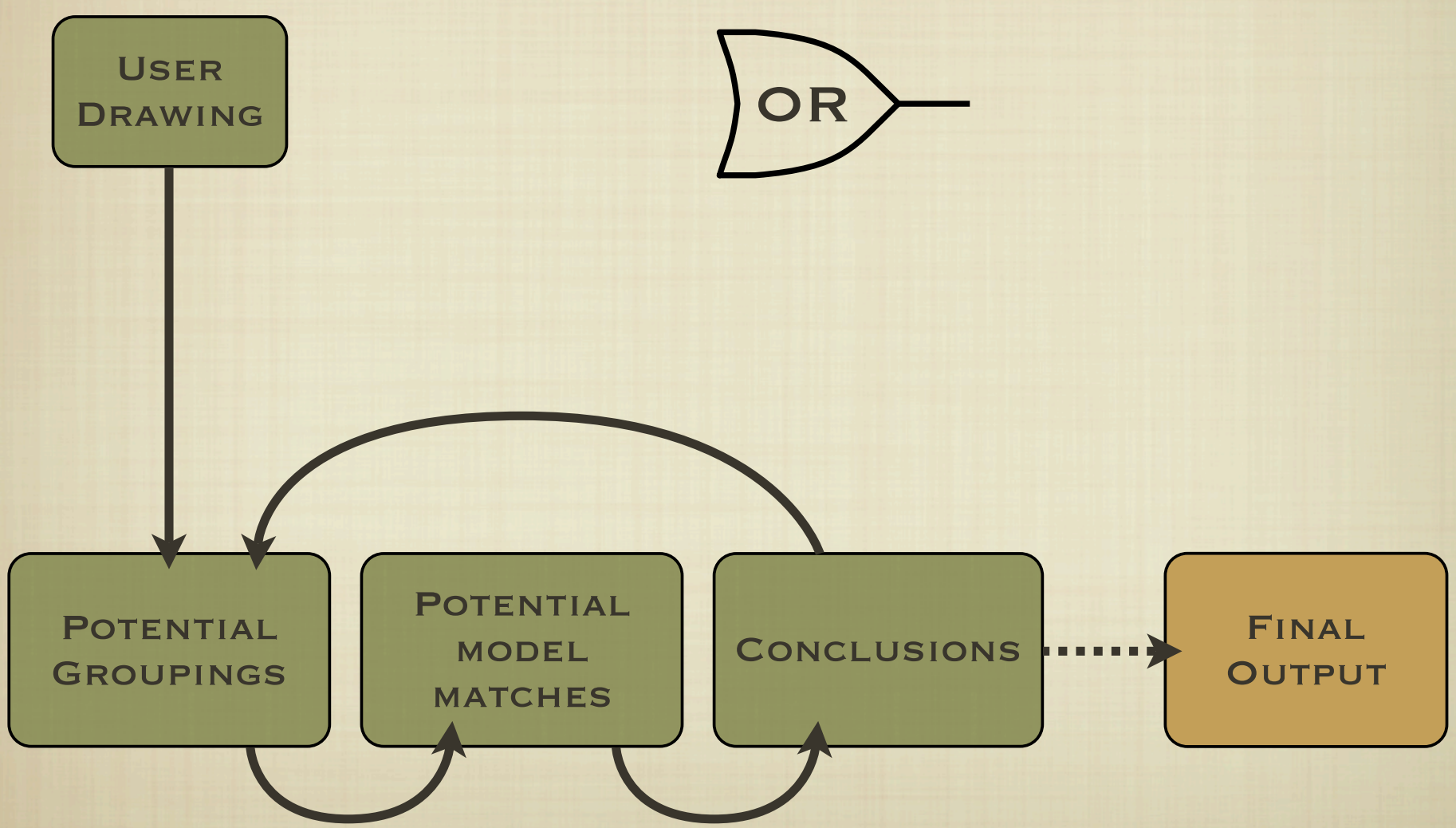
Potential Groupings

Potential model matches

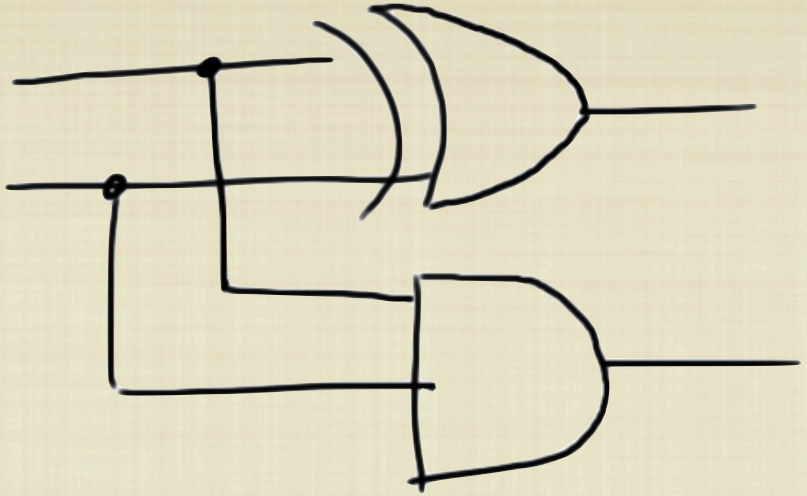
Conclusions

Final Output

Recognition Loop



Recognition Loop



User Drawing

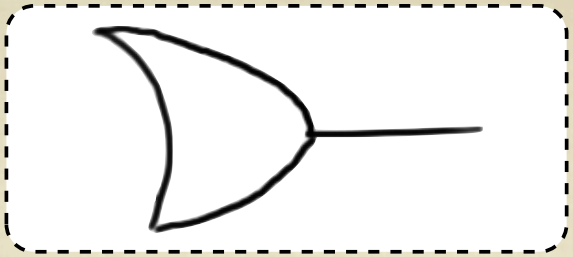
Potential Groupings

Potential model matches

Conclusions

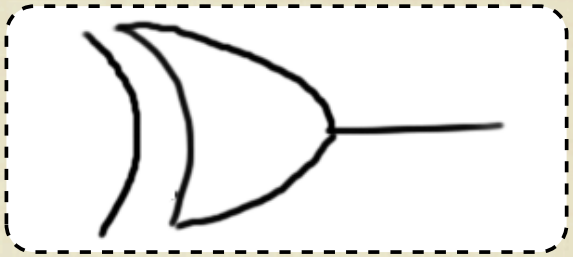
Final Output

Recognition Loop



OR

vs.



XOR

User Drawing

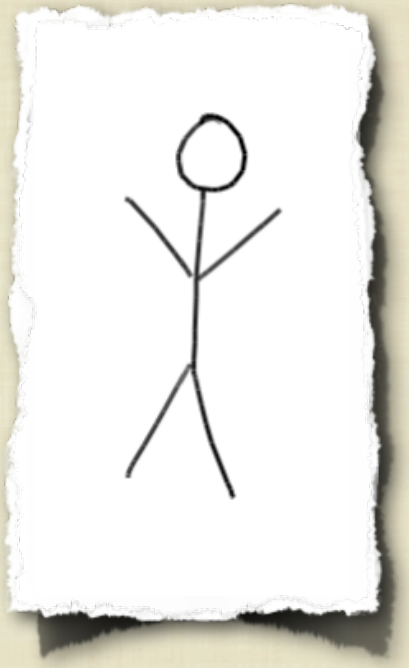
Potential Groupings

Potential model matches

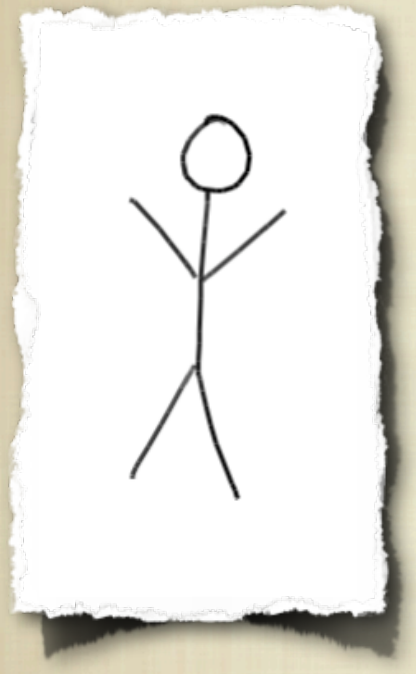
Conclusions

Final Output

Language-Level Support

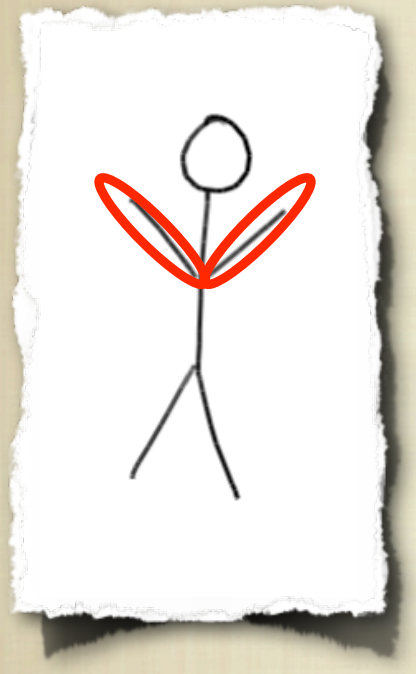


Language-Level Support



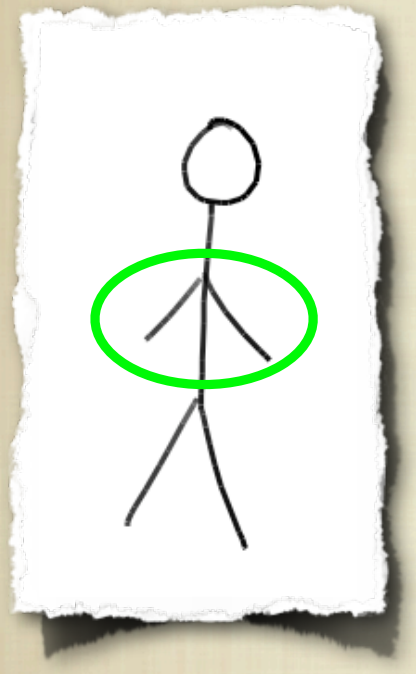
```
(define shape StickFigure
  (description "a stickfigure with two arms and two legs all sloping down at 45 degrees")
  (components (Circle head)(Line body)
              (Line larm)(Line rarm)(Line lleg)(Line rleg))
  (alias (Line feet_space (new Line (lleg.p2 rleg.p2))))
  (constraints (meet head body.p1)(!(intersect body head))
               (is-rotatable) (vertical body) (meet body larm.p1)
               (meet body rarm.p1) (coincident larm.p1 rarm.p1)
               (acute larm body)(acute body rarm)(left-of larm rarm)
               (coincident body.p2 lleg.p1)(coincident body.p2 rleg.p1)
               (obtuse body lleg)(obtuse rleg body)
               (perpendicular larm rarm)(perpendicular lleg rleg)
               (near body.p1 rarm.p1)(parallel rarm rleg)
               (parallel larm lleg)(!(intersect feet_space body))
               (equal-length lleg rleg)
               (equal-length larm rarm)) (bind ?head2 ?oa_head2)(bind ?head ?oa_head)
```

Describing A Stick Figure



```
(define shape StickFigure
  (description "a stickfigure with two arms and two legs all sloping down at 45 degrees")
  (components (Circle head)(Line body)
              (Line larm)(Line rarm)(Line lleg)(Line rleg))
  (alias (Line feet_space (new Line (lleg.p2 rleg.p2))))
  (constraints (meet head body.p1)(!(intersect body head))
               (is-rotatable) (vertical body) (meet body larm.p1)
               (meet body rarm.p1) (coincident larm.p1 rarm.p1)
               (acute larm body)(acute body rarm)(left-of larm rarm)
               (coincident body.p2 lleg.p1)(coincident body.p2 rleg.p1)
               (obtuse body lleg)(obtuse rleg body)
               (perpendicular larm rarm)(perpendicular lleg rleg)
               (near body.p1 rarm.p1)(parallel rarm rleg)
               (parallel larm lleg)(!(intersect feet_space body))
               (equal-length lleg rleg)
               (equal-length larm rarm)) (bind ?head2 ?oa_head2)(bind ?head ?oa_head)
```

Describing A Stick Figure



```
(define shape StickFigure
  (description "a stickfigure with two arms and two legs all sloping down at 45 degrees")
  (components (Circle head)(Line body)
              (Line larm)(Line rarm)(Line lleg)(Line rleg))
  (alias (Line feet_space (new Line (lleg.p2 rleg.p2))))
  (constraints (meet head body.p1)(!(intersect body head))
               (is-rotatable) (vertical body) (meet body larm.p1)
               (meet body rarm.p1) (coincident larm.p1 rarm.p1)
               (acute larm body)(acute body rarm)(left-of larm rarm)
               (coincident body.p2 lleg.p1)(coincident body.p2 rleg.p1)
               (obtuse body lleg)(obtuse rleg body)
               (perpendicular larm rarm)(perpendicular lleg rleg)
               (near body.p1 rarm.p1)(parallel rarm rleg)
               (parallel larm lleg)(!(intersect feet_space body))
               (equal-length lleg rleg)
               (equal-length larm rarm)) (bind ?head2 ?oa_head2)(bind ?head ?oa_head)
```

Systems Challenges

- General purpose recognition framework
- Programming language-level support
- Efficient hypothesize-model-measure loop[1]
- Board management

1. Alvarado **Dynamically constructed bayes nets**

References

AKT. (2005). AKT Large Area PECVD Capability, Retrieved July 3, 2007 from http://www.appliedmaterials.com

Dana Tenneson and Sascha Becker. ChemPad: Generating 3d Molecules from 2D Sketches. SIGGRAPH '05: ACM SIGGRAPH 2005 Posters, Pages 87, Los Angeles, California.

Christine Alvarado and Randall Davis. Dynamically constructed bayes nets for multi-domain sketch understanding. In Proceedings of IJCAI-05, pages 1407-1412, San Francisco, California, August 1 2005.

Joseph J. Laviola and Robert C. Zeleznik. Mathpad2: a system for the creation and exploration of mathematical sketches. ACM Trans. Graph., 23(3):432-440, August 2004.

Tracy Hammond and Randall Davis. LADDER: A language to describe drawing, display, and editing in sketch recognition. In Proceedings of the 2003 International Joint Conference on Artificial Intelligence (IJCAI), pages 461-467, Acapulco, Mexico, 2003.

J. Mahoney and M. Fromherz. Three main concerns in sketch recognition and an approach to addressing them, 2002.

Christine Alvarado. A natural sketching environment: Bringing the computer into early stages of mechanical design. Master's thesis, MIT, 2000.