

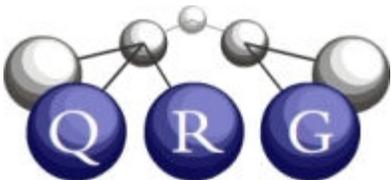
# CogSketch Tutorial

Ken Forbus

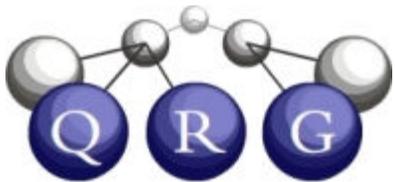
Andrew Lovett

Jon Wetzel

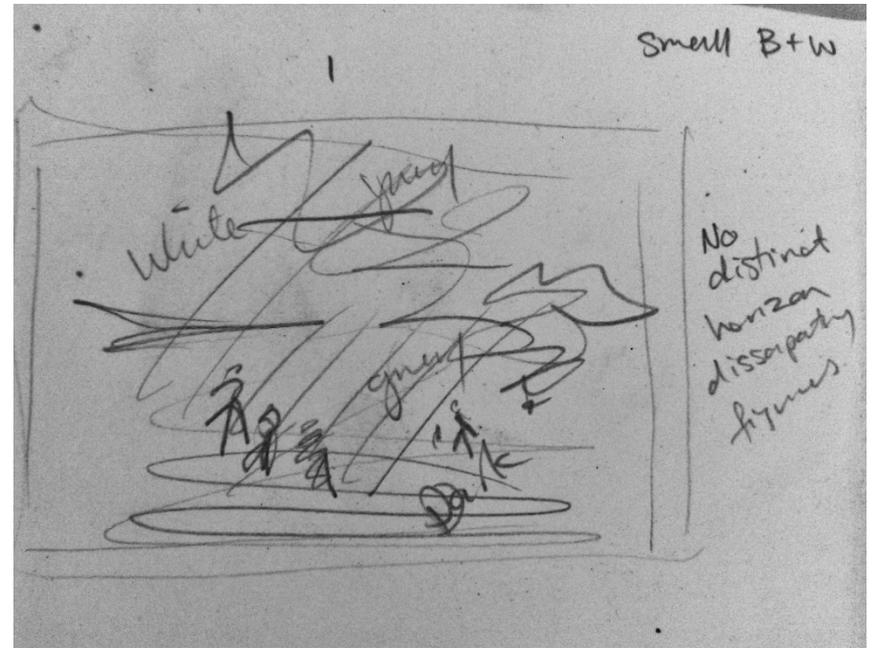
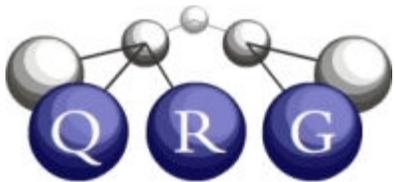
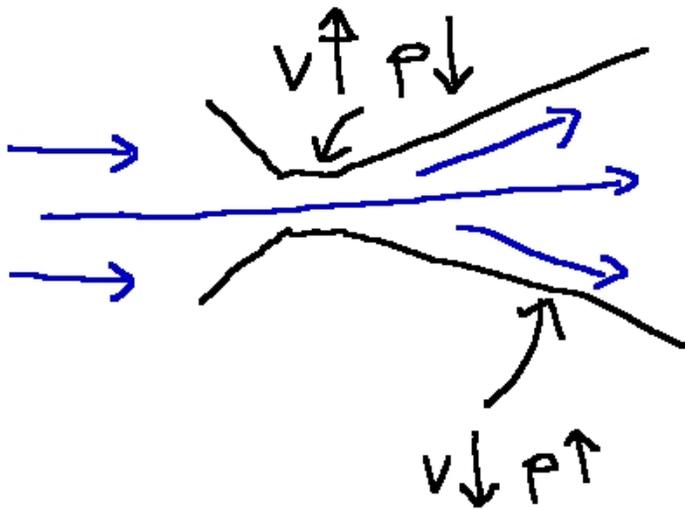
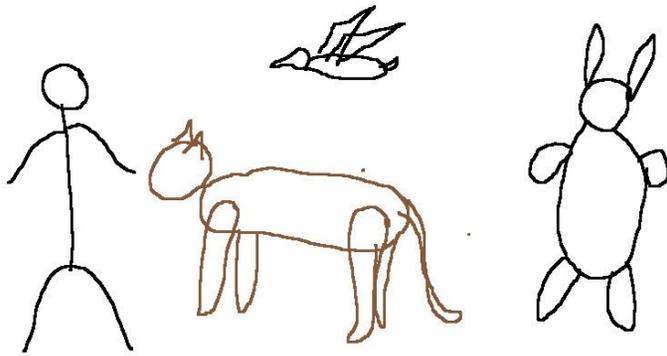
Northwestern University



# Welcome

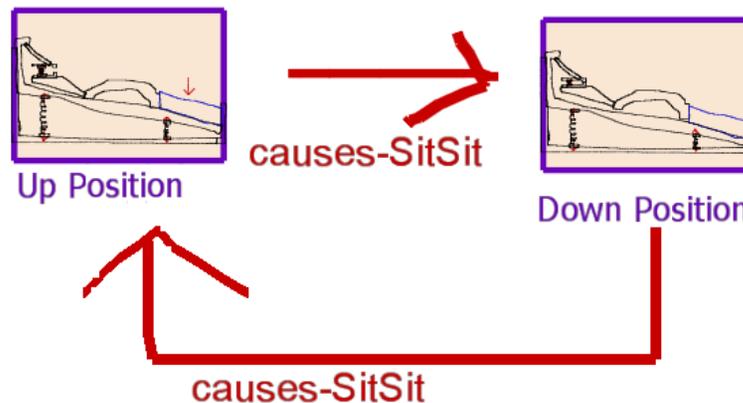
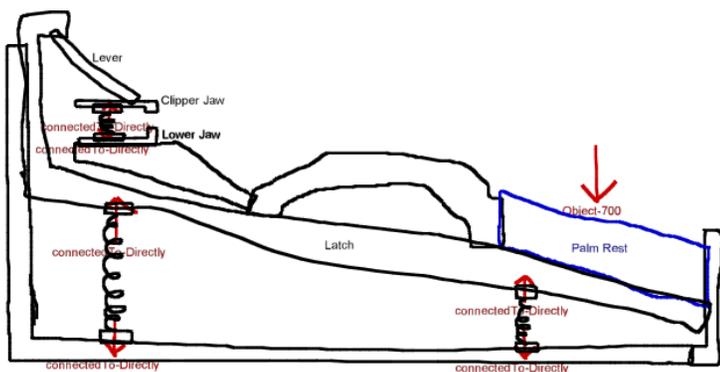
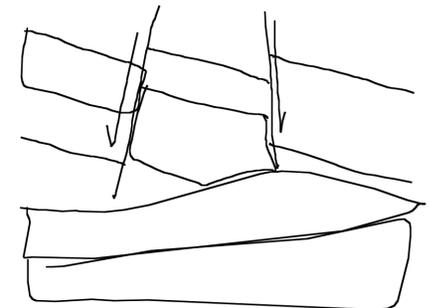


# Sketching as high-level vision



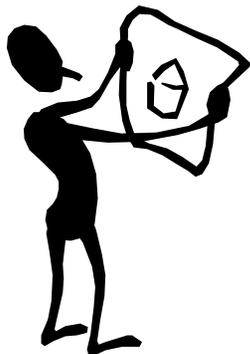
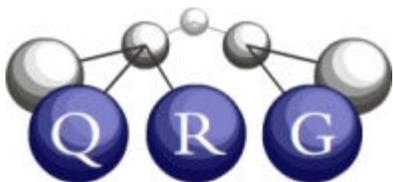
# Sketching = Important tool for spatial understanding

- People sketch when they are communicating ideas
  - e.g., maps, diagrams
- People sketch when they are working out ideas alone
  - e.g., designers, students studying
- Needed: Computational models of sketch understanding
  - To model the visual, spatial, and conceptual representations and processes involved
  - To create learning and thinking tools for students and professionals



# Computer tutors and learning environments need spatial capabilities

- Intelligent tutoring systems have provided valuable benefits for education
  - Immediate feedback, potentially any time, anywhere
- But not in spatially rich subjects (e.g., geology, engineering)
  - How to create human-like visual processing is a hard scientific question
  - Need to model the spatial & conceptual reasoning involved
- Sketch understanding software could change this



Ultimate goal:  
Software that  
understands sketches  
as you would



# Sketch Recognition Systems

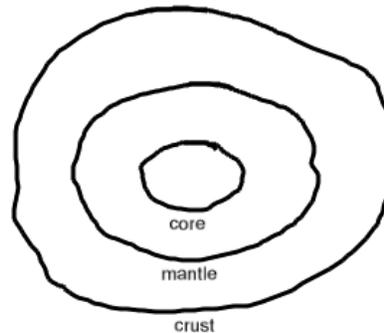
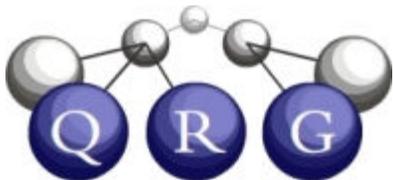
- Focus on object recognition
  - Only works in narrow domains
  - Requires user training
- Doesn't scale for education

System	Problem
OrganicPad	Draw 2D molecules, converts to 3D
Newton's Pen	Draw free-body diagrams
Kirchoff's Pen	Draw resistor networks
iCanDraw?	Draw human face from reference image
Mechanix	Draw trusses, get feedback
LAMPS	Mandarin Phonetic symbols
Hashigo	Japanese Kanji
LearnYourShapes!	Simple shapes



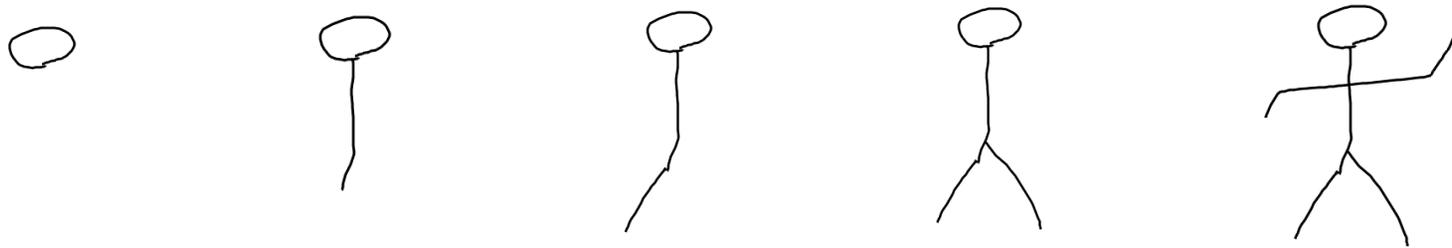
# Our approach: Open-domain sketch understanding

- Object recognition is not necessary
  - People talk when they sketch – they label objects
  - CogSketch enables people to label as they draw, avoiding the recognition bottleneck
- CogSketch models aspects of human visual and spatial representations and reasoning
  - Derives rich relational representations
  - Same software operates across many domains

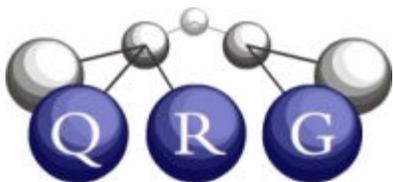


# Two Problems in Sketch Understanding

- *Segmentation*: How to break up ink into pieces corresponding to depicted entities?

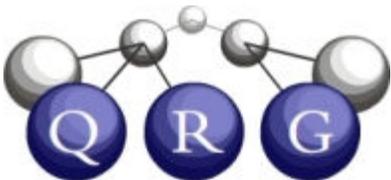


- *Interpretation*: What is being depicted?



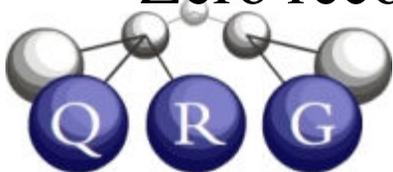
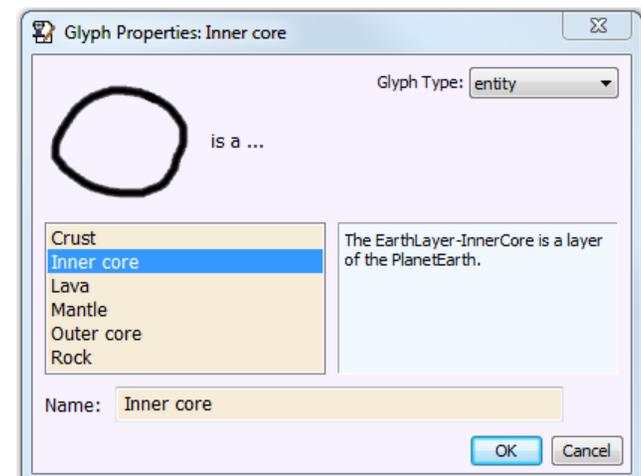
# Traditional Solutions

- Segmentation: Heuristics
  - Pen up, long pauses taken as evidence for segmentation
  - Overlapping speech
- Interpretation: *Which-of-N* recognition
  - Fixed vocabulary of entities (10-100)
  - Train system on each user individually
  - Train users via feedback



# How people interact with CogSketch

- Draw ink, clicking finish when an object is done
  - Resegment/regroup via lasso if needed
- Label objects via menus
  - Knowledge base provides concepts for labeling
  - 58,000 concepts provide breadth
  - Technical details hidden from users via UI
- Zero segmentation errors
- Zero recognition errors

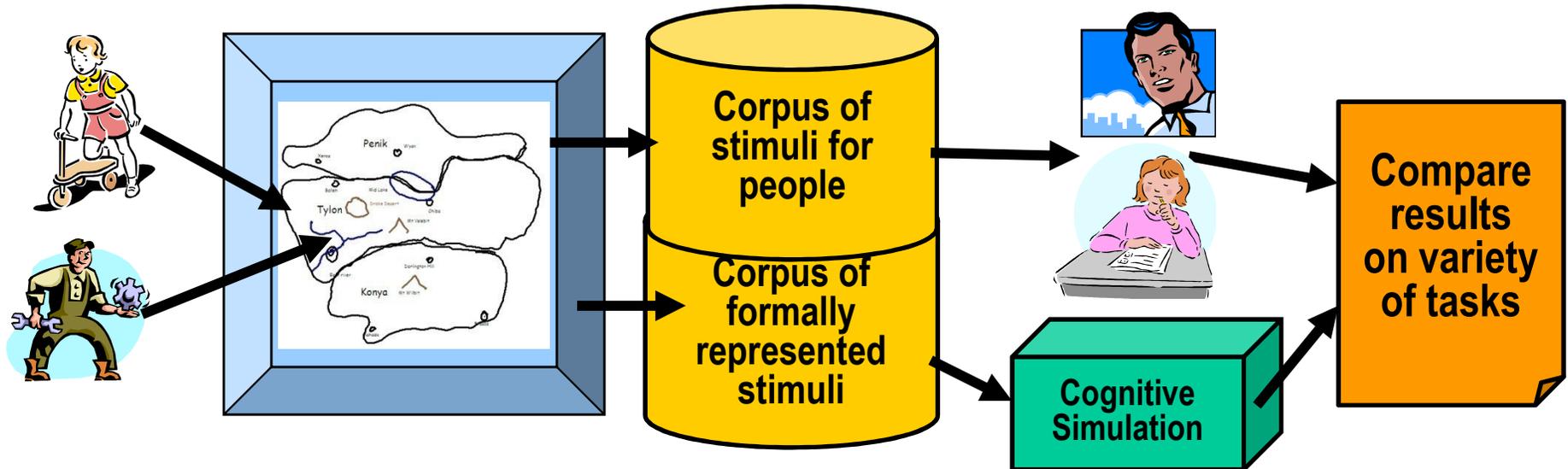


# CogSketch Research Goals

- Goal: A cognitive science research instrument.
  - A computational model of spatial reasoning and learning
  - A tool for gathering data in laboratory and classroom studies
- Goal: A platform for sketch-based intelligent educational software
  - Helping students learn STEM concepts
  - Helping students learn engineering design
- **Vision: Sketch understanding software to help students learn could be widely available in 5 years**



# CogSketch as Research Instrument

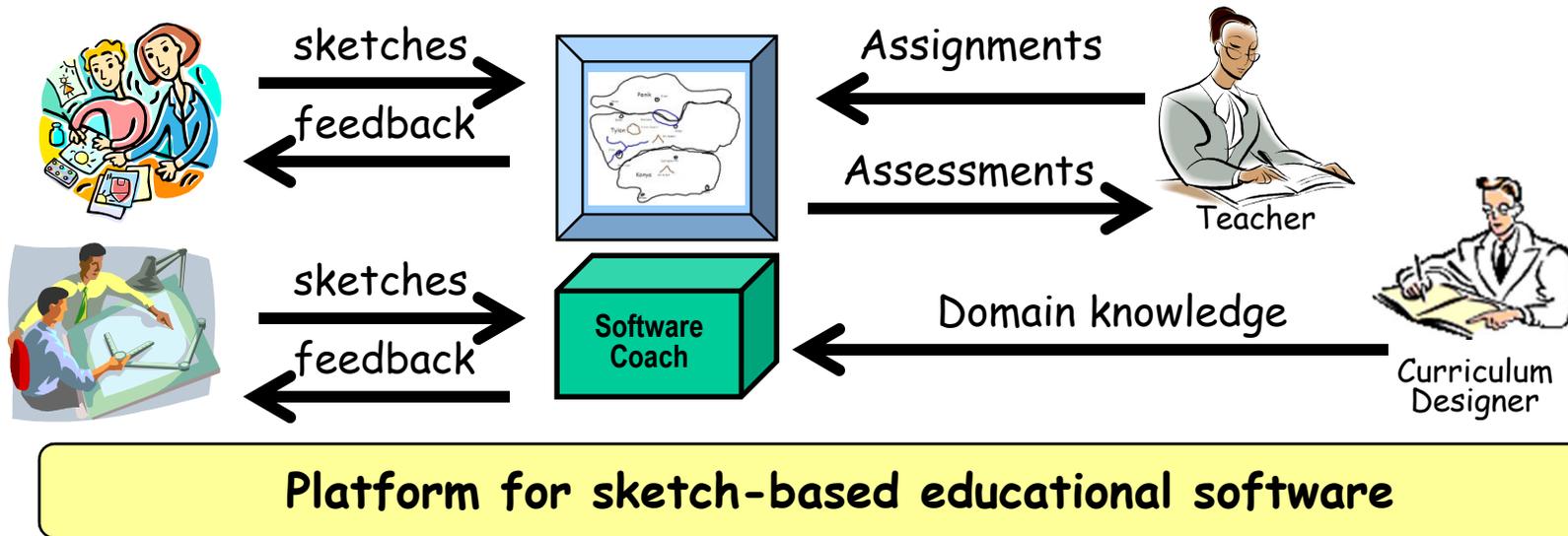


Gathering and modeling data in laboratory and classroom experiments

- Use cognitive simulation experiments to model visual/spatial processing in CogSketch
  - Constrain via results from multiple experiments
- Gather data in psychology experiments
  - Automatically gathers timing data
  - Automatic scoring of participant responses



# CogSketch in Education

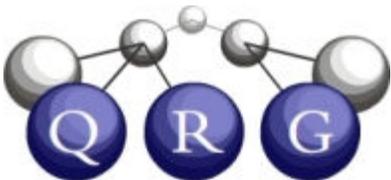


- Eventually, like a calculator
  - Always available
  - Useful across a broad variety of tasks
- But with more scaffolding
  - Access to intelligent tutors and coaches built in
  - Automated assessment support



# Overview

- Introduction to CogSketch ✓
- CogSketch Basics
- Visual processing in CogSketch
- CogSketch in Education
  - Making worksheets, potential for assessment, ...
- Using CogSketch for Cognitive Science research
  - Using analogical processing in simulation
- Advanced features
  - Extending the KB, exporting knowledge...
- Wrap-up



**Your feedback will help guide  
CogSketch development**

