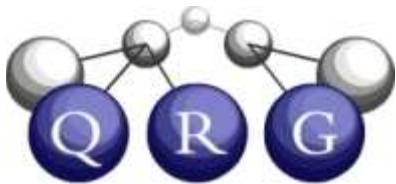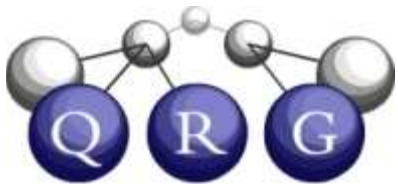# CogSketch Tutorial

Ken Forbus

Northwestern University
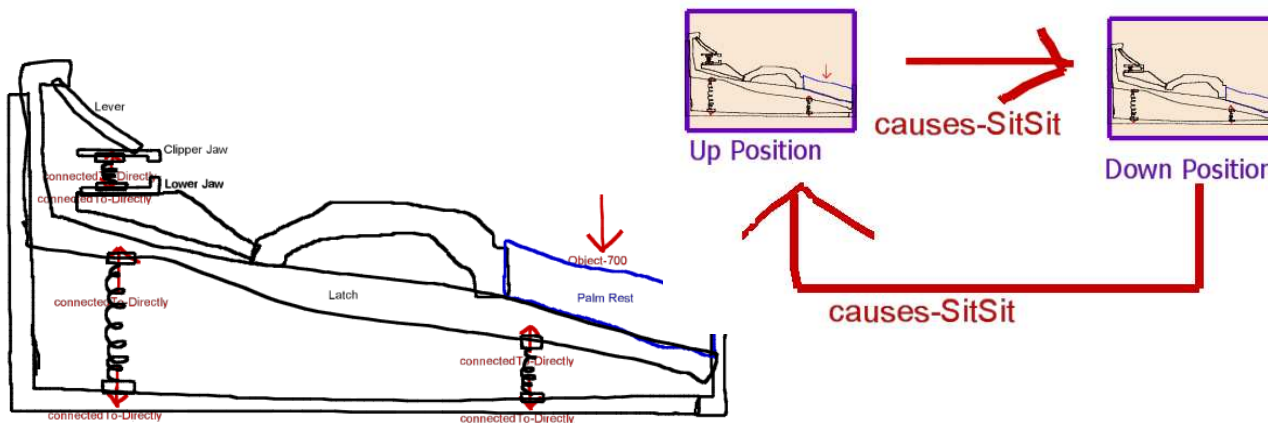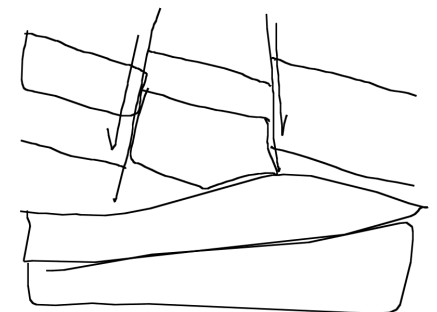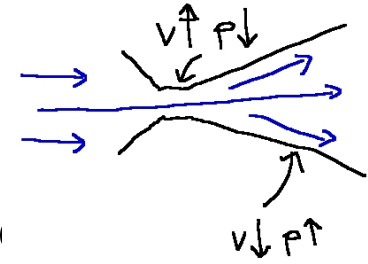
Welcome

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
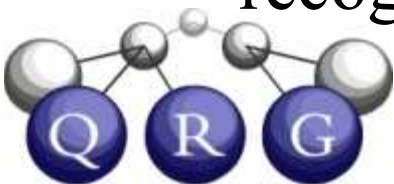 - To create learning and thinking tools for students and professionals

Sketch Understanding ≠ Sketch Recognition

- Traditional multimodal systems focus on recognition
  - E.g., Quickset, Electronic Cocktail Napkin, LADDER,…

- Limitations of today's recognition technologies sharply restrict their applicability
  - Statistical recognizers require lots of training, engineering of vocabularies and grammars
  - The broader the task, the more user training needed
  - Environments must be relatively noise-free
  - Significant individual differences in success rates

Flowcharts

| Transition | Empty Start | Empty Action | Empty Decision | Start | Action | Transition Descision | Decision |

UML Class Diagrams

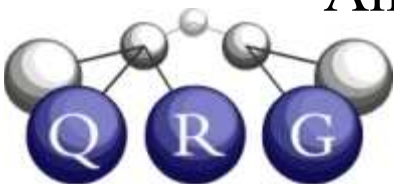| Interface Relation | Dependency | Inheritance | Aggregation | Dotted Arrow | Empty Interface | Empty Class | Interface | Class |

nuSketch insights

- Recognition is not essential in human to human sketching
  - People aren't artists in real time
  - People express more in sketches than are covered by visual symbologies
  - People use language to conceptually label pieces of ink
- Two key operations in entering a glyph:
  - *Segmentation:* What pieces of ink should be considered together as part of a glyph?
  - *Conceptual labeling:* What is the glyph intended to depict?
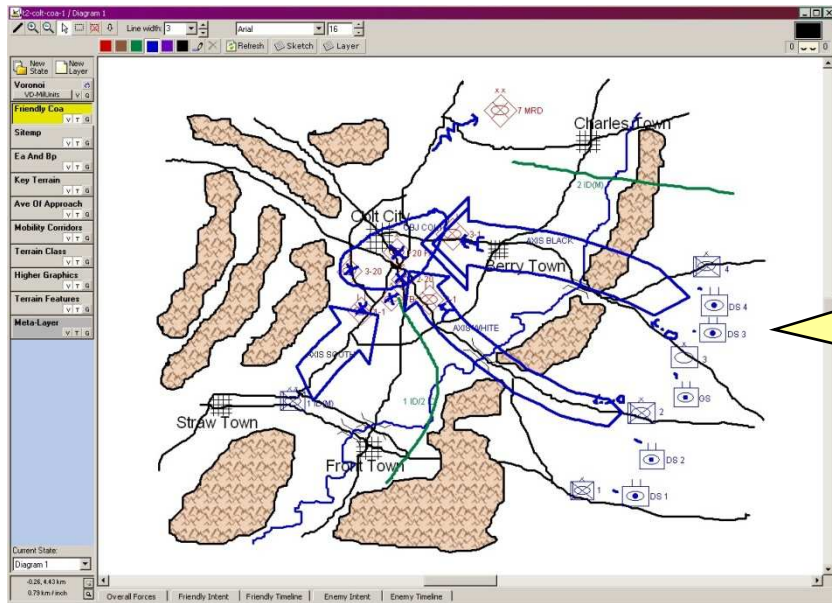- We can carry out these operations without recognition!
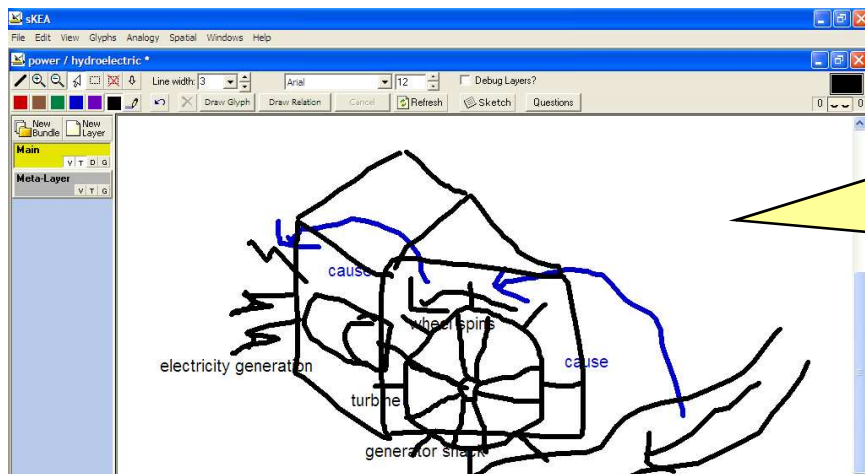
nuSketch approach

- *Open-domain* sketch understanding
- Focus on visual and conceptual understanding
    - Even if recognition were perfect, would still need this!
- Use engineering workarounds to sidestep recognition
    - Slightly more load on users, but no recognition errors
- Develop representations and reasoning for human-like understanding of what is sketched
    - Spatial representations and reasoning, esp. qualitative
    - *Comic graphs* to organize sequences and alternatives
    - Analogical reasoning and learning

Other nuSketch Systems: Precursors to CogSketch

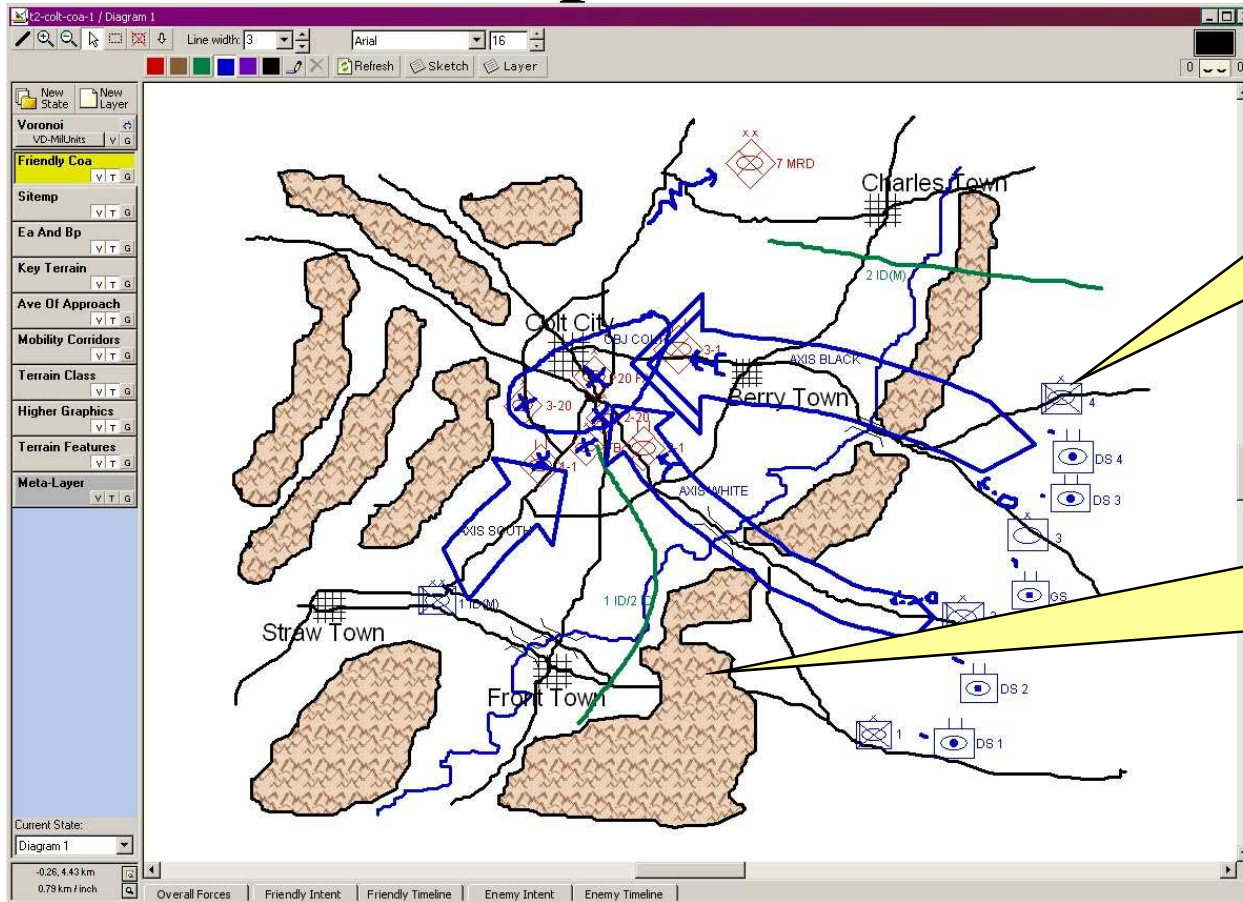nuSketch Battlespace supports generating courses of action, military reasoning

sketching Knowledge Entry Associate (sKEA) was the first open-domain sketch understanding system

nuSketch Approach: Understanding, not recognition

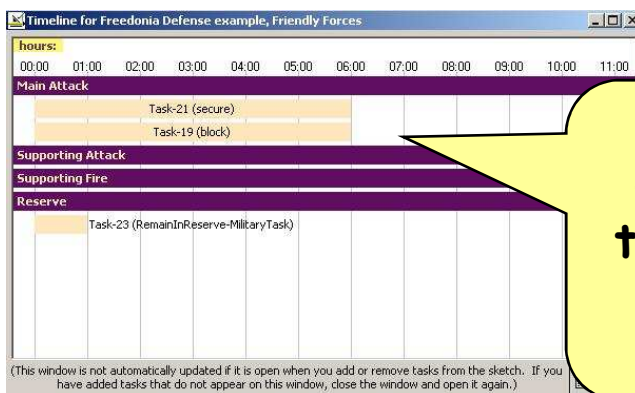KB = 1.2M fact subset of Cyc KB
Reasoner = FIRE

Example: nuSketch Battlespace

Each glyph contains formal representations of its domain semantics

Qualitative spatial reasoning about terrain carried out via visual processing

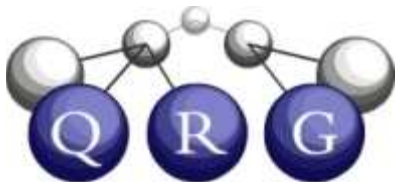Specialized dialogs used to enter non-spatial information

Only 20% of the code is domain-specific, rest is shared with our domain-independent system, sKEA
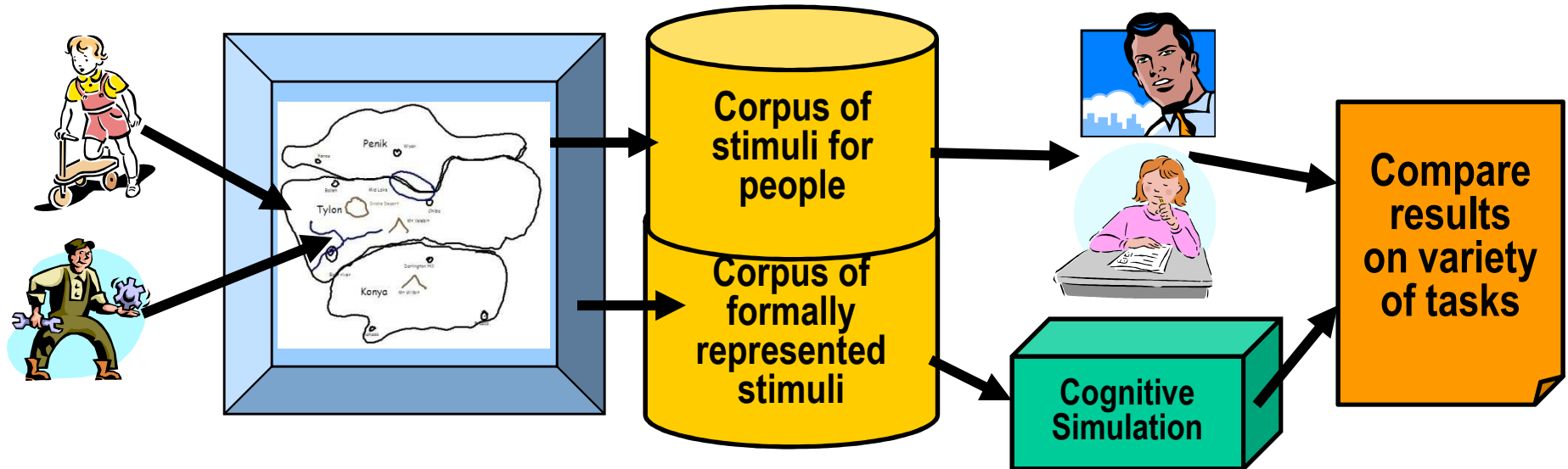
CogSketch Research Goals

- We are developing *CogSketch,* a new computational tool for studying and enhancing spatial learning.
  - A computational model of spatial reasoning and learning
  - A tool for gathering data in laboratory and classroom studies
  - A framework for building intelligent tutoring systems and learning environments
  - **Vision: Sketch understanding software to help students learn could be made widely available within 10 years**
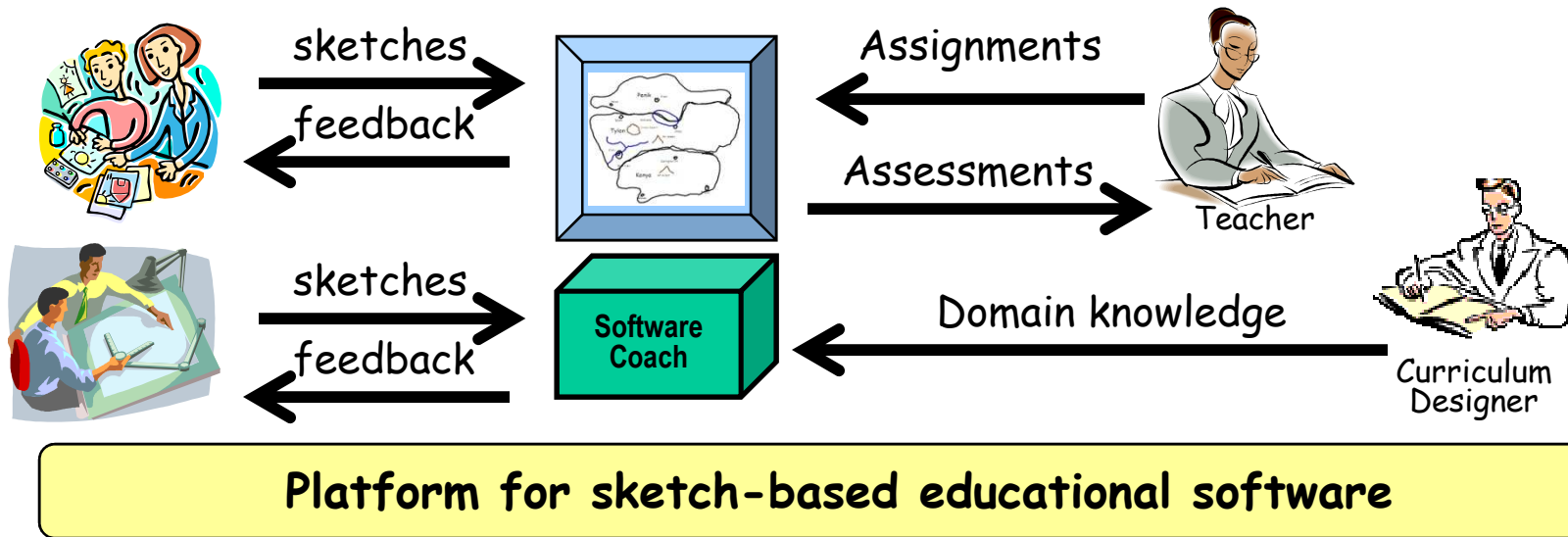
CogSketch as Research Instrument

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
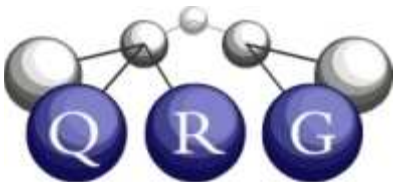
How CogSketch Might Be Used in Education

sketches → feedback ←

Assignments ←
Assessments →
Teacher

sketches → feedback ←

Software Coach

Domain knowledge ←
Curriculum Designer

Platform for sketch-based educational software

- **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**

Our Vision:
Sketch understanding software to help students learn could be made widely available within 10 years

SILC

Overview

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

Your feedback will help guide CogSketch development