Design visual thinking tools for mixed-initiative systems

Pearl Pu

Denis Lalanne

Ergonomics of Intelligent Systems & Design

Swiss Institute of Technology Lausanne

Monday, December 17, 2001

Maes v.s. Shneiderman

Executive notebook:

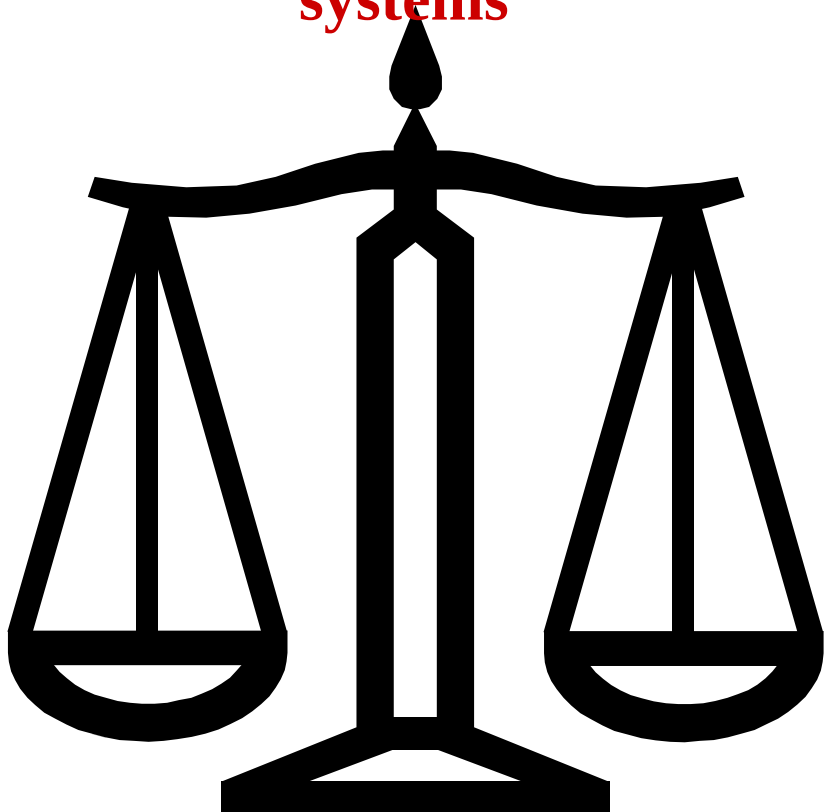
Future style of interaction

Autonomous agents

Proactive

Infering Users' goals

Mixed Initiative systems



Direct manipulation

Strictly tools

Users are in control

Overview of Mixed-initiative systems

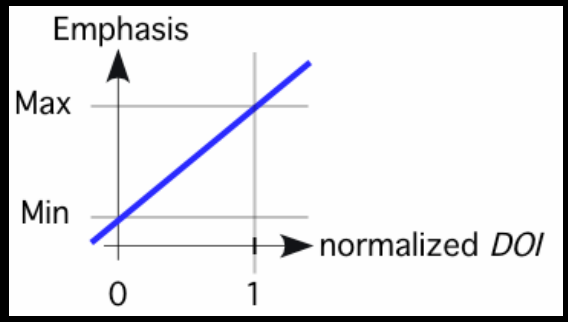
- Dialog-based
- Direct manipulation-based
- Visualization-based

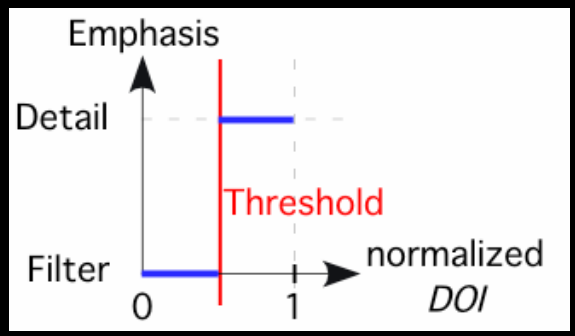
Information visualization

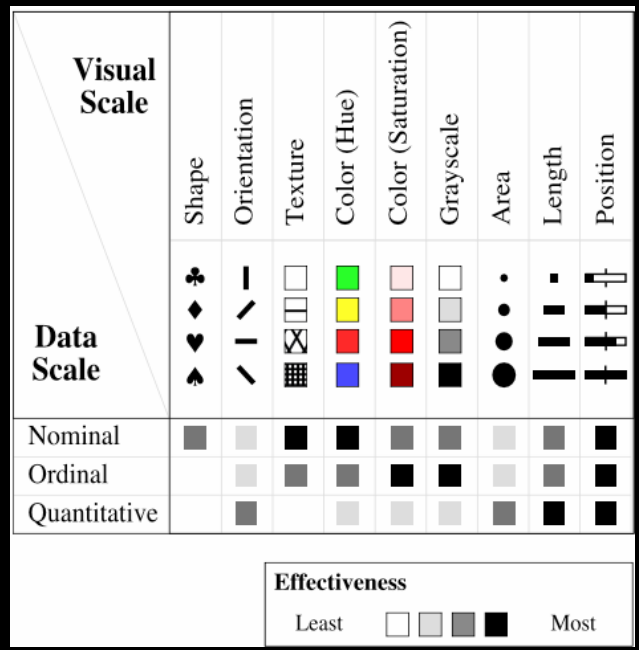
- Humans posses highly parallel perceptual processing power
- Visual affordance – how to react to an object by its appearance
- Thus infovis is about using images to
  - Reveal evidence, patterns, and trends
- How to present non-spatial data visually

Emphasis Techniques

- Use **preattentive** perception to allow users to "see" rather than "read" relationships
- Created by applying a transformation function to a visual scale







Outline of the talk

- Describe configuration tasks
- Design of visual cues in a visualization-enabled MI system (COMIND)
  - Kaleidoscope (search)
  - Tradeoff Map (select optimal solution)
  - Conflict lattice (detect formulation conflict, redefine problem, show unseen path)
- User study
- Conclusion -- visual thinking tools

Configuration tasks

- PCs, automobiles, travel planning, etc.
- Configure a set of objects so that the interrelationships of those objects respect a certain constraints
- Hard for both humans and machines
- Constraint problem solving (CSP) techniques are often used to solve configuraiton problems
- Constraints can be add to suit different user profiles

City planning

Land characteristics

- Lot3, lot5, lot7 and lot9 are all relatively flat sites with fairly good soil conditions.
- Lot10 and lot12 are moderately sloped sites in a nice wooded location, but have poor soil conditions.
- Lot17 is a very steep site.
- Lot11 ant lot17 are elevated sites facing southwest and down into a valley that has a lake and some wooded area.

Criteria and constraints

1. The dumpsite and the cemetery should not be visible from either of the dwellings.
2. Steep slopes are to be avoided for building.
3. Poor soil should be avoided for those land uses that involve
4. construction.
5. The recreational area has to be near the lake.
6. The highway is noisy and ugly and should be avoided when locating the apartments, the single-family housing complex and the recreational areas.
7. The supermarket can not be in front of the single-family houses,
8. of the dumpsite, and of the cemetery, mainly for esthetical reason.

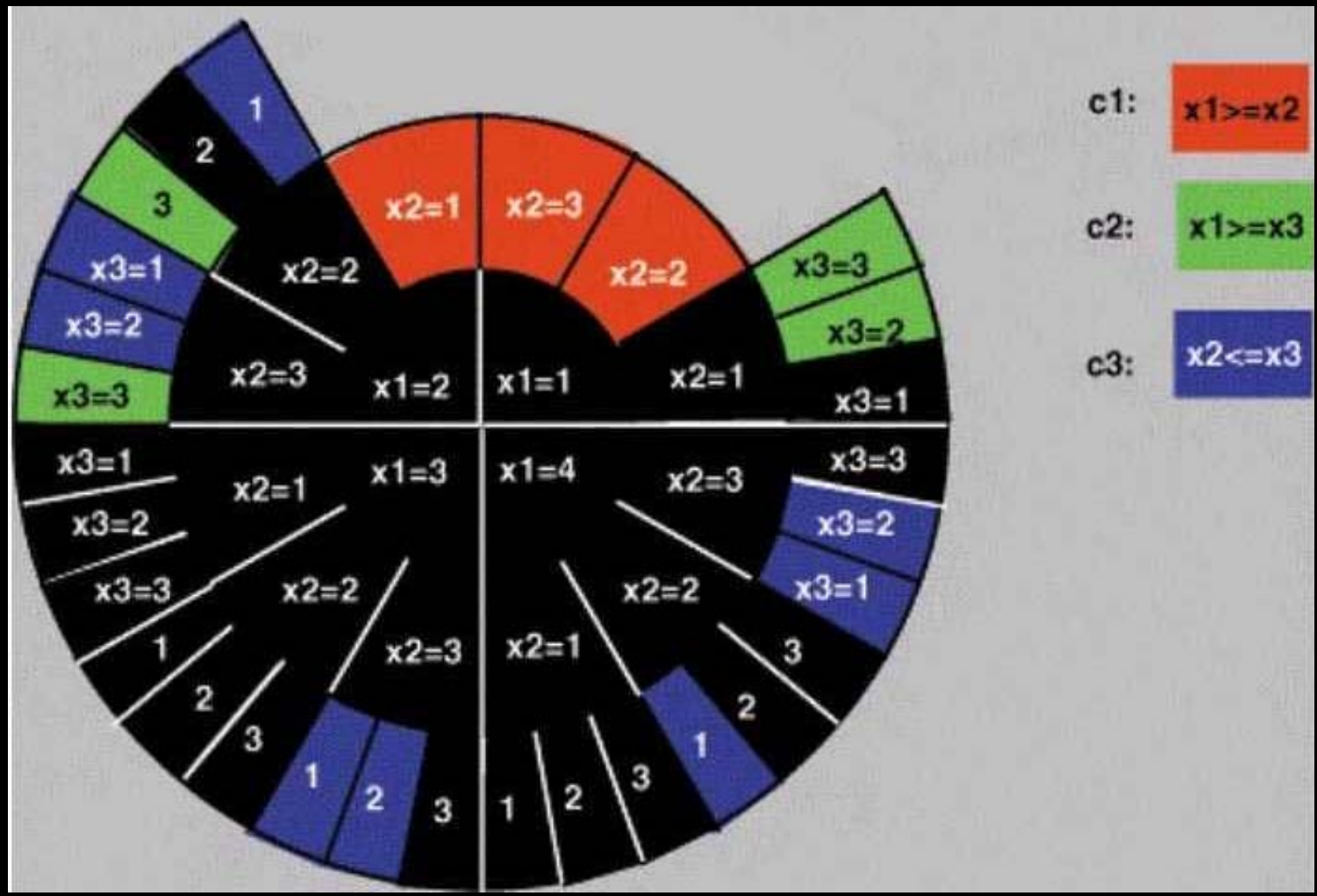
Solving configuration problem

- The problem-solver's task is to come up with assignments of land uses to sites.
- A complete design is one in which each land use has been assigned to a lot.
- The final design should be one which complies with a given set of criteria.

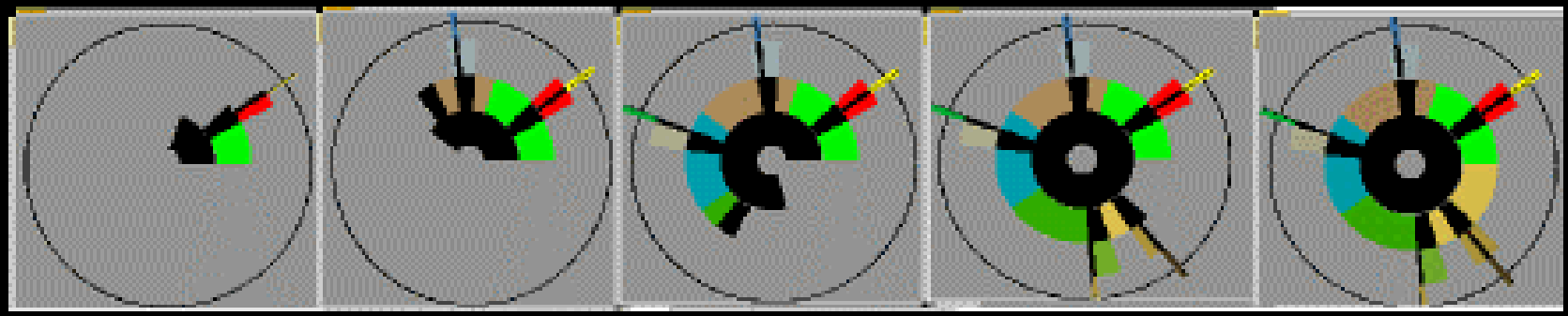
Search algorithms for CSP

- simple backtracking
- pre-processing and SB
- Monte Carlo method by Knuth
- algorithms are np-complete in general

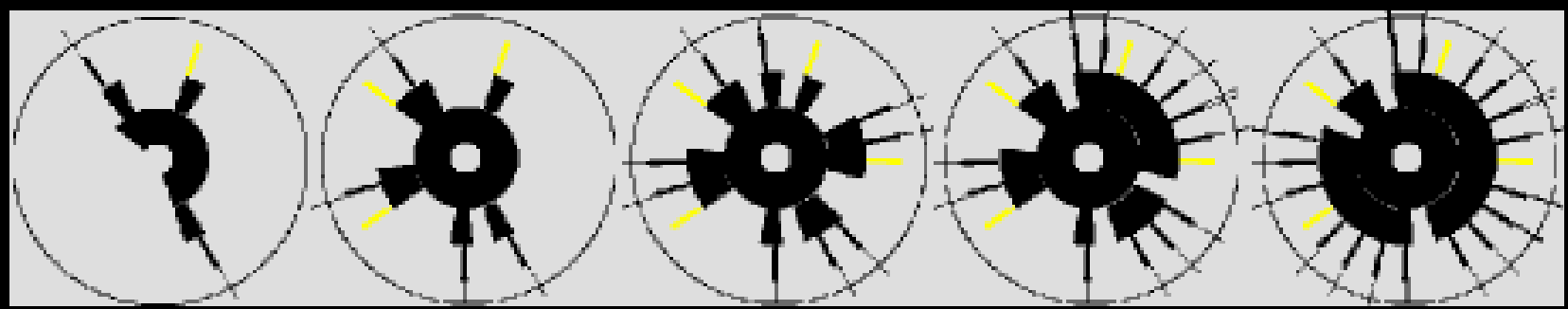
Kaleidoscope - for SB



Simple backtracking



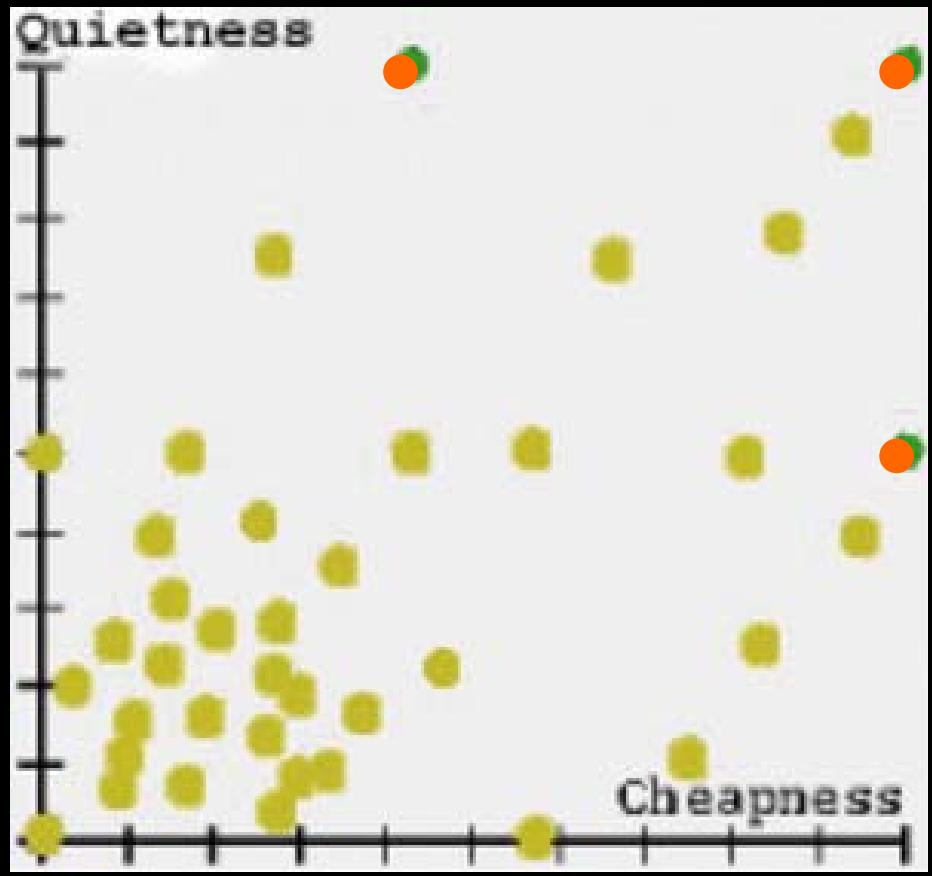
Knuth algorithm



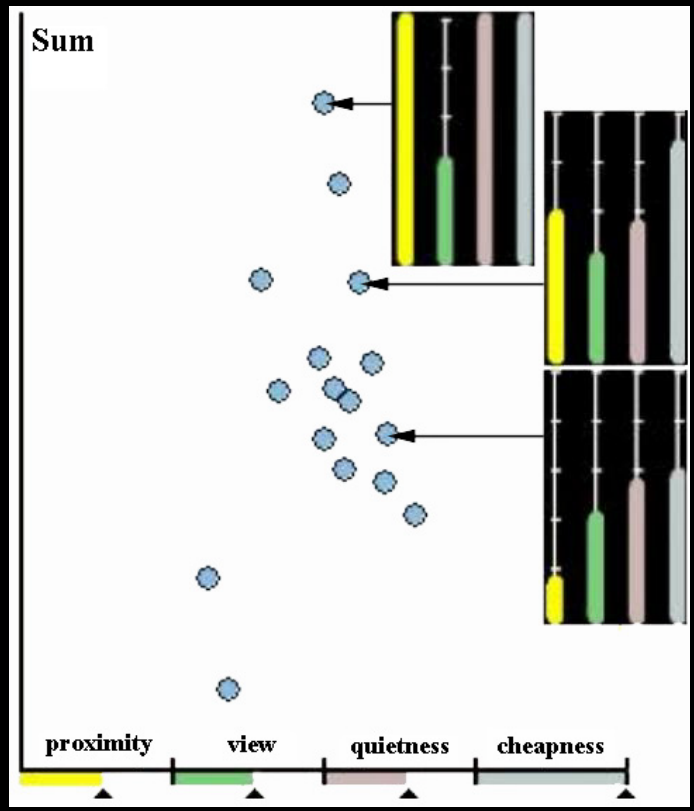
Discovery with Kaleidoscope

- does thrashing occur, frequently?
- Are solutions diversified or concentrated in clusters?
- Are solutions abundant or futile
- if variables re-ordered, does solution generation become faster?

TradeoffMap – under-constrained space



MAP: multiple attribute pareto

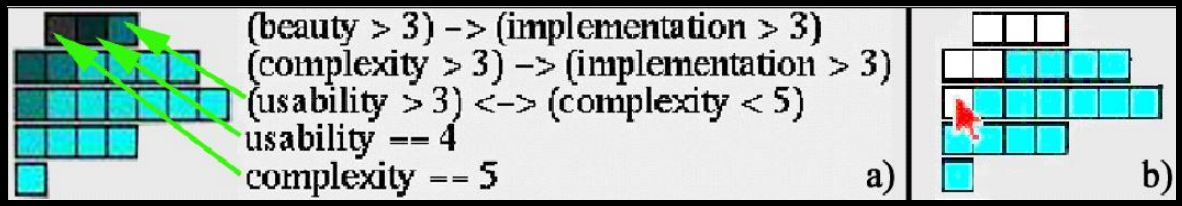


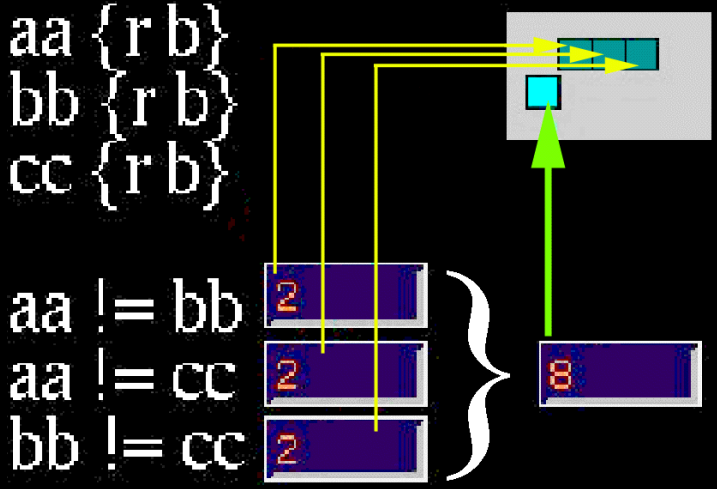
Decision making using MAP

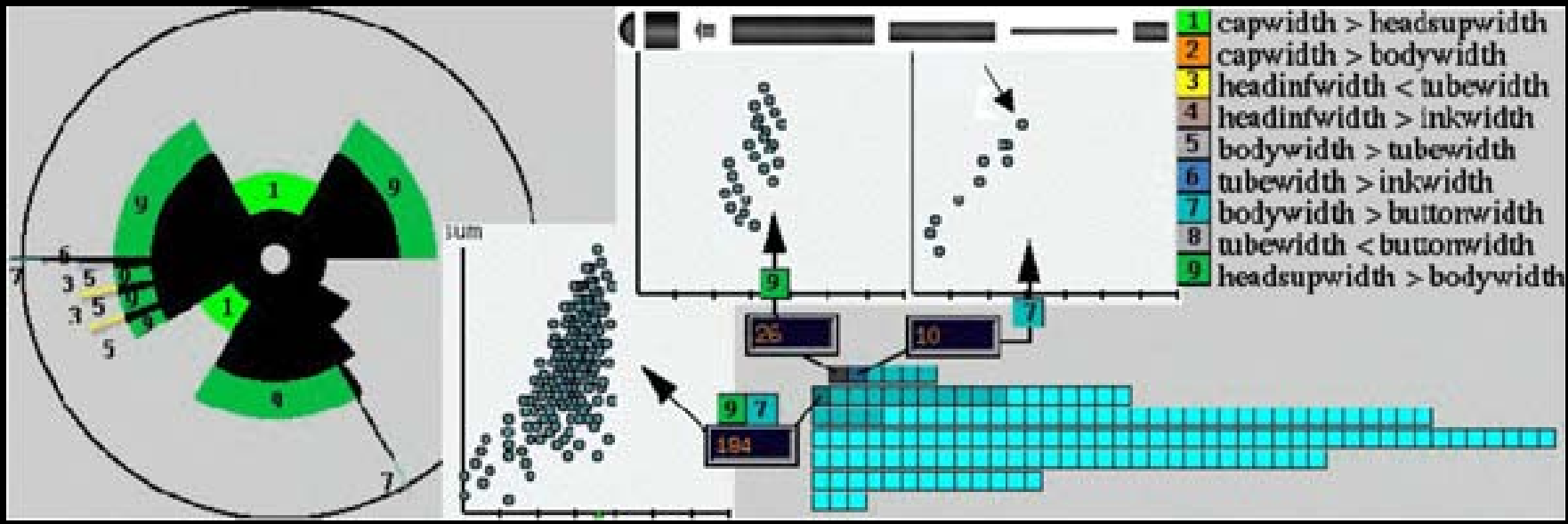
- Is there a dominant solution?
- Are there numerous or few non-dominant solutions?
- Should additional criteria be defined in order to push out dominant solutions?
- Are solutions cluttered around a certain area, or more spread out in the MAP?

Search in over-constrained space

- one or several sets of constraints contain no solution
- diagnosing them is hard without visualization
- Lattice visualization


(beauty > 3) -> (implementation > 3)
(complexity > 3) -> (implementation > 3)
(usability > 3) <-> (complexity < 5)
usability == 4
complexity == 5
a)
b)


aa {r b}
bb {r b}
cc {r b}
aa != bb
aa != cc
bb != cc
2
2
2
8



Kaleidoscope, MAP, and Lattice

Resolve conflicts

- Is there a single or several minimal conflicts (black squares) in the lattice?
- Which one of the conflict sets to relax?
- If certain conflicts are removed, which potential solutions are ideal? (use visualization of MAP)
- If the search is futile, then the degree of constrainedness will lead users to relax certain constraints.

Related works

- Mixed initiative system - general principles
- HCI principles for interactive search - specific principles
- Human-guided search – machines find local minima, humans pin point search space

- Differentiating factor
  - **Visualization-enabled MI interface**
  - **User task and context centered**

Usability study – what to test

- Hypotheses tested
  - Can humans solve the problems without COMIND?
  - Designers can perform better with visualization - yes
  - Help designers discover new solutions – yes
- Observations
  - More lateral behavior (users do not follow routines)
  - More eye movements

Visualization-enabled MIS – visual thinking tools

- Valued-added automation in the form of how results contribute to tasks
- Engage users in problem solving process
  - Add human criteria
- Suggest appropriate actions with visual affordances
  - Constrained set of operators (reduce errors, direct manipulation)
  - Evaluation of solution path by giving assessment between goals and current state (mirrors your strategy, progress gauge)

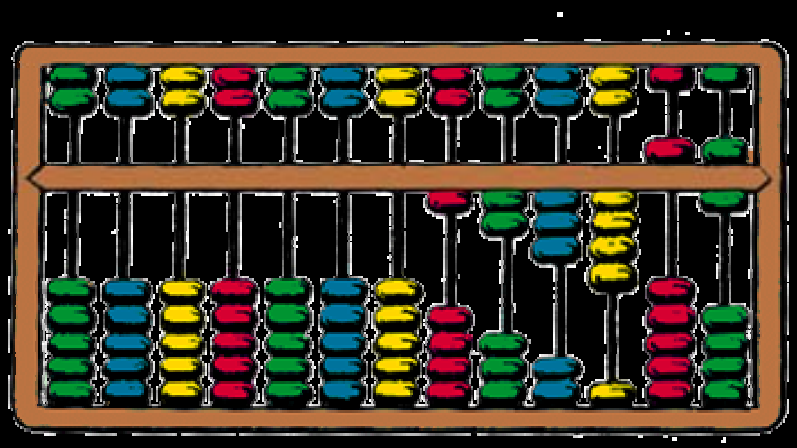
Requirements for visual thinking tools - conclusion

- Visual reification of **task**
- Constrained set of operations
- Visual affordances to cue human's intervention
- Fix problem formulation and point out unseen paths

Our objectives

- Does MIUI stands a chance to be the next generation interaction style?
- Designing Visual thinking tools

An example of visual thinking tool



- Input, output
- Calculates (add)
- Transforms cognitive task into motor and reading task
- = constrains and guides computation

External representation work (Zhang & Norman)

- External representation is more than inputs, stimuli, memory aids
- Intrisinc components of cognitive tasks
- Not enough – must also empower cognitive tasks with computation components