

Intelligent Patterning

or

Why I've been doing computer
science

Brief overview of where I'm headed:

- General problem solving
- Pattern recognition
- Symbols and signs
- Intelligent patterning
- Some history
- What's wrong in computing today
- The intelligent mathematical assistant

General problem solving

- Understanding the problem
 1. Problem context and statement of the problem
 2. Solving the right problem (ill-posed and ill-conditioned problems)
 3. Preconceptions
 4. Language and restating the problem

- The role of experience
 1. Similar problems and analogy
 2. Appropriate tools
 3. Specific experience

- Three basic methods
 1. Plug and grind
 2. Guess and prove
 3. Look it up

- Hypothesis generation and testing
 1. Flexibility and freedom — willingness to try and fail
 2. Recognizing blind alleys, and the value of exploring
 3. Appropriate hypotheses
 4. Lateral thinking

- Recognizing solutions

1. “A” solution vs. “the” solution

2. Useful solutions

3. When a “solution” solves an un-posed, but more significant problem

Pattern recognition

- Images (“visual patterns”) vs. “syntactic” patterns
- Symbols as patterns, and symbols as pattern labels
- Patterns of symbols
- Hierarchies of patterns, and symbols as tools for recognizing patterns
- Pattern manipulation
- Learning to recognize patterns, and pattern recognition as learning

Pattern recognition examples

- What number comes next in the sequence?
1, 1, 2, 3, 5, 8, 13, ...
- What number comes next in the sequence?
8, 5, 4, 9, 1, 7, 6, 3, ...
- What letter comes next in the sequence?
E, T, A, O, I, N, S, H, ...
- In which row does Z go?
A, E, F, H, I, K, L, M, N, T, V, W, X, Y
B, C, D, G, J, O, P, Q, R, S, U
- What letter comes next in the sequence?
W, L, C, N, I, T, ...

Symbols and signs

- The utility and power of symbols
- Choosing symbols, naming and pointing
- Symbols as “chunking” tools
- When to use symbols
 1. The importance of anonymity (e.g., the lambda calculus)
 2. Place holders (variables)
 3. Temporary and tentative symbols
- Signs, symbols, content and meaning

Intelligent patterning

- Creativity and Art
 1. Knowing when to pattern
 2. Symbol attachment and creation; patterns/symbols as revealers and concealers
 3. Levels of patterning
- Multiple patterns and selection
$$(x - 1)(x - 2)(x - 3) - 6$$
$$x^3 - 6x^2 + 11x - 12$$
$$(x - 4)(x^2 - 2x + 3)$$
- Adaptive pattern recognition
- Are the patterns really there?

Some history

- Physics
- Philosophy (theory of knowledge)
- Mathematics
 1. Matrix manipulation
 2. Topology
 3. Algebra
 4. Lie groups
 5. Manifolds and relativity theory
 6. Algebraic topology

We have the map $b_n : \Sigma^2 U(n) \rightarrow SU(n+1)$ given by

$$b_n(g, r, s) = [i(g), v_n(r, s)]$$

where $i(g)$ is the inclusion, $[g, h] = ghg^{-1}h^{-1}$ and

$$v_n(r, s) =$$

$$\begin{bmatrix} \alpha & 0 & 0 & \cdots & 0 & \beta(-\bar{\alpha})^0 \\ \beta(-\bar{\alpha})^0 \bar{\beta} & \alpha & 0 & \cdots & 0 & \beta(-\bar{\alpha})^1 \\ \beta(-\bar{\alpha})^1 \bar{\beta} & \beta(-\bar{\alpha})^0 \bar{\beta} & \alpha & \cdots & 0 & \beta(-\bar{\alpha})^2 \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ \beta(-\bar{\alpha})^{n-1} \bar{\beta} & \beta(-\bar{\alpha})^{n-2} \bar{\beta} & \cdots & \cdots & \alpha & \beta(-\bar{\alpha})^n \\ -(-\bar{\alpha})^n \bar{\beta} & -(-\bar{\alpha})^{n-1} \bar{\beta} & \cdots & \cdots & -(-\bar{\alpha})^0 \bar{\beta} & -(-\bar{\alpha})^n \end{bmatrix}$$

where

$$\alpha = \alpha(r, s) = \cos(\pi r) + i \sin(\pi r) \cos(\pi s)$$

$$\beta = \beta(r, s) = i \sin(\pi r) \sin(\pi s)$$

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What's wrong in computing today

- Not enough resolution on displays
- Not enough processing power and memory
- Not enough parallelism
- Software tools are “flat” and sequential rather than hierarchical

The intelligent mathematical assistant

- Adaptive symbolic input and output
- Strong basic skills (all of arithmetic through college calculus and elementary discrete structures)
- First order logic capabilities
- Adaptive “patterning” and “symboling”
- Elementary hypothesis generation and testing