

Human problem solving: Introduction to human optimization

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Douglas Vickers (1940-2004)

- We first pause to remember the life and career of Douglas Vickers, who died on October 31 last year.

Historical background

- Würzburg group (Külpe) – beginning of the 20th century:
 - Rejection of associationism
 - Goal-directedness of thinking
- Otto Selz (1930s):
 - Means-ends (automatic) analysis in problem solving

Gestalt School

- Köhler (1917), Duncker (1935), Wertheimer (1945):
 - The role of mental representation
 - The concept of insight
 - e.g. construct 4 triangles from 6 matches
 - Verbal protocol as the dependent variable

Newell & Simon (1972)

- Computer simulations
- Search through the problem space as the main aspect of human problem solving
- Less emphasis on problem representation

Polya's (1945) contributions

- Understanding the problem and forming a plan for solution is more important than executing the plan
 - Consider using search in solving the task of constructing a triangle given one angle, altitude drawn from the vertex of the angle, and the perimeter of the triangle
- Heuristics, as rules of discovery. For example:
 - (i) have brains and good luck
 - (ii) sit tight and wait till you get a good idea

The New Approach

- Looking back on the last 10-15 years, it becomes apparent that we – the assembled company – have developed a new approach to human problem solving

Significance

- Studying how humans solve optimization problems, such as the traveling salesman, represented quite a dramatic shift in research on human thinking and problem solving

Optimization Problems

- These problems are computationally difficult, but humans achieve high performance
- Compare Wason's selection task: “not true that if p then q ”
 - Mathematically easy
 - Psychologically difficult

Experimental Methodology

- Solid experimental methodology (like that in psychophysics), can be adopted
 - Large number of randomly generated trials
 - Quantitative dependent variables: response time, proportion correct, magnitude of error
- Compare solving Tower of Hanoi
 - One trial per subject
 - Qualitative dependent variable (recording subject's reports about what he thought he was thinking when he was solving a problem)

Formulating Models

- Computational models are formulated and tested against quantitative data
 - Fitting models to the data
- Compare the challenging task of fitting a computational model to verbal reports (without a plausible theory of verbal communication)

The emerging field of human optimization

- As interest in the psychology of human optimization has gradually increased, we might ask:
 - “How does this fit into the big picture?”

The 1962 Procter & Gamble competition

- One prize of \$10,000 and 54 prizes of \$1,000 were offered for finding the shortest round-trip route through 33 US cities, starting and finishing in Chicago
- Attracted much interest from academics and laypeople

Combinatorics of the problem

- $\sim 1.32 \times 10^{35}$, or 132 billion trillion trillion possible routes through a 33-city TSP
- If one entered the competition, and programmed a computer to find every single route and select the optimal (shortest), it would take about 417 billion trillion years (assuming the computer found 10,000 routes per second, at 1962 speeds)

Importance of combinatorial optimization problems

- Pure mathematics and computer science
 - $P=NP???$
 - Finding efficient algorithms
- Operations research and management science
 - Real life solutions to optimization problems
 - Constraints
- Psychology and neuroscience
 - Human optimization ability
 - Cognitive/neural heuristics for optimization

Progress and communication

- Considerable progress in individual fields
 - e.g. recent solution of the 24,978 cities of Sweden TSP; elucidation of candidate human heuristics
- Not a great deal of interdisciplinary communication
- This meeting was conceived as an effort to bring together scientists with a shared interest in human optimization ability

Cross-fertilization

- What do psychologists need to learn from mathematical scientists?
- What do mathematical scientists need to learn from psychologists?
- What are the priority themes and challenges for interdisciplinary research at a basic science level?
- What are the priority themes and challenges for end-user focused research?

A unique opportunity

- A chance to come together in a spirit of openness and cooperation, to share ideas and methods
- We hope that the program will stimulate plenty of discussion and the emergence of new collaborations

A flexible timetable

- We want to make the program flexible
 - no “Psychonomic Time”
 - no “2-minute warnings”
 - we’ll reschedule on the fly if need be
 - nominal 45 minutes per talk, including discussion
 - Tuesday morning plenary sessions

An optimization challenge

- Where SHOULD we have held this meeting, to minimize the total distance traveled by delegates (assuming straight line travel, and using the list of delegates printed in the program)?
- A small prize will be awarded for the most convincing answer provided by Tuesday morning