Chapter 25. Controversies and Alternative Paradigms

The Quest for Artificial Intelligence, Nilsson, N. J., 2009.

Lecture Notes on Artificial Intelligence, Spring 2012

Summarized by Lee, Bado and Seok, Ho-Sik

Biointelligence Laboratory
School of Computer Science and Engineering
Seoul National Univertisy

http://bi.snu.ac.kr

Contents

Overview of Chapter 25

- A number of controversies among AI researchers themselves arises
  - About Logic, “Kludginess”, About Behavior
- Scaling Back AI’s Goals
  - More effort on what AI could *actually* achieve
  - From Good-old-fashioned AI to new paradigms

Chapter 25. Controversies and Alternative Paradigms

25.1 About Logic

About Logic

- “Logicists”
  - GOFAI: Good-old-fashioned AI
  - Those who used logical representations and logical reasoning methods
- Drew McDermott – doubts on logic of AI
  - Prominent Logicist who began to have doubts about the role of logics in AI
  - In 1987 paper
    - “…a lot of reasoning can be analyzed as deductive or approximately deductive, is erroneous”, “Unfortunately, the more you attempt to push the logicist project, the less deduction you find. What you find instead is that many inferences which seem so straightforward that they *must* be deductions turn out to have nondeductive components”
  - The discussions about the role of logic in artificial intelligence helped reshape AI’s use of logic, and, in extended form, it still serves as the primary means for representing declarative knowledge

Chapter 25. Controversies and Alternative Paradigms

25.2 Uncertainty

Uncertainty

- Human knowledge is uncertain
  - Whereas logical sentences must be either true or false
- Examples of expert systems with uncertainty
  - MYCIN
    - "Certainty factors"
  - PROSPECTOR
    - Use of probability values
- Alternative for the use of probability
  - Dempster-Shafer (D-S) theory
    - Assigning degrees of belief to statements and for combining degrees of belief based on independent items of evidence

“Fuzzy Logic” as an Alternative for use of probability

- “Fuzzy Logic”
  - Invented by computer scientist Lotfi Zadeh (1921- ; Fig 25.1)
  - Allows truth values of statements to take on any value between 1 (certainly true) and 0 (certainly false)
  - Based on fuzzy set theory in which set membership can take on intermediate values between “in the set” and “not in the set”
  - Zadeh points out that his truth values and set membership values cannot be construed as probabilities
  - “Soft Computing”

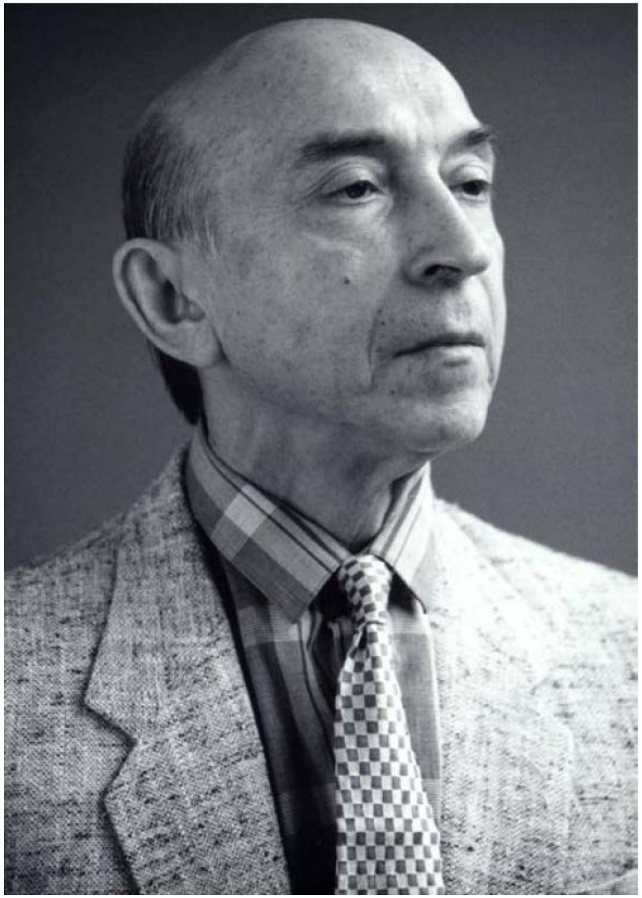

Figure 25.1: Lotfi Zadeh.
(Photograph courtesy of Lotfi Zadeh.)

Chapter 25. Controversies and Alternative Paradigms

25.3 “Kludginess”

"Kludginess"

- Human brain intelligence is "kludge"
- Definition of "kludge"
  - 1. A system, especially a computer system, that is constituted of poorly matched elements or of elements originally intended for other applications
  - 2. A clumsy or inelegant solution to a problem
- Minsky said
  - "Each part of brain is what engineers call a kludge"
  - Evidence: human brain has many hundreds of parts – if our minds were based on only a few basic principles, we wouldn't need so much complexity
- "scruffies" vs. "neats"
  - Scruffies: who favored systems consisting of collections of experimentally derived, ad hoc routines designed to solve specific problems
  - Neats: who favored programs based on theoretically based principles

Chapter 25. Controversies and Alternative Paradigms

25.4 About Behavior

25.4.1 Behavior-Based Robots

- Behavior-Based approach to building robots that operate in the real world
- Genghis
  - Brooks's robots using layered circuitry
  - Six-legged robot with two front sensors "whiskers"
  - "Subsumption architecture"
  - "augmented finite-state machines"
- "Elephants Don't Play Chess"
  - Quite complex behavior (elephant for example) can be achieved with systems that do not have the representational and resoning powers required for intelligent activities such as playing chess

Figure 25.2: Rodney Brooks (top) and his Crawling Robot, Genghis (bottom).

25.4.2 Teleo-Reactive Programs

- A T-R program
  - Intermediate-level agent control program that robustly directs a robot toward a goal in manner that continuously takes into account the robot's perceptions of its dynamically changing environment
- Example of T-R program

kick(x)

1. Close (x) AND Facing (x) - > foot-swing
2. Close (x) - > face (x)
3. Facing (x) - > move-forward
4. True - > moveto (x)

face (x)

1. Facing (x) - > do-nothing
2. Left (x) - > rotate-ccw
3. True - > rotate-cw

moveto (x)

1. Close (x) - > do-nothing
2. Facing (x) - > move-forward
3. True - > face(x)

Chapter 25. Controversies and Alternative Paradigms

25.5 Brain-Style Computation

25.5.1 Neural Networks

Figure 25.3: David Rumelhart (left) and James McClelland (right). (Rumelhart photograph courtesy of Donald Rumelhart. McClelland photograph courtesy of James McClelland.)

25.5.2 Dynamical Processes

- Some researchers believe that dynamical processes, similar to those exhibited by Hopfield and Boltzmann networks (and including those described by sets of differential or difference equations), underlie much of the computation performed by the brain.

  A dynamical system for current purposes is a set of quantitative variables changing continually, concurrently, and interdependently over quantitative time in accordance with dynamical laws described by some set of equations. Hand in hand with this first commitment goes the belief that dynamics provides the right tools for understanding cognitive processes.

  . . .

  A central insight of dynamical systems theory is that behavior can be understood geometrically, that is, as a matter of position and change of position in a space of possible overall states of the system. The behavior can then be described in terms of attractors, transients, stability, coupling, bifurcations, chaos, and so forth – features largely invisible from a classical perspective.

  Tim van Gelder, *The MIT Encyclopedia of Cognitive Science*

- Randall Beer
  - Dynamical Approaches to Cognitive Science
  - Dynamical approaches are beginning to engage substantive empirical questions in cognitive science
  - Example: a simulated agent whose horizontal motion is controlled by a dynamical system implemented by a fourteen-neuron, continuous-time recurrent neural network

Chapter 25. Controversies and Alternative Paradigms

25.6 Simulating Evolution

Simulating Evolution (1/2)

- Genetic Algorithms
  - Gas attempt to evolve strings of symbols that encode a solution to some particular problem
  - Travelling salesman problem
    - We have a list of cities that must be visited, and we must find a tour that starts at one city, visits all of the others just once, and returns to the starting city
    - The problem is to find an ordering of the cities that minimizes the total distance traveled
    - The evolutionary process

1. Assembling a large population of random strings

2. Mutation and Crossover
   - Mutation: some of the strings undergo mutations in which the values of some of their components are changed.
   - Crossover: pairs of strings within a population that have relatively high fitness are selected to participate in an operation called “cross-over,” which generates an “offspring” string
   - Caution: the operation must preserve the “legality” of the offspring string

3. At each stage of the evolutionary process, the current generation of strings gives rise to a new generation → succeeding generations eventually contain strings that are better and better at solving the problem at hand

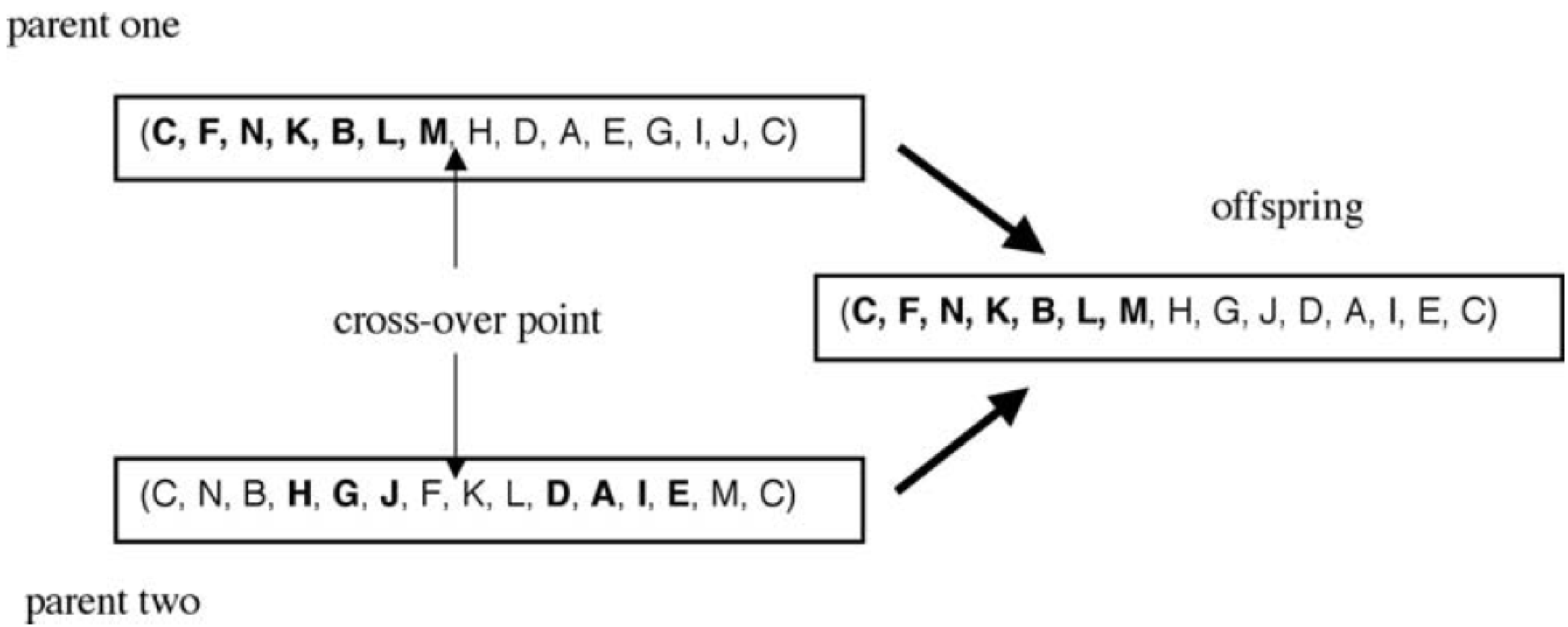

Figure 25.4: A cross-over operation.

Simulating Evolution (2/2)

- A genetic algorithm as a search process attempting to locate high points in a "fitness landscape."
  - Each possible GA string can be thought of as a "place" in a contour map, with the fitness of that string being the elevation at that place
  - Initially, GA strings are located randomly over the landscape and some of them move from their current positions (mutation and crossover)
  - After several generations, a GA process may find one peak in the fitness landscape
  - AI has used what mathematicians call hill-climbing (or gradient ascent) procedures, but before GAs these techniques usually involved only one "climber." GAs, along with other evolutionary algorithms, allow several climbers to search simultaneously, resulting in what is called "parallel search."
- Genetic Programming
  - GP evolves LISP programs rather than strings.
  - Starting with a random collection of programs containing some basic LISP functions and constants → random mutations and cross-over are used to produce new generations of programs
  - "Virtually all problems in artificial intelligence, machine learning, adaptive systems, and automated learning can be recast as a search for a computer program. Genetic programming provides a way to successfully conduct the search for a computer program in the space of computer programs" – John Koza.

Figure 25.5: John Koza.

Chapter 25. Controversies and Alternative Paradigms

25.7 Scaling Back AI's Goals

Scaling Back AI's Goals

- AI researcher began to focus on more modest and achievable goals than on those of previous years
- More work on limited or "weak" AI and less on "strong AI"
- Using AI to help humans rather than to replace them
- AI technologies were used, when appropriate, as components of large, integrated systems.
- AI researchers began to be satisfied with adding bits of intelligence here and there to the large, integrated systems to make them more useful and appealing