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A Technique to Combine Hill-Climbing With a Random Walk towards Efficiency and Completeness

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Abstract: Biological systems interact within their environment by actuation, speech, etc. All behavior is centered around actions in the world. Examples include controlling the steering of a Mars rover or autonomous vehicle, or suggesting tests and making diagnoses for a medical diagnosis system. Includes areas of robot actuation, natural language generation, and speech synthesis. The cost threshold is initialized to the heuristic estimate of the initial state, and in each successive iteration is increased to the total cost of the lowest-cost node that was pruned during the previous iteration. This paper provides a technique to combine hill-climbing with a random walk towards efficiency and completeness.

Index Terms: Artificial Intelligence, AI Systems, Intelligent systems

1. INTRODUCTION

- Artificial Intelligence is concerned with the design of intelligence in an artificial device. The termwas coined by John McCarthy in 1956.
- Intelligence is the ability to acquire, understand and apply the knowledge to achieve goals in theworld.
- AI is the study of the mental faculties through the use of computational models
- AI is the study of intellectual/mental processes as computational processes.
- AI program will demonstrate a high level of intelligence to a degree that equals or exceeds theintelligence required of a human in performing some task.
- AI is unique, sharing borders with Mathematics, Computer Science, Philosophy, Psychology, Biology, Cognitive Science and many others.
- Although there is no clear definition of AI or even Intelligence, it can be described as an attempt to build machines that like humans can think and act, able to learn and use knowledge to solve problems on their own.

Building AI Systems

1) **Perception**

Intelligent biological systems are physically embodied in the world and experience the world through their sensors (senses). For an autonomous vehicle, input might be images from a camera and range information from a rangefinder. For a medical diagnosis system, perception is the set of symptoms and test results that have been obtained and input to the system manually.

2) **Reasoning**

Inference, decision-making, classification from what is sensed and what the internal "model" is of the world. Might be a neural network, logical deduction system, Hidden Markov Model induction, heuristic searching a problem space, Bayes Network inference, genetic algorithms, etc.

Includes areas of knowledge representation, problem solving, decision theory, planning, game theory, machine learning, uncertainty reasoning, etc.

Intelligent Systems

In order to design intelligent systems, it is important to categorize them into four categories (Luger andStubberfield 1993), (Russell and Norvig, 2003)

1. Systems that think like humans
2. Systems that think rationally
3. Systems that behave like humans
4. Systems that behave rationally

	Human- Like	Rationally
Think:	**Cognitive Science Approach** *"Machines that think like humans"*	**Laws of thought Approach** *"Machines that think Rationally"*
Act:	**Turing Test Approach** *"Machines that behave like humans"*	**Rational Agent Approach** *"Machines that behave Rationally"*

Scientific Goal: To determine which ideas about knowledge representation, learning, rule systemssearch, and so on, explain various sorts of real intelligence.

Engineering Goal: To solve real world problems using AI techniques such as Knowledge representation,learning, rule systems, search, and so on.

Traditionally, computer scientists and engineers have been more interested in the engineering goal, while psychologists, philosophers and cognitive scientists have been more interested in the scientific goal.

Cognitive Science: Think Human-Like

a. Requires a model for human cognition. Precise enough models allow simulation by computers.
b. Focus is not just on behavior and I/O, but looks like reasoning process.
c. Goal is not just to produce human-like behavior but to produce a sequence of steps of the reasoning process, similar to the steps followed by a human in solving the same task.

Laws of thought: Think Rationally

a. The study of mental faculties through the use of computational models; that it is, the study of computations that make it possible to perceive reason and act.
b. Focus is on inference mechanisms that are probably correct and guarantee an optimal solution.

c. Goal is to formalize the reasoning process as a system of logical rules and procedures of inference.
d. Develop systems of representation to allow inferences to be like “Socrates is a man. All men are mortal. Therefore Socrates is mortal”

Turing Test: Act Human-Like

a. The art of creating machines that perform functions requiring intelligence when performed by people; that it is the study of, how to make computers do things which, at the moment, people do better.
b. Focus is on action, and not intelligent behavior centered around the representation of the world
c. Example: Turing Test

- 3 rooms contain: a person, a computer and an interrogator.
- The interrogator can communicate with the other 2 by teletype (to avoid the machine imitate the appearance of voice of the person)
- The interrogator tries to determine which the person is and which the machine is.
- The machine tries to fool the interrogator to believe that it is the human, and the person also tries to convince the interrogator that it is the human.
- If the machine succeeds in fooling the interrogator, then conclude that the machine is intelligent.

Rational agent: Act Rationally

a. Tries to explain and emulate intelligent behavior in terms of computational process; that it is concerned with the automation of the intelligence.
b. Focus is on systems that act sufficiently if not optimally in all situations.
c. Goal is to develop systems that are rational and sufficient

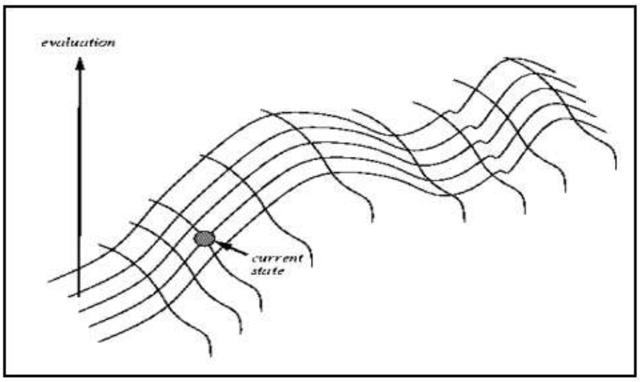
I. Hill Climbing Algorithm

We will assume we are trying to maximize a function. That is, we are trying to find a point in the search space that is better than all the others. And by "better" we mean that the evaluation is higher. We might also say that the solution is of better quality than all the others.
The idea behind hill climbing is as follows.

1. Pick a random point in the search space.
2. Consider all the neighbors of the current state.

3. Choose the neighbor with the best quality and move to that state.
4. Repeat 2 thru 4 until all the neighboring states are of lower quality.
5. Return the current state as the solution state.

We can also present this algorithm as follows (it is taken from the AIMA book (Russell, 1995) and follows the conventions we have been using on this course when looking at blind and heuristic searches).



Algorithm:
Function HILL-CLIMBING(Problem) **returns** a solution stateInputs: Problem, problem
Local variables: Current, a node
Next, a node
Current = MAKE-NODE(INITIAL-STATE[Problem])
Loop do
Next = a highest-valued successor of Current
If VALUE[Next] < VALUE[Current] **then return** CurrentCurrent = Next

End
Also, if two neighbors have the same evaluation and they are both the best quality, then the algorithm will choose between them at random.

II. Simulated annealing search
A hill-climbing algorithm that never makes “downhill” moves towards states with lower value (or higher cost) is guaranteed to be incomplete, because it can stuck on a local maximum. In contrast, a purely random walk –that is, moving to a successor chosen uniformly at random from the set of successors – is complete, but extremely inefficient. Simulated annealing is an algorithm that combines hill-climbing with a random walk in some way that yields both efficiency and completeness.

- IDA* is complete & optimal Space usage is linear in the depth of solution. Each iteration is depth first search, and thus it does not require a priority queue.
- Iterative deepening A* (IDA*) eliminates the memory constraints of A* search algorithm without sacrificing solution optimality.
- Each iteration of the algorithm is a depth-first search that keeps track of the cost, f(n) = g(n) + h(n), of each node generated.

- As soon as a node is generated whose cost exceeds a threshold for that iteration, its path is cut off, and the search backtracks before continuing.

2. CONCLUSION

The main problem with hill climbing (which is also sometimes called **gradient descent**) is that we are not guaranteed to find the best solution. In fact, we are not offered any guarantees about the solution. It could be abysmally bad. You can see that we will eventually reach a state that has no better neighbours but there are better solutions elsewhere in the search space. The problem we have just described is called a local maxima. This paper provided a technique to combine hill-climbing with a random walk towards efficiency and completeness

3. REFERENCES

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