EEL5840: Elements of Machine Intelligence

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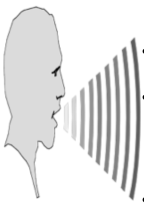
Announcements



- Reading Assignment:
  - > Nilsson chapters 9, 10
- Announcements:
  - > Tentative 2nd Exam Dates:
    - – 12/1/09 (Tuesday)
    - – 12/3/09 (Thursday)
  - > LISP Project due 12/01/09
- Today's Handouts in WWW:
  - > Outline Class 24
- Web Site
  - > www.mil.ufl.edu/eel5840
  - > Software and Notes

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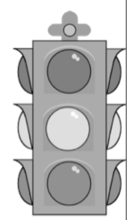
Today's Menu

- Finish up Heuristic Search (Chapter 9)
  - ⇒Final Comments on the Admissibility of A*
  - ⇒IDA* & RBFS
  - ⇒Search Efficiency



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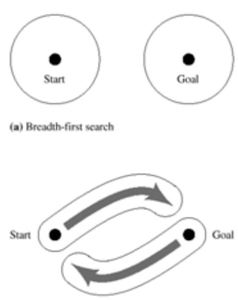
Heuristic Searches

Related Algorithms
- Bi-Directional Search
  - >Breadth-First may expand less nodes bi-directionally than uni-directionally as shown in the Figure.
  - >However, if the *h*(n) used by the bidirectional process are slightly inaccurate, the search frontiers may not intersect.



(a) Breadth-first search

(b) Heuristic search

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Heuristic Searches

Related Algorithms
- Staged Search : Prune the tree at some stages of computation in order to free up storage. At the end of each stage you keep only the most promising nodes (those with good *f* values). Obviously, staged search carries no guarantee of optimality

- Limitation of Successors - to keep Γ(n) small we also keep only the "best" nodes
  - >We will need additional problem domain knowledge (i.e., a DEADEND)
  - >We either modify A^* or assign to some nodes very high *h*(n) values
  - >Consider evaluating *h*(Γ(n)) *before* evaluating the DBs themselves and only select those nodes with high promise

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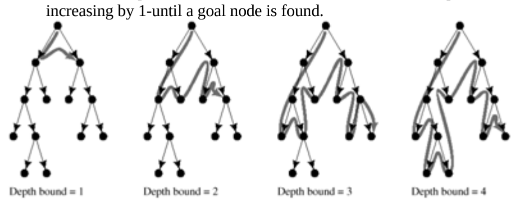
Heuristic Search

- Iterative Deepening
  – Enjoys the same linear memory requirements of DFS while guaranteeing that a goal node of minimal depth will be found- memory grows linearly with the depth of the goal.
  – Successive depth-first searches are conducted-each with a depth bound increasing by 1-until a goal node is found.



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Heuristic Search

- How many nodes are expanded by BFS?
  Assuming uniform branching factor b, with a goal at depth d
  $1 + b + b^2 + \ldots + b^d = (b^{d+1} - 1)/(b-1)$
- How many nodes are expanded by iterative deepening?
  Down to level j we have $N_{dfj} = (b^{j+1} - 1)/(b-1)$
  At worst, we must conduct d such searches for the goal at depth d
  $N_{id} = \sum_{j=0}^{d} (b^{j+1} - 1)/(b-1) = (b^{d+2} - 2b - bd + d + 1)/(b-1)^2$
  for large d this reduces to
  $N_{id}/N_{bf} \approx b/(b-1)$
  For b=10 and large d this is about 1.11% or ID expands about 11% more nodes than BFS

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Heuristic Search

- IDA* (Korf, 1985)
  > Allows us to find minimal cost paths with memory that grows linearly with the depth of the goal.
  > Execute a series of depth-first searches. In the first search we establish a cost cutoff equal to $f(n_0)=g(n_0)+h(n_0)=h(n_0)$ with $n_0=s$.
  > Expand nodes in a DFS fashion—backtrack whenever the f value of a successor of an expanded node exceeds the cutoff value.
  > If this terminates at a goal node, then you have a minimal path, else the cost of an optimal path must exceed the cutoff value.
  > Use as your next cutoff value the value of a node visited but not expanded
  > IDA* does have to repeat node expansions, but there are potential tradeoffs involving reduced memory requirements and ease of implementation

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Performance Issues

Penetrance

- The penetrance P of a search algorithm measures the extent to which the search focuses toward a goal and does not wander off
  P = L/T where L = length of a found path to the goal
  T = total number of nodes (excluding s)
  P_{max}=1 P is a function (difficulty, efficiency of search)
  T grows faster than L and thusly P is usually high for small L and small for large L
  P measures when a tree is elongated vs bushy

Branching Factor

- The branching factor B is based on a tree having
  > depth equal to path length
  > a total number of nodes = to the nodes generated during search
  B measures the constant number of successors of each node in such a tree

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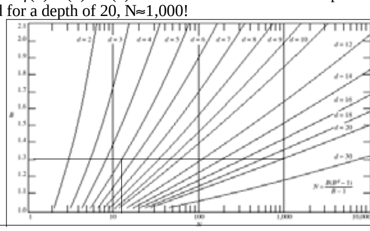
Performance Issues

Branching Factor

$B + B^2 + B^3 + \ldots + B^L = N$ L = total path length
N = total number of nodes

$\frac{[B^L - 1]B}{B - 1} = N$ if $B \approx 1$ we have a *focussed* search

For the problem f(n)=d(n)+W(n) the B value is $B \approx 1.3$ For a depth of 18, N≈500 nodes and for a depth of 20, N≈1,000!



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The End!