Informed Search

(A* Search & Heuristics)

★ The One Queue

⇒ All these search algorithms are the same except for fringe strategies.

↳ Conceptually, all fringes are priority queue

{Collection of nodes with attached priorities}

★ Search Heuristics

⇒ A heuristic is a function that estimates how close a state is to a goal.

↳ Designed for a particular search problem.

★ Greedy Search

⇒ Expand the node that looks closest.

⇒ Worst case: like a badly guided DFS.

★ A* Search

⇒ Let $g(n)$ ⇒ Path cost

$h(n)$ ⇒ heuristic cost (distance of goal)

⇒ A* Search orders by the sum:

$$f(n) = g(n) + h(n)$$

⇒ Admissble (optimistic) heuristics slow down bad plans but never overweights true cost.

⇒ Inadmissible (pessimistic) heuristics breaks optimality by trapping good plans on the fringe.

⇒ A heuristic h is admissible if

$$\boxed{0 \leq h(n) \leq h^*(n)}$$

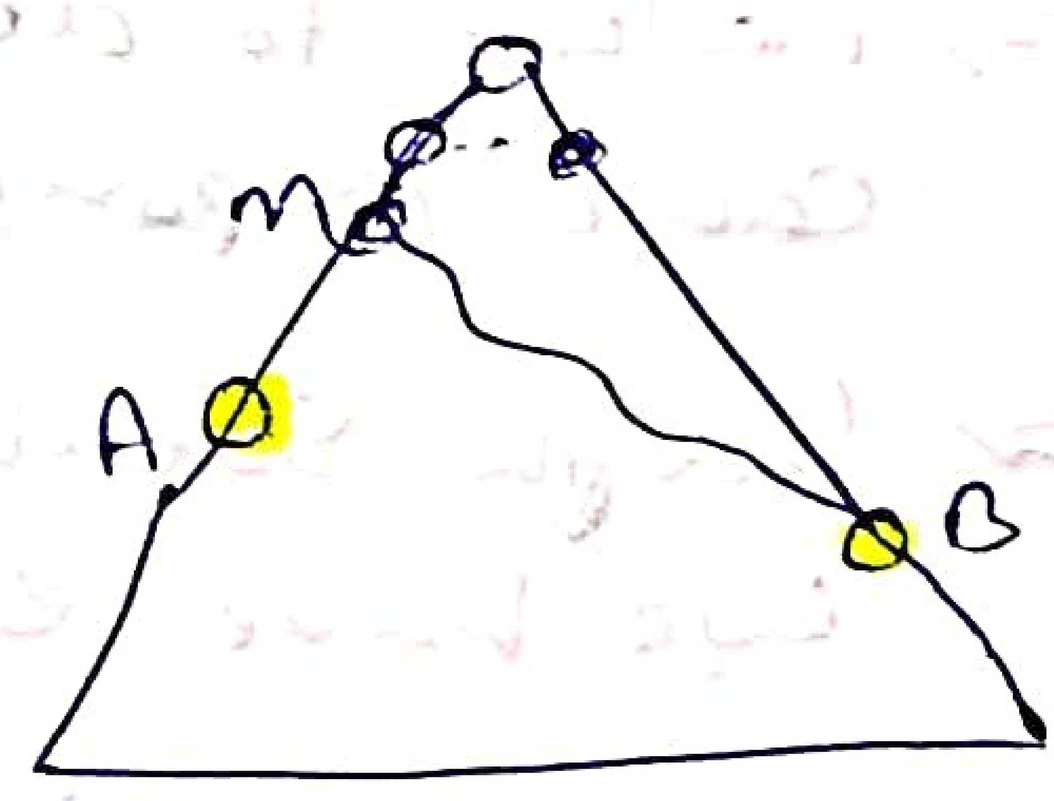
where $h^*(n)$ is the true cost to a nearest goal.

⇒ If heuristic is admissible then A* Search is optimal.

Proof

Assumptions

* A is optimal goal node
* B is suboptimal goal node
* h is admissible



Claim
→ A exits the fringe before B

⇒ Imagine B is on the fringe
⇒ Some ancestor n of A is on the fringe, too

- $f(n) \leq f(A)$ {As h is admissible}
- $f(A) < f(B)$ {As B is suboptimal}
- $f(n) < f(B)$ ⇒ So n expands before
- If n=A then A expands before B

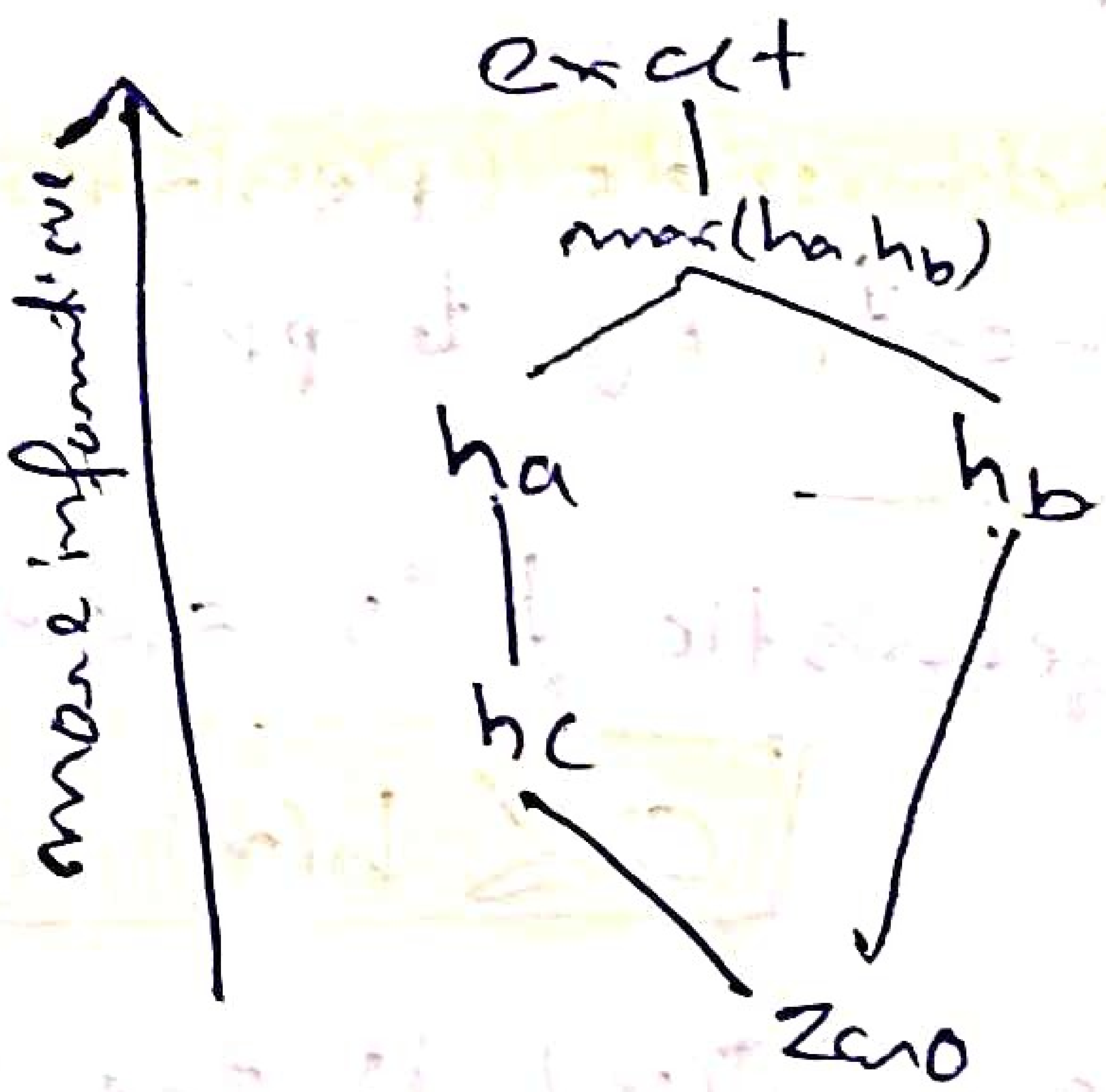
⇒ Most of the work in solving hard search problems optimally is coming up with admissible heuristics.

⇒ Relaxed-problem heuristic

★ **Dominance**

$\forall n \; h_a(n) > h_c(n)$

⇒ Max of admissible heuristics is admissible.



★ **Graph Search**

Tree Search ⇒ Extra Work!

⇒ Failure to detect repeated states can cause exponentially more work.

⇒ Graph Search will keep track of list of node we have expanded and not expand them again.

⇒ How to implement:

* Tree Search + Set of expanded states ("Closed Set")
* Expand the search tree node-by-node but
* Before expanding a node, check to make sure its state has never been expanded before.
* If not new skip it, if new add it to closed set.

⇒ For a graph A* search to return optimal path, heuristic need to be consistent.

{A stronger condition than admissible heuristics}

⇒ Consistent heuristic:

$$\boxed{h(A) - h(C) \leq \text{Cost}(A \text{ to } C)}$$

⇒ Consequence of Consistency:

↳ The f value along a path never decreases

$$h(A) \leq \text{Cost}(A \text{ to } C) + h(C)$$

$$f(A) = g(A) + h(A) \leq \underbrace{g(A) + \text{Cost}(A \text{ to } C) + h(C)}_{= f(C)}$$

$$\boxed{f(A) \leq f(C)}$$