

lec #8Bi-directional Search (BDS)

ال branch factor على ادى ال states لتقريبه انما في ال goal فيه.  
فعلوا كل يقينيه، واحد يقينيه ال initial، على يمين ال goal  
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لـ لو اتقابلوا في المنتصف، مجموع ال path يتاخم وده بيتسمى ال  
Final Solution

- one forward from initial to goal and one backward from goal to initial; hoping they meet in the middle.

- Complexity:  $b^{d/2} + b^{d/2} = O(b^{d/2})$

- Implemented by replacing the goal test with a check to see whether the frontiers of the 2 searches intersect

كل واحد من ال searches ممكن يستخدم اي technique من ال technique  
بقية

forward: by successors → القادم  
backward: by predecessors → السابق

- Complete and optimal (if both are BFS or any other optimal technique)

the uninformed technique: BFS  
DFS  
UCS  
DFS-limited  
iterative

## Informed (Heuristic) Search strategies

عند معلومات إضافية عن توجيه (الهدف) Search وتوجيه

يتم استخدام Evaluation Function لترتيب كل الـ values بناءً على children التي تم Expand

- informed search is more efficient than uninformed search
- use problem-specific knowledge
- the search is goal directed

Goal-directness is done by an evaluation function that assigns a number to each node indicating how the node is closed to the goal.

بتوجيه مدى قرب اربعد النقطة من الـ goal.

- general approach: Best-First search

### ① Best-First Search

- nodes with the lowest evaluation are expanded first

- use: priority queue.

هو مثل الأولاد

- evaluation function = Heuristic function  $h(n)$ .  
if:  $h(n) = 0 \rightarrow$  the  $(n)$  is the goal

the most common form

Note:  
the evaluation function is constructed as a cost estimate function.  
ترتيب كل الـ values بناءً على children التي تم Expand



## [2] Greedy Best-fit Search

- expand nodes close to the goal and lead to the solution quickly.

$f(n) = h(n)$   
 ← مقياس مدى الاقتراب من الهدف Heuristic  
 ← evaluation      Heuristic

- need to choose a particular problem because the Heuristic Function is problem-specific.

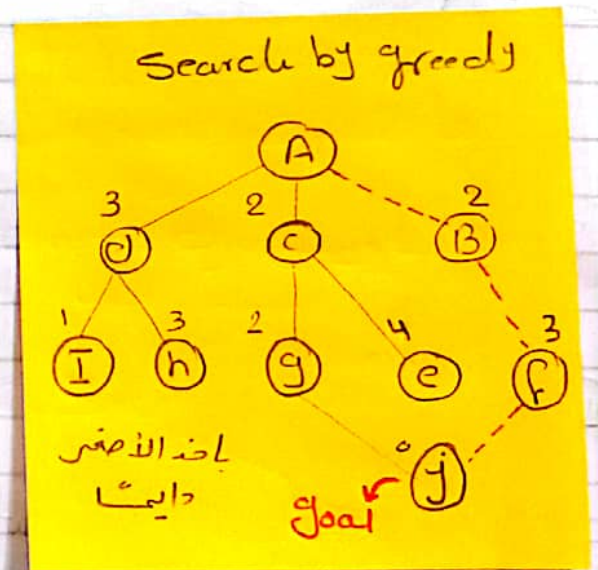
كل مشكلة لها التقييم الخاص بها  
 على اساسه نحدد max او min  
 او اي حاجة تقربنا للهدف

(المرجع عند الحل)

- Heuristic is not optimal  
 ممكن يبقى عنى طيات احسنه  
 اسرع وبالتالي ال search منه صعبه

- greedy is incomplete

without systematic  
 checking of repeated  
 states. (infinite path)



Time and space complexity:  $O(b^m)$

- fully dependent on Heuristic Function

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### ③ A\* (A star) search

initial Heuristic  $h(n)$   $g(n)$  Actual  $g(n)$

A\* search combines Greedy and Uniform Cost search

$$\text{evaluation function } f(n) = g(n) + h(n)$$

total path  
Cost

actual Cost  
to reach  $(n)$

estimated Cost  
to reach  $(n)$

من الانفر اختار ان  
total Path cost

### Conditions for Optimality:

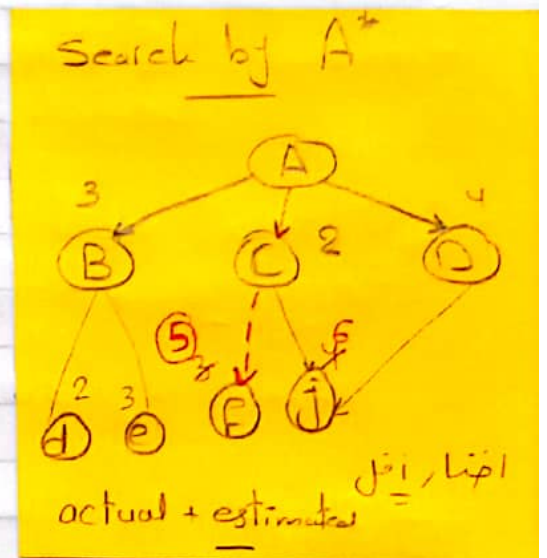
#### ① 1st Condition

- Heuristic is, admissible

estimation  $h(n)$  never overestimates  
Actual  $g(n)$  the cost to reach the  
بأي حال goal.

$$h(n) \leq h^*(n) \quad \text{actual}$$

↓  
estimated



- Heuristic is optimistic optimal (Never estimate the actual road).

Theorem: if  $h(n)$  is admissible then A\* is optimal using tree-search!!



⑤

Subject

موضوع الدرس

Date

التاريخ

## ② 2<sup>nd</sup> Conditions : Consistency (Monotonicity)

$$h(n) \leq c(n, a, n') + h(n')$$

طول ضئلا ما هي  
افضل انك الموضوع  
Consistent

actual cost  
from n to n'

estimated cost  
from n → goal

(ال actual دائما يزيه) - every consistent heuristic is admissible

theorem : if  $h(n)$  is consistent,  $A^*$  using graph search is optimal.

- Optimal and Complete