Artificial Intelligence Planning

Heuristic Search Planning

A Tiny (But Tasty) Appetizer

Jörg Hoffmann

SAARLAND UNIVERSITY
COMPUTER SCIENCE

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Thanks to everybody who contributed to the work described here!

Agenda

1. Why?
2. What?
3. How?
4. Theory
5. Practice
6. And Now?

Why?

IPC = The International Planning Competition:

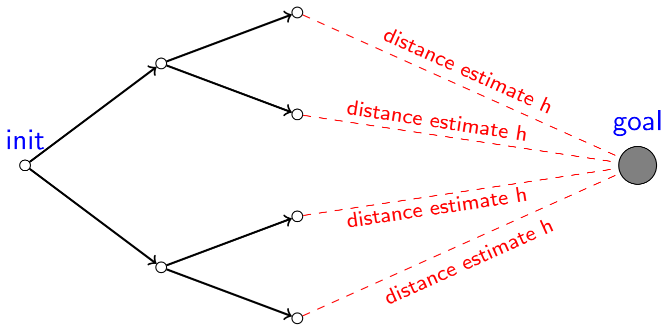
- **IPC 2000 Winner:** heuristic search.
- **IPC 2002 Winner:** heuristic search.
- **IPC 2004 Winner:** satisficing: heuristic search, optimal: SAT.
- **IPC 2006 Winner:** satisficing: heuristic search, optimal: SAT.
- **IPC 2008 Winner:** satisficing: heuristic search, optimal: symbolic search.
- **IPC 2011 Winner:** satisficing: heuristic search (first 12 places), optimal: heuristic search (first 9 places).

ATTENTION!

- This is only for the fully-automatic deterministic tracks of the IPC.
- This does NOT mean heuristic search is universally better; it's only the IPC setup.
- "Winner" is a very inadequate summary of such huge and complex events.

→ All I'm saying is: This approach has been mainstream in academic planning research during the last decade, and has produced a lot of interesting results.

What (1): Heuristic (Forward) Search

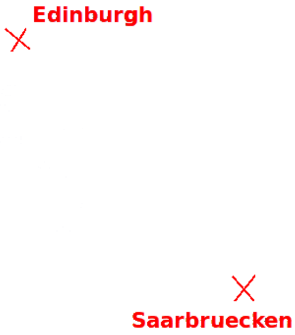


→ Heuristic function h maps world states s to an estimate $h(s)$ of goal distance. Search prefers to explore states with small h.

What (2): Heuristic Functions

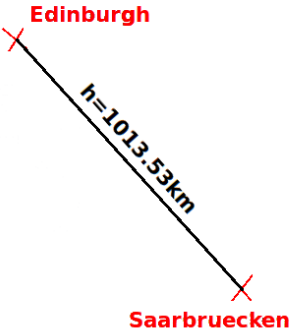
Problem: Find a route from Saarbruecken To Edinburgh.

What (2): Heuristic Functions



Simplified Problem: Throw away the map.

What (2): Heuristic Functions



Heuristic function: Straight line distance.

How?

Ignoring Deletes

$h^{\max}$

h^{+}

Abstractions

PDB

M&S

Critical Paths

h^1

h^2

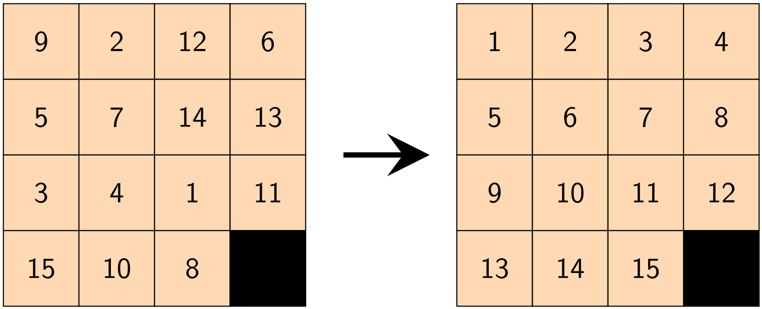
h^3

...

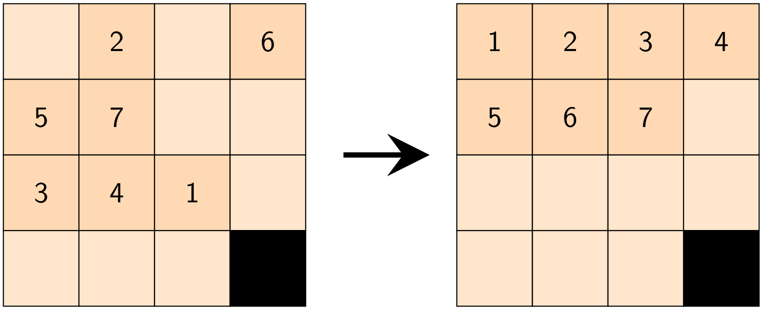
Landmarks

h_L^{LM}

Abstractions in the 15-Puzzle



Abstractions in the 15-Puzzle



$\rightarrow h =$ **Solution to Smaller (and Easier) Puzzle**

How?

Ignoring Deletes

h^{max}

h^{+}

Abstractions

PDB

M&S

Critical Paths

h^{1}

h^{2}

h^{3}

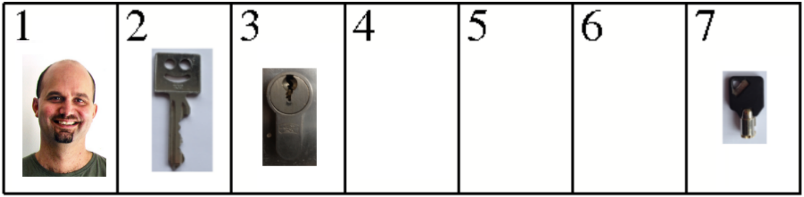
...

Landmarks

h_{L}^{LM}

Landmarks

Problem: Bring small key to position 1.



Landmarks:

- Joerg-at-2, Joerg-at-3, Joerg-at-4, Joerg-at-5, Joerg-at-6, Joerg-at-7.
- Lock-open.
- Have-big-key.
- Have-small-key.
- ...

$\rightarrow h =$ **"Number of open items on the to-do list"**

How?

Ignoring Deletes

h^{max}

h^+

Abstractions

PDB

M&S

Critical Paths

h^1

h^2

h^3

$\dots$

Landmarks

h_L^{LM}

Critical Paths in TSP

$\rightarrow h^m =$ **Most Expensive** m**-Sub-Tour**

How?

Ignoring Deletes

h^{max}

h^{+}

Abstractions

PDB

M&S

Critical Paths

h^1

h^2

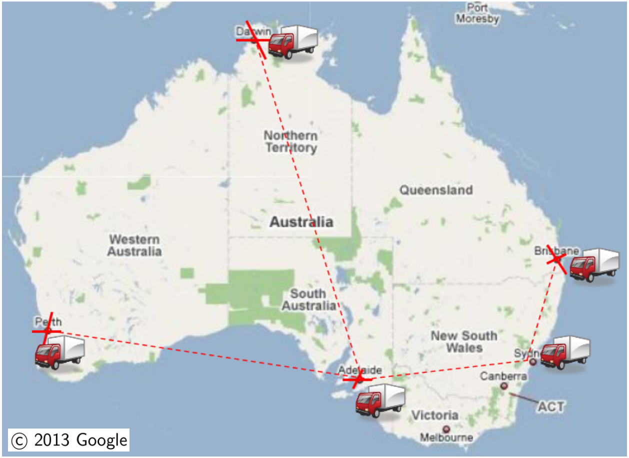
h^3

$\ldots$

Landmarks

h_L^{LM}

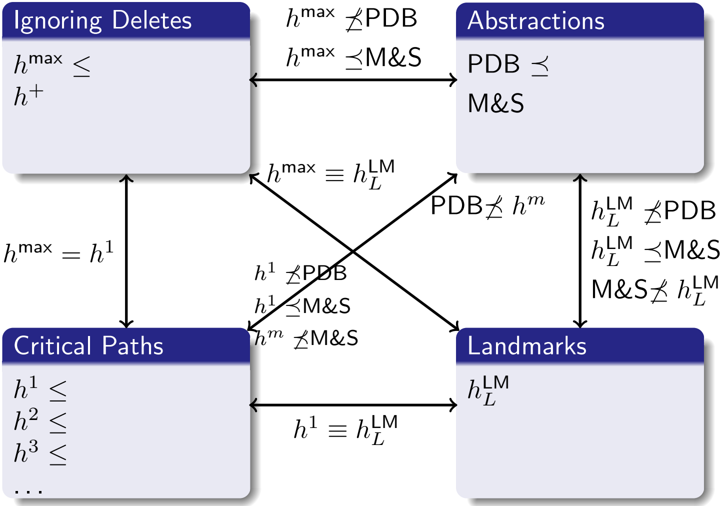
Ignoring Deletes in TSP



$\rightarrow h =$ **Minimum Spanning Tree**

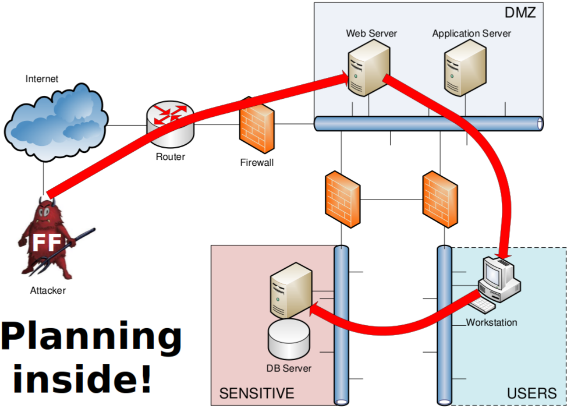
Theory

Compilability between lower-bound h:



Practice

Problem: Regular security checks by running (millions of) attacks.



Planning inside!

$\rightarrow$ Solution@Core Security: Heuristic Search Planning!

And Now?

If your appetite is stimulated, you can have a look at my lecture slides . . .

`http://fai.cs.uni-saarland.de/teaching/winter12-13/planning.html`

. . . and/or google some of the great people who contributed to this area:

- Blai Bonet
- Carmel Domshlak
- Hector Geffner
- Patrik Haslum
- Malte Helmert

→ This list is very incomplete, there's lots more people who contributed!

And Now?

You can also have a look at some papers:

- Abstractions: [Edelkamp (2001); Haslum *et al.* (2007); Helmert *et al.* (2007)]
- Landmarks: [Hoffmann *et al.* (2004); Karpas and Domshlak (2009); Richter and Westphal (2010)]
- Critical Paths: [Haslum and Geffner (2000)]
- Ignoring deletes: [Bonet and Geffner (2001); Hoffmann and Nebel (2001); Keyder *et al.* (2012)]
- Compilability: [Helmert and Domshlak (2009)]
- Security tests: [Lucangeli *et al.* (2010); Sarraute *et al.* (2012)]

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