COMP90054 – Week 5 tutorial

Last updated: 27 March 2023

Generating heuristic function via relaxation

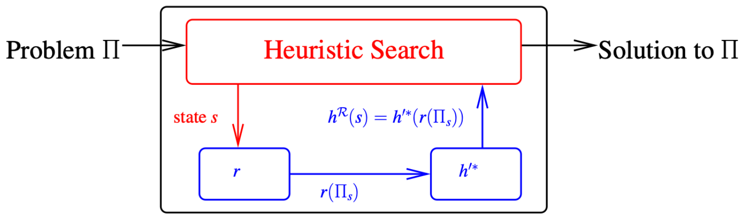
Objective

- Find an estimate of the perfect heuristic h^* for problem $\mathcal{P}$

Relaxation

- Relaxation is a method to compute heuristic functions
- Steps
    - Simplifying the original problem $\mathcal{P}$ to a relaxed problem $\mathcal{P}'$
    - $\mathcal{P}'$ has perfect heuristic h'^* which can be used to admissibly estimate h^*
    - Define a transformation r that simplify $\mathcal{P}$ to $\mathcal{P}'$
    - Given a specific planning task $\Pi \in \mathcal{P}$, estimate $h^*(\Pi)$ by $h'^*\big(r(\Pi)\big)$
- Relaxation can be native, efficiently constructible ($r(\Pi)$), and/or efficiently computable ($h'^*(\Pi')$)

Using a relaxation $\mathcal{R} = (\mathcal{P}', r, h'^*)$ during search:



→ Π_s: Π with initial state replaced by s, i.e., $\Pi = (F, A, c, I, G)$ changed to (F, A, c, s, G).

Example

- **Problem**: Grid world (move up/down/left/right, can't move through walls)
- **Simplified problem $\mathcal{P}'$**: Grid world but can move through walls
- **Transformation r**: Remove preconditions of checking wall at target cell
- **Optimal Heuristic for $\mathcal{P}'$ h'^***: Manhattan distance from current position to goal

PDDL

Propositional Domain Definition Language

- Components of a PDDL planning task
  - Objects: Things in the world we defined
  - Predicates: Properties of the objects, can be true or false
  - Initial state: The state of the world that we start in
  - Goal specification: Things that we want to be true
  - Actions/Operators: Ways of changing the state of the world
- An implementation of PDDL planning task consists of two files
  - Domain file: defines the predicates and operators
  - Problem file: defines the objects, the initial state and the goal state
  - One domain can have many different problems
- Tips
  - Asymmetric predicates: *predicate(x, y)* does not imply *predicate(y, x)*
  - `:typing` can be useful if have multiple types of objects, so PDDL only search the relevant type of variables during search

TSP Example

- Let C be the set of cities, E be the set of directed edges showing connected cities
- $P = \langle F, O, I, G \rangle$
  - $F = \{at(x), visited(x), connected(x, y) \mid x \in C, (x, y) \in E\}$
  - $I = \{at(sydney), visited(sydney), connected(x, y) \mid (x, y) \in E\}$
  - $G = \{visited(x) \mid x \in C\}$
  - $O = \left\{ move(x, y) \begin{Bmatrix} pre: at(x), connected(x, y) \\ add: at(y), visited(y) \\ del: at(x) \end{Bmatrix} \mid (x, y) \in E \right\}$

- Domain

```
;; TSP PDDL ***Domain File***

    (define (domain tsp)
        (:requirements :typing)
        (:types node)

        ;; Define the facts in the problem
        ;; "?" denotes a variable, "-" a type
        (:predicates
            (at ?pos - node)
            (connected ?start ?end - node)
            (visited ?end - node)
        )

        ;; Define the action(s)
        (:action move
            :parameters (?start ?end - node)
            :precondition (and
                (at ?start)
                (connected ?start ?end)
            )
            :effect (and
                (at ?end)
                (visited ?end)
                (not (at ?start))
            )
        )
    )
```

- Problem

```
;; TSP PDDL ***Problem File***

    (define (problem tsp-01)
    (:domain tsp)
    (:objects Sydney Adelade Brisbane Perth Darwin - node)

    ;; Define the initial situation
    (:init  (connected Sydney Brisbane)
            (connected Brisbane Sydney)
            (connected Adelade Sydney)
            (connected Sydney Adelade)
            (connected Adelade Perth)
            (connected Perth Adelade)
            (connected Adelade Darwin)
            (connected Darwin Adelade)
            (at Sydney)
    )
    (:goal
            (and
                (at Sydney)
                (visited Sydney)
                (visited Adelade)
                (visited Brisbane)
                (visited Perth)
                (visited Darwin)
            )
    )
    )
```