Artificial Intelligence

Exercise Sheet 5

November 29, 2021

Task 1.1

$\forall x\ Yum(x) \implies [\exists p\ Person(p) \land Loves(p, x)]$

1. Eliminate Implications:
   $\forall x\ \neg Yum(x) \lor [\exists p\ Person(p) \land Loves(p, x)]$
2. Move $\neg$ inwards (nothing changes
3. Standardize Variables: (all variables already have different names)
4. Move quantifiers to the beginning
   $\forall x \exists p\ \neg Yum(x) \lor [Person(p) \land Loves(p, x)]$
5. Skolemize
   $\forall x\ \neg Yum(x) \lor Person(f(x)) \land Loves(f(x), x)$
6. Drop Quantifiers
   $\neg Yum(x) \lor Person(f(x)) \land Loves(f(x), x)$
7. CNF
   $(\neg Yum(x) \lor Person(f(x))) \land (\neg Yum(x) \lor Loves(f(x), x))$

Task 1.2

Goal: $Loves(Peter, Muffins)$
Negate goal (proof by contradiction): $\neg Loves(Peter, Muffins)$
Clause set: $(\neg Yum(x) \vee Person(f(x))) \wedge (\neg Yum(x) \vee Loves(f(x), x)) \wedge$
$\neg Loves(Peter, Muffins) \wedge Yum(Muffins)$
Resolution:

(1) $(\neg Yum(x) \vee Person(f(x)))$

(2) $(\neg Yum(x) \vee Loves(f(x), x))$

(3) $\neg Loves(Peter, Muffins)$

(4) $Yum(Muffins)$

(5) $Person(f(Muffins))$(aus (1) und (4), wird aber nicht benötigt)

(6) $Loves(f(Muffins), Muffins)$ (aus (2) und (4))

(7) Resolution fails, because $f(Muffins) = Peter$ can't get infered ($Loves(Peter, Muffins)$ and $Loves(f(Muffins), Muffins)$ can't be unified). Therefore $Loves(Peter, Muffins)$ cannot be infered from the clause set.

Task 2.1

Action(go(from, to)
PRECONDITION: $at(from)$
EFFECT: $at(to) \wedge \neg at(from)$)
Action(drive(a,b)
PRECONDITION:
$at(from) \wedge CarAt(from) \wedge ParkingLot(from) \wedge ParkingLot(to)$
EFFECT: $\neg at(from) \wedge \neg CarAt(from) \wedge at(to) \wedge CarAt(to)$)
Action(cycle(from, to)
PRECONDITION: $at(a)$
EFFECT: $\neg at(from) \wedge at(to)$)
Action(bus(from, to)
PRECONDITION: $at(from) \wedge BusStop(from) \wedge BusStop(to)$
EFFECT: $\neg at(from) \wedge at(to)$)

Task 2.2

Initial State: $\{CarAt(ParkingSlotAtHome),$
$ParkingLot(ParkingSlotAtHome),\ ParkingLot(ParkingSlotInf),$
$BusStop(BusStopA),\ BusStop(BusStopB),\ at(Home)\}$
Goal: at(Inf)
Plans with different modes of transport:

1. Gehen: $go(Home, Inf)$
2. Fahrrad: $cycle(Home, Inf)$
3. Auto: $go(Home, ParkingSlotAtHome)$, $drive(ParkingSlotAtHome, ParkingSlotInf)$, $go(ParkingSlotInf, Inf)$
4. Bus: $cycle(Home, BusStopA)$, $bus(BusStopA, BusStopB)$, $go(BusStopB, Inf)$

Task 3.1

Question:
When planning, people usually do backward-state search, i.e. search from destination to start. In artificial intelligence, however, forward-state search methods have established themselves. Why?

Task 3.1

Solution:
Both forward state search and backward state search can have a large branching factor. As a rule, however, the branching factor of Backward State Search is smaller (since only this goal is considered and not all possible goals that can be derived from the start states and actions). That is why we usually use heuristics or pruning to shorten or avoid unnecessary paths. Creating a heuristic function is, however, easier for the forward state search and much more complicated and difficult to define for the backward state search. As humans, we unconsciously use such complicated heuristics, which is why we always start from the goal. (e.g. when designing an engine, we start with the engine and not with screws, as there would also be many other final states to use the screws)

Task 3.2

Question: In hierarchical planning, the use of plan libraries on a high level of abstraction already results in an enormous reduction in the search space. This can be improved considerably if you can check whether an HLA description (high level action) can be carried out. What approaches exists to achieve this?

Task 3.2

Solution:

1. Determine the goal states that can be achieved by implementing the plan $\rightarrow$ Optimal solution, not feasible in practice, as the amount of goal states can become extremely large
2. Angelic Search: Use estimates of the reachable set:
   Optimistic estimation (overestimating the amount of reachable states)
   Pessimistic estimation (underestimating the amount of reachable states)
   $\rightarrow$ If the goal is in the pessimistic estimation, the HLA can be reliably carried out; if the goal is not in the optimistic estimation, the HLA is guaranteed to be unfeasible.

Task 3.3 Knowledge representation

Question: How can the following concepts be representated? Give an example for each!

a Categories of objects (e.g. medical diagnoses)

Solution: Hierarchical (ICD) or compositional (SNOMED)

b Relations between categories of objects (e.g. connections between diagnoses and therapies)

Solution: Using first-order logic statements
e.g. $therapy(HighBloodPressure, Betablocker)$

c Events (e.g. a lecture hour in presence and as a web lecture)

Solution: Events with Reification
e.g. Event: OP1 "is" surgery, $Patient(Op1, Mueller)$, $Surgeon(OP1, Maier)$, $Duration(OP1, 30minutes)$

d Physical objects that can change in terms of place and time (e.g. a nation)

Solution: Generalized Events with Fluents (e.g. T(Equals (President (USA), George Washington), Begin (AD1789), End (AD1797))

e Knowledge of the knowledge of other agents

Solution: Modallogic, e.g. Peter knows, that Davis is happy:
$K_{Peter} Happy(David)$