Abstract

- Domain modelling is a recognised bottleneck in the use of automated planning.
- Engineering domain models using a hybrid representation is particularly challenging.
- We consider the problem of the refinement of an engineered hybrid domain model.
- We use the problem of modelling traffic flows in an Urban Traffic Management setting as a case study.
- We demonstrate that the refined domain models provide more accurate simulation, which can lead to higher quality plans.

UTM: Urban Traffic Management

- UTM problem modelled using PDDL+
- Process used to model flow of PCUs through green light:

\[
\text{process flowrun\_green} \text{-leaf-1} \text{-- parameters (p? - stage ?r1 ?r2 \& link)}, \text{precondition (and (+ (occupancy ?r1) 1.0) (active ?p)) \& effect (and (increase (occupancy ?r2) (* (?a (turnrate ?p ?r1 ?r2))) (decrease (occupancy ?r1) (* (?a (turnrate ?p ?r1 ?r2))))))}
\]

- Observed behaviour varies
- E.g., graph indicates "warm-up" period, as PCUs accelerate.

Reprocess: Approach

- Our aim is to refine a PDDL+ Domain Model.
- Using observations from executions in the environment.
- Learn a predictive model to explain the difference between the model's expectations and the observed reality.
- This model is used to refine the original planning model.

Reprocess Algorithm

- Generate/select features
- Set as Machine Learning problem
- Compile back into PDDL+

Compiling the Predictive Model

- Function `chooseFeatures(DM)`
  - `F = ChosenFeatures(DM)`
  - `tmData = makeProcessOrientated(tmObs, P)`
  - `vData = makeProcessOrientated(valObs, P)`
  - `t = GrowTree(tmData, F)`
  - `PruneTree(vData, t)`
  - `RValTree(tmData = vaData, t)`
  - `P = extractProcesses(P)`
  - `extendModel(DM, P)`

- Each path from the root to a leaf identifies a specific situation
- Each is used to define a new process
- The values at the leaf are used as factors on the process's effects

Results

- Plan Simulation Accuracy: Observation vs. Model
  - Both learned models reduce error – the expert selected features perform best.
  - Original: provided model; Auto: filter based feature selection; Expert assisted: expert feature selection

- Efficiency of Refined Models: Simulation Time
  - As the complexity of the refinement is increased, the computational effort of simulating the planning model increases.

Conclusion

- A general approach for refining hybrid planning models
- Exploiting observation data from executions
- Reduces knowledge engineering effort → Compiles predictive model into PDDL+
- Examined feature space –generated by combining domain functions– is limited

- Demonstrated on a real world application domain → UTM
- Improved accuracy of simulation and planning using the refined models - particularly expert selected features
- FW: Alternative feature languages
- FW: Examine the balance between model accuracy, planning time and feature computation cost