

Introduction to Artificial Intelligence

Planning and Acting

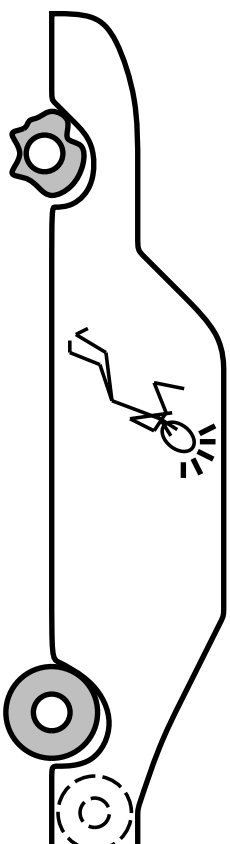
Chapter 13

Dieter Fox

Outline

- ◇ The real world
- ◇ Conditional planning
- ◇ Monitoring and replanning

The real world



START

*~Flat(Spare) Intact(Spare) Off(Spare)
On(Tire1) Flat(Tire1)*

FINISH

On(x) ~Flat(x)

On(x)

Remove(x)

Off(x) ClearHub

Off(x) ClearHub

Puton(x)

On(x) ~ClearHub

Intact(x) Flat(x)

Inflate(x)

~Flat(x)

Things go wrong

Incomplete information

Unknown preconditions, e.g., *Intact(Spare)*?

Disjunctive effects, e.g., *Inflate(x)* causes

Inflated(x) ∨ SlowHiss(x) ∨ Burst(x) ∨ BrokenPump ∨ ...

Incorrect information

Current state incorrect, e.g., spare NOT intact

Missing/incorrect postconditions in operators

Qualification problem:

can never finish listing all the required preconditions and possible conditional outcomes of actions

Solutions

Conditional planning

Plan to obtain information (observation actions)

Subplan for each contingency, e.g.,

$[Check(Tire1), If(Intact(Tire1), [Inflate(Tire1)], [CallAAA])]$

Expensive because it plans for many unlikely cases

Monitoring/Replanning

Assume normal states, outcomes

Check progress *during execution*, replan if necessary

Unanticipated outcomes may lead to failure (e.g., no AAA card)

In general, some monitoring is unavoidable

Conditional planning

[...] , **If**(p , [*then plan*], [*else plan*]), ...]

Execution: check p against current KB, execute “then” or “else”

Conditional planning: just like POP except

- if an open condition can be established by **observation** action
- add the action to the plan
- complete plan for each possible observation outcome
- insert conditional step with these subplans

CheckTire(x)

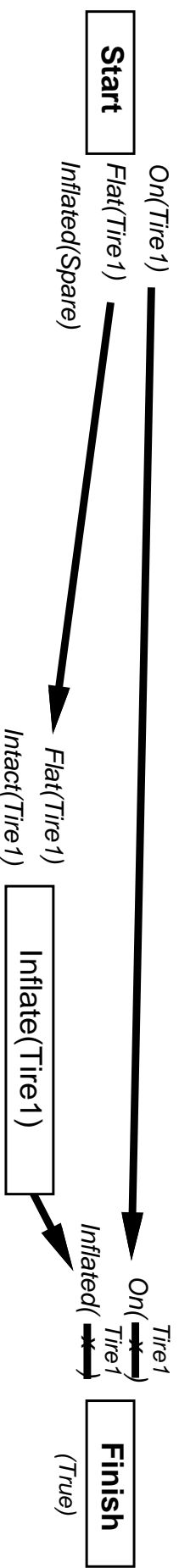
KnowsIf(Intact(x))

Conditional planning example

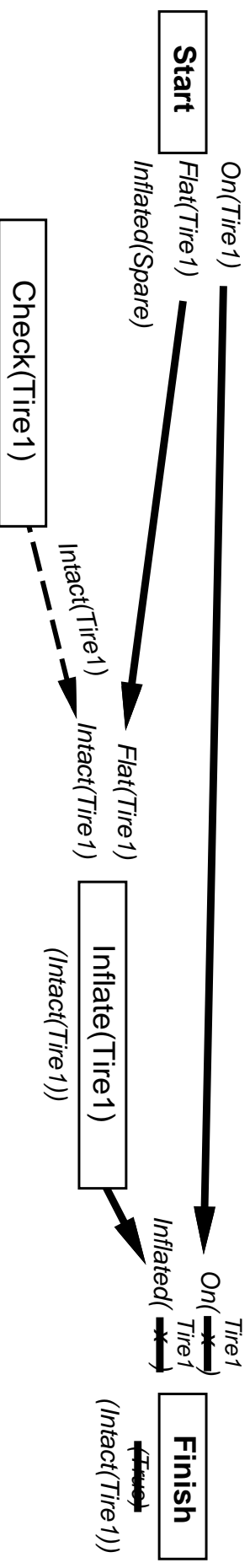
On(Tire1)
Flat(Tire1)
Start
Inflated(Spare)

On(x)
Inflated(x)
Finish
(True)

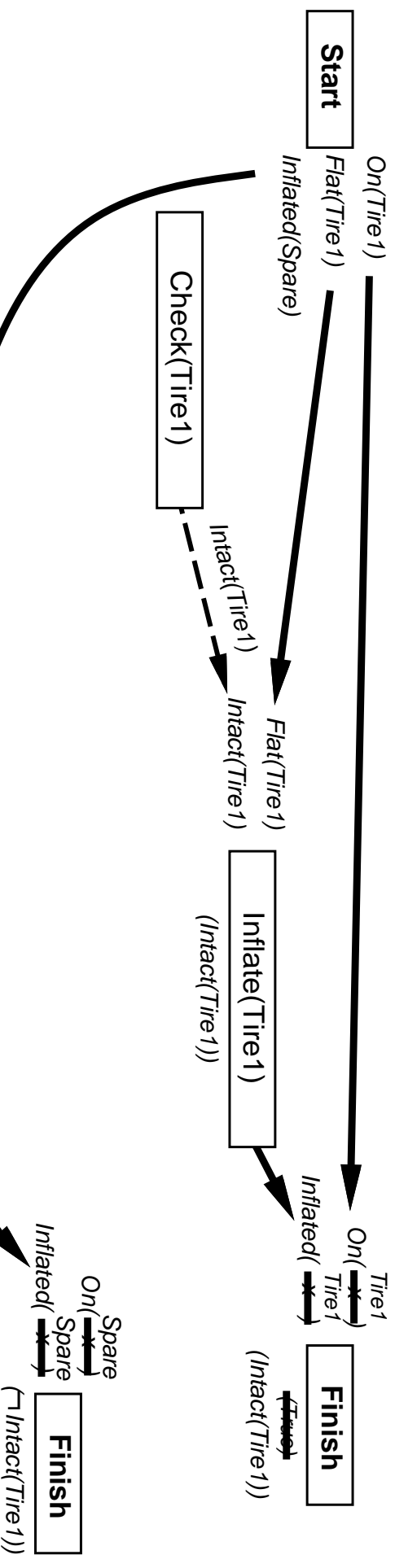
Conditional planning example



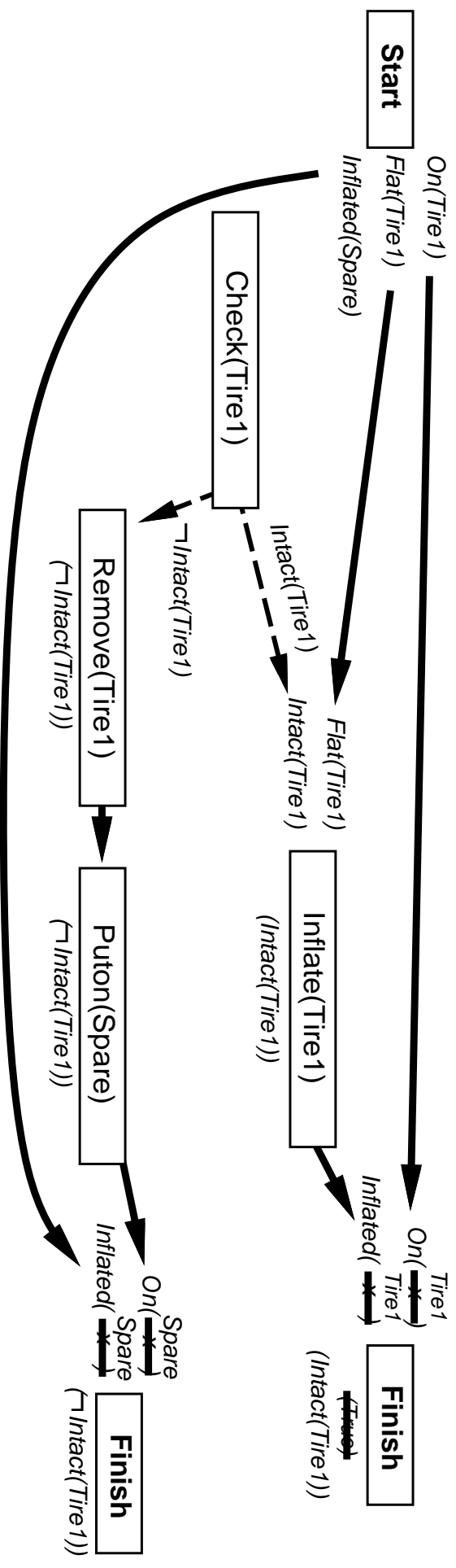
Conditional planning example



Conditional planning example



Conditional planning example



Monitoring

Execution monitoring

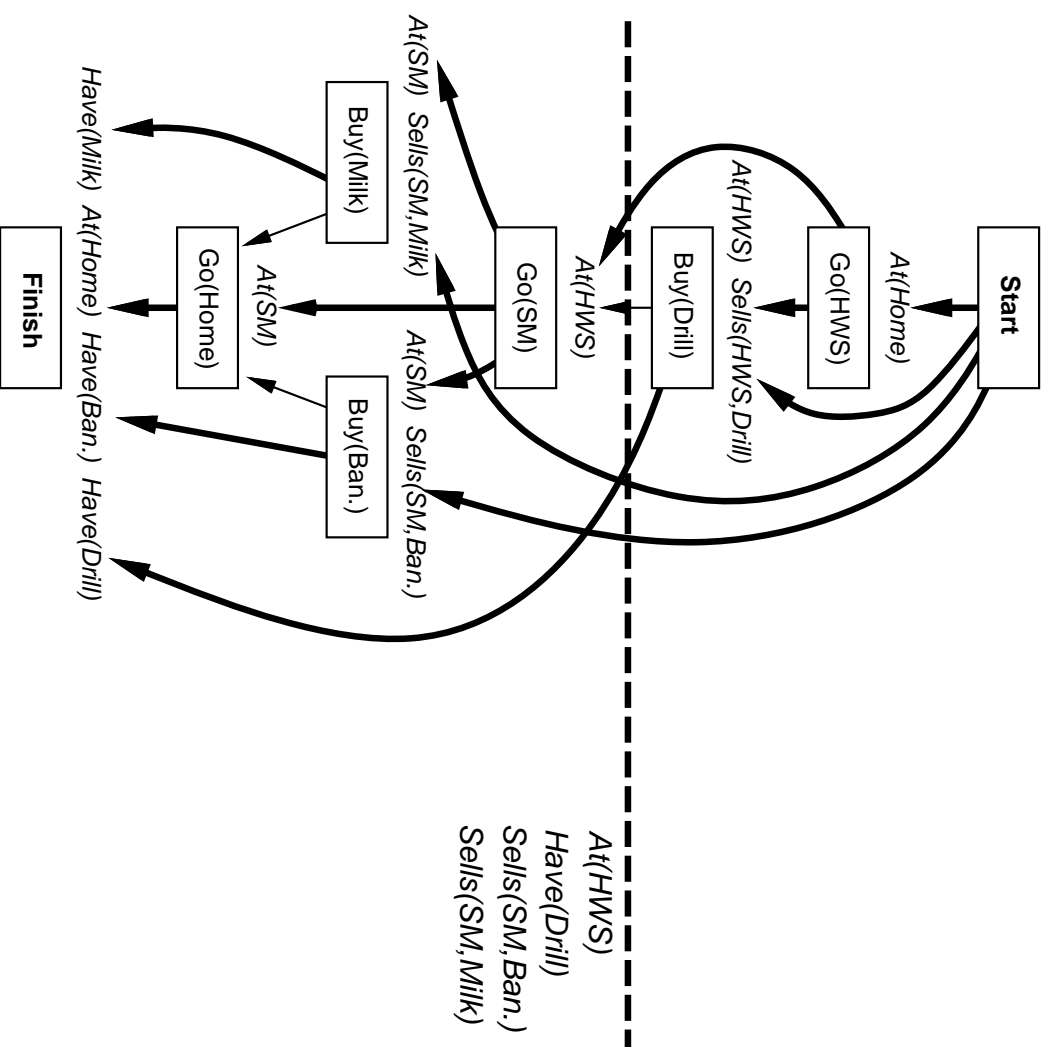
“failure” = preconditions of *remaining plan* not met
preconditions = **causal links at current time**

Action monitoring

“failure” = preconditions of *next action* not met
(or action itself fails, e.g., robot bump sensor)

In both cases, need to *replan*

Preconditions for remaining plan



Replanning

Simplest: on failure, replan from scratch

Better: plan to get back on track by reconnecting to best continuation
Generates “loop until done” behavior with no explicit loop

