

Motivation

A service robot needs:

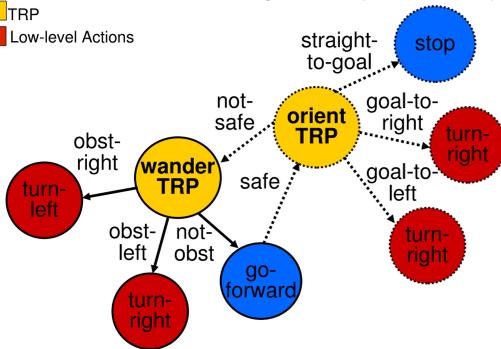
- Basic skills to perform tasks in dynamic environments
- Complex skills that combines previously learned skills to perform different tasks
- Ability to apply its skills in different environments

Teleo-Reactive Programs

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trpA(State,Action) ← goal(State).
trpA(State,Action) ← pred1(State,...),
                    pred2(State,...),...
trpA(State,trpB(State,Action)) ←
                    pred1(State,...),
                    pred3(State,...),...
    
```

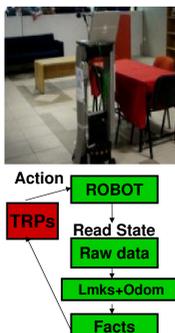
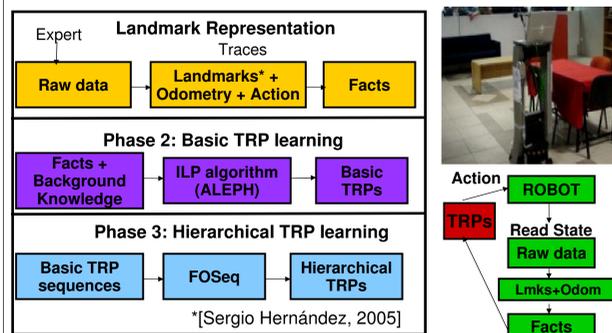
- Goal
- TRP
- Low-level Actions



Set of clauses that continuously perform an action in the current state while their conditions are satisfied [Nilsson, 1994].

Learning Phases

Relational Learning Approach:



Landmark Representation

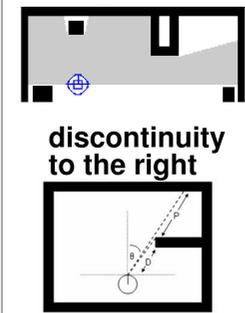
- LASER SICK LMS200
- Sonar ring
- Get traces from the task to be learned



Raw-data traces are transformed into high-level traces

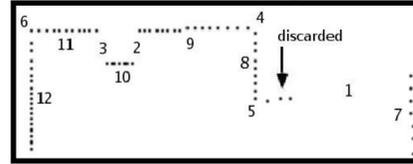


Getting the traces

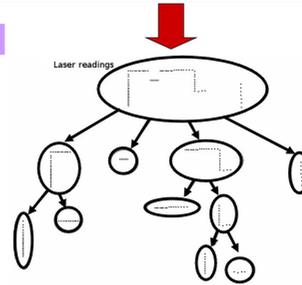


No	Dist	Theta	Att	Type
1	2.18	-73	1.41	left
2	1.10	-6	0.40	left
3	1.11	10	0.41	right
4	2.17	-47	0	corner
5	1.71	-68	0	corner
6	1.84	36	0	corner
7	3.46	-89.5	1.06	wall
8	1.59	-89.75	0.85	wall
9	1.49	0	1.36	wall
10	1.10	0	0.39	wall
11	1.50	0	0.80	wall
12	1.10	89.75	1.43	wall

Laser readings



discontinuities
corners
walls



Landmark identification process

State-Action pairs
[[robot(4.85,-0.04,248.60), rear(n), goal(0,0), landmark(2.18, -73,1.41,l), landmark(1.10,-6,0.40,l), landmark(1.11,10,0.41,r), landmark(2.17,-47,0,c),...,],Action]

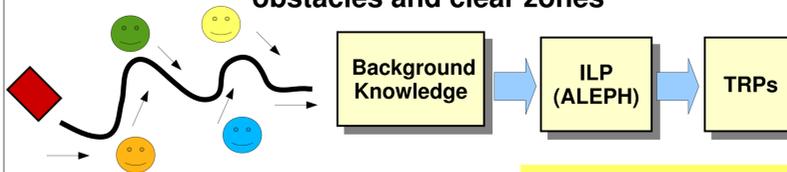
Basic TRP Learning

Behavioural cloning. Technique to learn skills from traces.

Example: Learning how to wander

- Given a trace with 1,617 state-action pairs (525 for turn-right, 554 for turn-left, an 548 for go-forward).
- Generate: a trace with negative examples
- Given possible conditions, background knowledge and an action-set
- Learn TRPs using ALEPH (an ILP system)

Traces: the robot is guided through obstacles and clear zones



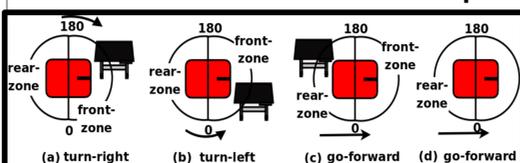
wander(State,Action)

Possible conditions and background knowledge	Action-set
front-zone(State,obst-free)	go-forward (goal)
front-zone(State,obst)	turn-right
rear-zone(State,obst)	turn-left
rear-zone(State,obst-free)	
closest-obst(State,Lmk,Dist,Ang)	
lteq(Ang,Angval1)	
gteq(Ang,Angval2)	

Depending on the teacher's guidance, the distance criteria to avoid obstacles will be different.

The robot may show a "cautious" or a "daring" behavior. Distance and angular ranges capture the differences between guidance's styles. This background knowledge can be learned.

Example



front-zone(State,Action)

```

front-zone(State,obst) ←
closest-obst(State,_,Dist,_),
lteq(Dist,0.49).
front-zone(State,obst-free).
    
```

Hierarchical TRP Learning

- We introduce FOSeq, an algorithm to learn TRPs that produces particular sequences of actions satisfying a particular goal (e.g. goto)
- TRPs can be expressed in terms of other TRPs.

Given a set of sequences of TRPs, FOSeq:

- Learns a grammar for each sequence, identifying repeated elements in the sequence
- Evaluates the sequences with each learned grammar.
- Selects the best evaluated grammar and a list of candidates to improve the evaluation of the best grammar
- Applies a generalization process to the selected grammars using adaptation rules to modify/add a new rule.
- Transforms the grammar into a TRP

The following TRPs have been learned:

- Goto
- Orient
- Leave-a-trap
- Follow-a-mobile-object

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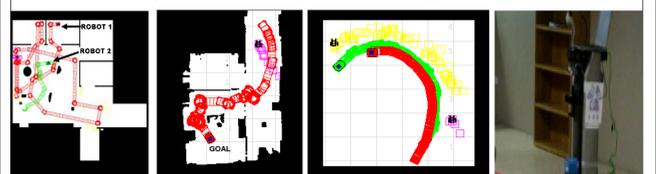
goto(State,nil) ←
in_goal(State).
goto(State,Action) ←
orient(State,straight-to-goal),
wander(State,Action).
goto(State,Action) ←
wander(State,go-forward),
orient(State,Action).
goto(State,Action) ←
wander(State,Action).
    
```

Experiments

The TRPs were tested in simulation and in a PeopleBot ActivMedia robot called Markovito. The tasks were:

- following a person,
- navigating to several places designated semantically (e.g. kitchen, room),
- finding one of a set of objects in a house, and
- delivering messages and/or objects

The first three tasks are part of the RoboCup@Home Challenge.



Goto TRP's accuracy:	
Simulation	Tasks
87.5%	120
85%	25