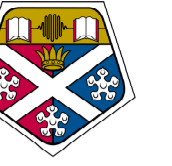




Evolving Macro-Actions for Planning

Hakim Newton, John Levine



Macro-Actions

- Also called Macros
- Groups of Actions
- Compound Statements
- Procedures/Subroutines
- Plan Segments/Subplans

Motivations

- ★ Examples do not always cover all system aspects.
- ★ Planners often prune useful choices to make hasty moves.
- ★ Relaxed domains are incoherent but useful in search.
- ★ Incoherent macros may be useful in the same way.

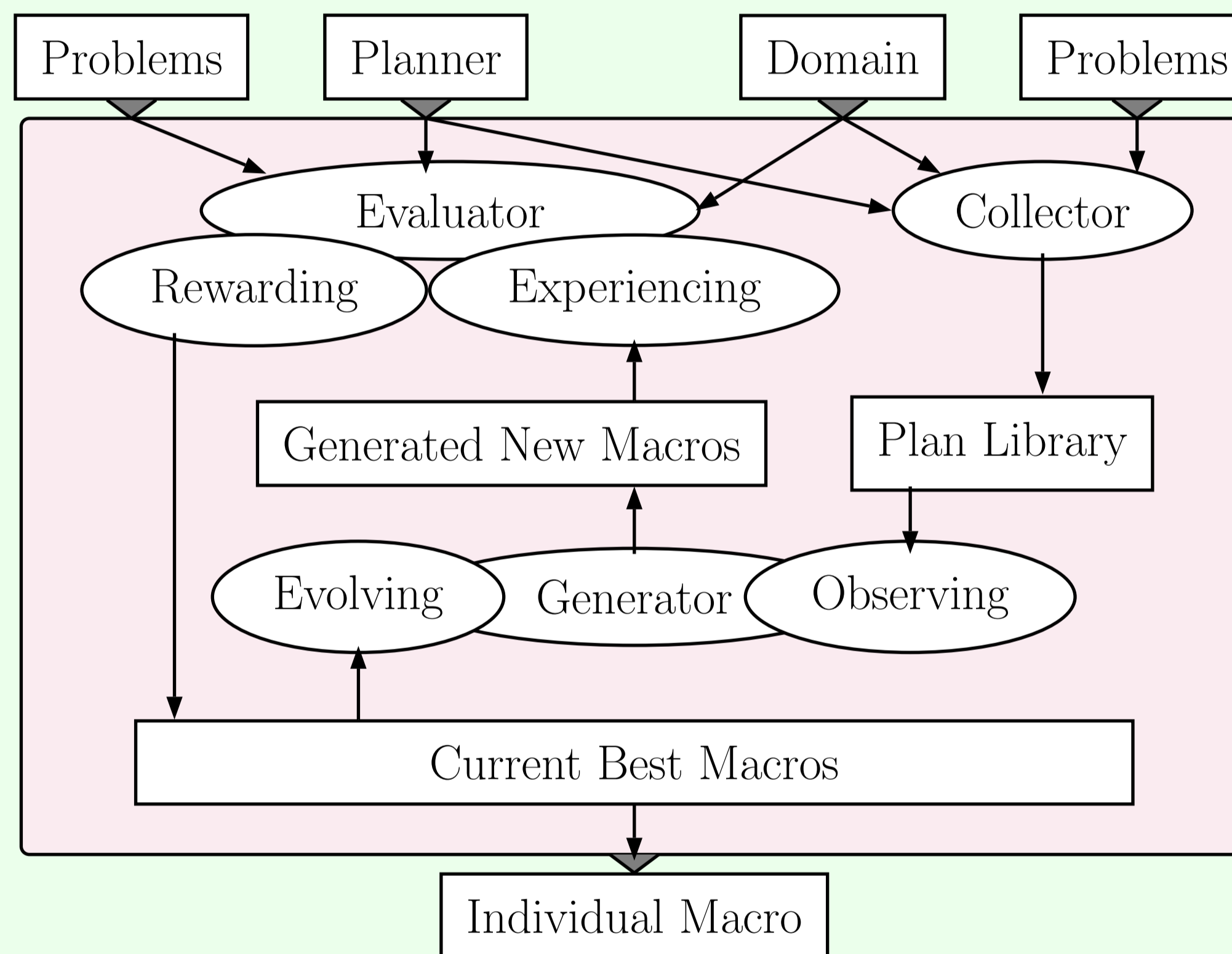
Existing Methods

Characteristic	Domain/Planner	Solution
Plateau escaping sequence	Fast Forward	MARVIN
Valley travelling sequence	One heuristic planner	MACLEARN
Causally linked macro	Fast Forward	Macro-FF
Don't care; don't know	Any planner	Wizard
Symmetry, almost symmetry	Briefcase, Gripper, etc.	MARVIN
Component abstraction	Gripper, Rover, etc.	Macro-FF
Operator decomposability	Rubik's cube, etc.	Korf's MPS
Don't care; don't know	Any domain	Wizard

Hypotheses

- ★ Existing work explores observable macros only.
- ★ Non-observable macros may be more useful.
- ★ Incoherent macros have potentials to be useful.

System Architecture and Macro Space



domain: blocks, planner: ff

Incoherent/Catalytic Macros
 (drop ?b5)
 (unstack ?b5 ?b0)
 (stack ?b5 ?b2)
 (pick ?b0)
 (stack ?b0 ?b5)

Coherent Macros
 (unstack ?b5 ?b0)
 (stack ?b5 ?b2)
 (pick ?b0)
 (stack ?b0 ?b5)

Observable Macros
 (unstack ?b5 ?b0)
 (stack ?b5 ?b2)
 (pick ?b0)

Macros Conceptually

- Frequently used subplans
- Difficult to find subplans
- Trouble avoiding subplans
- Trouble recovering subplans

- Extended search space visibility
- Fewer intermediate states visited
- Additional search neighbourhood
- More branches at search nodes

Macros Technically

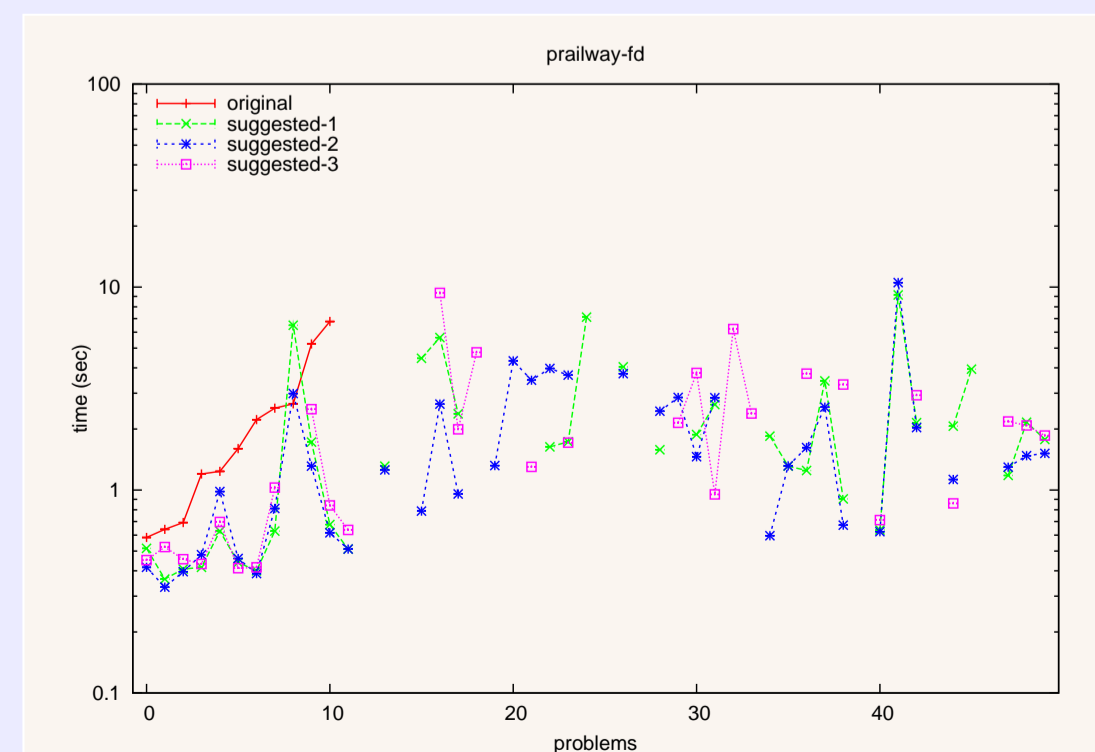
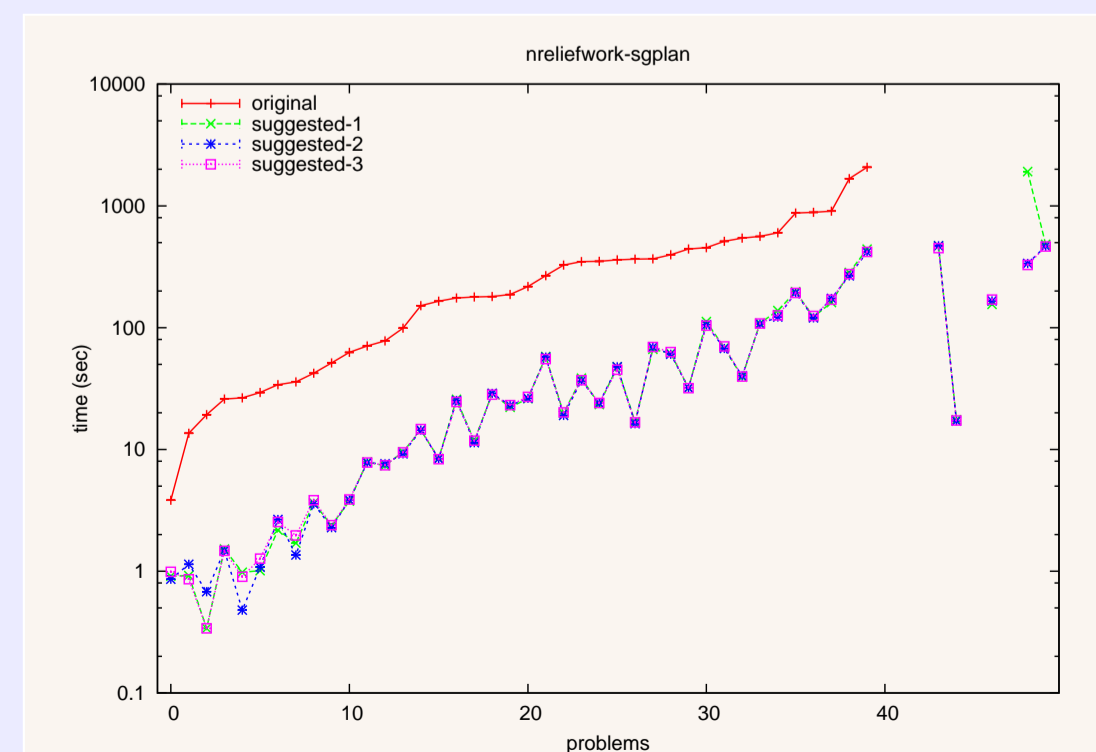
Macro Generation

- Operators on macros' sequences
- Various operators are used
- Macro pruning strategies used
- Syntactical pruning only, not semantic

- Cover = % problems solved
- Scope = Weighted mean time gain
- Point = % problems solved faster
- Utility = Cover × Scope × Point

Macro Evaluation

No Exploitation of Specific Structural Properties



Performance of Non-observable Macros

domain-planner-macro	+S -s	+T -t	P ± p	+L -l	Q ± q
NRailway-FF-1	+24 -0	+36 -12	58 ± 7	+2 -34	-12 ± 2
NRailway-SGPlan-1	+16 -0	+60 -14	1 ± 34	+2 -62	-18 ± 2
NReliefWork-FF-1	+30 -0	+70 -0	99 ± 0	+16 -44	-1 ± 0
NReliefWork-SGPlan-1	+10 -0	+80 -0	88 ± 1	+0 -20	0 ± 0
PRailWay-FD-1	+50 -0	+20 -2	41 ± 18	+18 -2	13 ± 3
PRailWay-FF-1	+14 -4	+22 -4	10 ± 23	+0 -18	-5 ± 1
PRailWay-SGPlan-1	+14 -0	+50 -12	34 ± 7	+24 -34	0 ± 0
PReliefWork-FD-1	+0 -0	+80 -20	7 ± 3	+20 -36	0 ± 0
PReliefWork-FF-1	+0 -0	+100 -0	89 ± 0	+0 -100	-3 ± 0
PReliefWork-SGPlan-1	+20 -0	+54 -8	44 ± 5	+0 -12	0 ± 0
PReliefWork-VHPOP-1	+16 -0	+24 -0	92 ± 2	+0 -2	0 ± 0

S,s: % problems with solvability gain,loss
 T,t,L,l: % problems solved faster, slower quality better, worse
 P,p,Q,q: % mean gain time P ± p quality Q ± q

These macros are suggested over best observable ones

