A reactive mobile robot based on a formal theory of action

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One of the agenda behind research in reasoning about actions is to develop autonomous agents (robots) that can act in a dynamic world. The early attempts to use theories of reasoning about actions and planning to formulate a robot control architecture were not successful for several reasons:

- The early theories based on STRIPS and its extensions allowed only observations about the initial state. A robot control architecture using these theories was usually of the form: (i) make observations (ii) Use the action theory to construct a plan to achieve the goal, and (iii) execute the plan.

  For such an architecture to work the world must be static so that it does not change during the execution of the plans. This assumption is not valid for a dynamic world where other agents may change the world and/or the robot may not have all the information about the environment when it makes the plan.
- Moreover, planning is a time consuming activity and it is not usually wise for the robot to spend a lot of time creating a plan, especially when it is supposed to interact with the environment in real time.

This led to the development of several robot control architectures that were reactive in nature and usually were based on the paradigm of 'situated activity' which emphasized ongoing physical interaction with the environment as the main aspect in designing autonomous agents. These approaches were quite successful, especially in the domain of mobile robots. But most of them distanced themselves from the traditional approach based on theories of actions.

Our intention in the AAAI 96 robot contest is to use reactive rules. But, we will show that the reactive rules we use are *correct* w.r.t. a formal theory of action called $\mathcal{L}$[1]. Unlike STRIPS, the language $\mathcal{L}$ allows specification of dynamic worlds. But it makes assumptions such as: we know the effect of actions, the observations (sensor data) are correct, the robot has perfect control, etc.

The last two assumptions are not consistent with the real world. Nevertheless, as we explain in the succeeding paragraphs, our approach based on this language is appropriate.

Consider a reactive rule of the form

if $f_1, \ldots, f_n$ **then** a,

where, f_i's are fluents (that depend on the sensor readings) and a is an action. A simple reactive control module may consist of a set of such rules such that at any time the 'if' part of only one of the rules is satisfied.

A robot equipped with this control after sensing finds a rule in the module whose 'if' part is satisfied and performs the corresponding action. *We say a reactive rule is correct w.r.t. an action theory and a goal if for any situation that is consistent with the 'if' part of the rule, the action in the 'then' part is the first action in a minimal plan that will take the robot from the current situation to a situation where the goal is satisfied.*

The fact that we only have the first action of the minimal plan in the reactive rule is important. Having a complete minimal plan will not work because of the dynamic nature of the world. By having only the first action of the minimal plan we can take into account the possibility of incorrect sensors, world unpredictability and imperfect control.

After the robot executes an action based on its sensing and the reactive rules, it does not rely on a model of the world, rather it senses again. Hence the assumptions in $\mathcal{L}$ only mean that the minimal plan works if everything is perfect for a reasonable amount of time.

Based on these ideas we are currently developing reactive control programs for the AAAI 96 robot contest on a B-14 mobile robot from RWI. A detailed report on our approach can be found through http://cs.utep.edu/chitta/chitta.html.

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[1] Please see the paper by Baral, Gabaldon and Provetti in this volume and the proceedings of the AAAI 96 workshop on 'Reasoning about actions, planning and control: Bridging the gap'.