Dynamic Constraint-based Planning in Trauma Management

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This research deals with planning in domains with dynamically changing, multiple, interacting goals. What distinguishes this work from reactive planners (e.g. (Firby 1987)) is the fact that the goals for which planning is done are *not known in advance*; rather, goals are formed and change rapidly during the planning process itself. Although planners that produce appropriate plans exist for such domains (Rymon *et al.* 1993), we want a planner that also provides a basis for explaining why some action is chosen over another or why some goal is no longer relevant etc., which is necessary for effective decision support (Gertner 1994).

I am developing an efficient, 3-level, dynamic constraint based planner for one such domain, trauma management. The three levels show how plans are naturally formed in this domain. The top level corresponds to goals, the second level corresponds to the various, alternative procedures that can be used to address these goals, while the third level corresponds to the actions that constitute these procedures. Different kinds of constraints are added at each level. For example, urgency constraints (e.g. "shock" must be treated first) hold between goals, while precedence constraints (e.g. perform IVP before arteriogram) hold at the action level. Constraints at higher levels are inherited by the lower levels. The network is dynamically updated by adding/deleting nodes and/or modifying constraints as goals are created, discarded or achieved. If an action/procedure cannot be done, or a goal cannot be addressed, the corresponding nodes are deactivated, but not removed. Then, if the situation changes later, the nodes are reactivated and again considered during the planning process. This structure, similar to dynamic constraint networks (Dechter *et al.* 1988), offers several distinct advantages.

First, by maintaining consistency and recording justifications for elimination/selection of actions, easy critiquing is facilitated. Consider a scenario involving, among others, the goals of treating a tension pneumothorax (TP) as well as ruling out a pericardial tamponade (PT) and a renal injury (RI) in a patient in shock. Urgency constraints are added requiring that TP, RI and PT be addressed before realizing other goals or performing time consuming actions. For treating the TP, a chest tube is the only option. However, making the network consistent and recording justifications not only causes a needle aspiration to be chosen for diagnosing the PT (over the normally preferred but lengthy ultrasound due to urgency constraints), but also enables the system to explain its choice.

Second, the three level structure with different, dynamic constraints at each level makes the planning process very efficient. In the above example, for ruling out a RI, an IVP is chosen over the normally preferred CT_scan (never done if patient in shock). Now, suppose that the planner considers scheduling an arteriogram to address a non-urgent goal. Although, precedence constraints require that an arteriogram precede an IVP, urgency constraints requiring the IVP to be performed first cause the arteriogram to be deactivated. This information is propagated upwards, thus deactivating all procedures involving an arteriogram. This causes alternative procedures to be chosen for all goals corresponding to the deactivated procedures; if there is no other procedure to satisfy some goal, the goal is left unaddressed. If planning is done using backtracking or a 'flat' constraint network, this would not be discovered until the later goals are planned for.

Third, the current plan can be easily modified to incorporate new information and/or goal changes, without re-planning from scratch. In the above example, assume that a chest tube relieves the shock. This causes the urgency constraints to be eliminated. Since nodes corresponding to the ultrasound, arteriogram and IVP (along with the relevant constraints) were only deactivated and not removed from the network, they are simply reactivated. This enables the planner to easily modify the current plan and schedule the ultrasound (preferred over needle aspiration) followed by an arteriogram (since CT_scan and IVP can now be done later) and a CT_scan (preferred over IVP).

References

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