Crisis Response Planning: A Task Analysis*

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The ability to respond effectively and efficiently to crisis is essential in many problem-solving domains such as disaster relief, business, and military operations, where significant amounts of highly valued assets can be at risk. An analysis of the crisis response task can be used to understand the limitations on the performance of human crisis response planners, and ultimately, to provide "requirements specifications" for intelligent, computer-based crisis response assistants.

Crisis Response Task The three central elements of crisis are threat, urgency, and uncertainty (Rosenthal et al., 1989). *Threat* refers to the fact that something of great value to an agent is at risk—without intervention, the agent will lose this thing of great value. *Urgency* refers to the limited time available to the agent for developing and implementing a course of action to avert the threat. *Uncertainty* refers to the incompleteness and incorrectness of the information (due to noisy sensors, exogenous events, etc.) available to the agent.

We define the crisis response task for an individual agent as follows: Given a crisis situation $\langle E, A, I, V \rangle$, determine a plan P to resolve the crisis. The environment E threatens some value $v \in V$ of the agent. The progression of E is such that given the available actions A, the agent has limited time in which to resolve the threat. Furthermore, the agent's information I about the world and its knowledge about its actions A are at best uncertain. Given such a situation, the agent must come up with its response P.

Task Analysis A *task analysis* (Newell & Simon, 1972) bounds the space of possible problem solvers for some problem or task. A problem solver may be defined as the combination of a state space, the operators for searching this space, and a search control strategy. In crisis response planning, the necessary and desirable features of these components are mandated by the three elements of crisis.

The state space is a set of knowledge states, each consisting of I, A, V, and optional internal memory structures. Threat corresponds to goals of prevention that have temporal scope, unlike traditional planning goals of achievement. Urgency also requires that the representation have the expressiveness to describe a changing world. A crisis response planner must thus be able to deal with time—e.g., by associating states with time values, by using full-blown temporal reasoning. Uncertainty means the agent can neither perfectly represent the current state of the world nor predict future states. A crisis response planner must thus also be able to handle the discrepancy between I and E, and the imperfect A—e.g., by augmenting A with sensor actions, by associating probabilities with states and state transitions, by representing actions as having multiple possible outcomes.

The operators for traversing the problem space relate primarily to urgency and uncertainty. Through the use of higher-order operators (e.g., macro-operators, abstract operators, cases), a problem solver can make larger leaps in the problem space, thereby addressing urgency by reducing the time required to construct an appropriate response. Through the use of plan modification operators such as adding contingency plans or choosing more widely applicable actions, a problem solver can make plans more robust, thereby addressing uncertainty.

Search control is responsible for determining when to stop deliberating and when to start acting, and it impacts all three elements of crisis. Because the goal of the search is to find a state that resolves the threat, the issue of threat is implicitly addressed by the search control strategy. Urgency can be addressed through the use of more efficient search strategies that guide the search to a goal state quickly, as well as through mechanisms that directly control deliberation time through externally imposed constraints. Uncertainty can be addressed through the use of feedback from the execution environment to correct or complete imperfect initial information.

Through the task analysis, we have determined that the central crisis elements of threat, urgency, and uncertainty require crisis response planners to have representations capable of handling time and imperfect information, and they favor those planners with the ability to find good, robust solutions within the time available for crisis response. With our goal of developing intelligent crisis response assistants, the next step is to focus on the interaction between these requirements and the cognitive capacities of human crisis response planners. We can then evaluate the effects of different aspects and magnitudes of crisis on different crisis response systems.

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