Developing autonomous systems is challenging because complete and correct models do not exist for complex domains such as aircraft flight. Realistic systems bound the state set expanded during planning and compensate for unexpected situations with reactive mechanisms. This abstract describes a method by which a system can determine if it is unprepared for the current world state and a means to successfully respond to such an unhandled state.

We first identify subclasses of unhandled states, then investigate how system performance improves when detecting them. The Cooperative Intelligent Real-time Control Architecture (CIRCA) (Musliner, Durfee, & Shin 1995) combines a planner, scheduler, and real-time plan executor to provide guaranteed performance for controlling complex systems. Domain knowledge includes action (ac) and temporal transitions (tt) that model how the world state changes over time. We have implemented and tested algorithms to detect and respond to unhandled states in CIRCA.

Figure 1 shows the relationship between subclasses of possible world states. Modeled states have distinguishing features/values represented in the planner knowledge base; we have not considered methods (e.g., discovery) to handle unmodeled states. The planned-for set are states from which failure is avoided. Handled states are on a path to a goal, while deadend are not. The planner can model other states, including those that are reachable but "removed" due to resource limitations, and "imminent-failure" that are not considered reachable but, if reached, are modeled as leading to failure. As shown in Figure 1, states actually reached may include any subclass.

Figure 2. Unhandled State Illustrations.

Upon detecting an unhandled state (D, R, or IF), CIRCA reacts by replanning based on the current state. We have performed tests using an aircraft simulator. After CIRCA successfully flew normal "flight around an airport pattern", we modeled an unhandled "gear fails on final approach to landing" emergency. By differing CIRCA's aircraft gear model, we produced each type of unhandled state. CIRCA was able to detect and respond (e.g., execute "go-around" and "gear-down" action) to each D, R, or IF state, whereas without detecting that unhandled state it would consistently fail (i.e., plane would crash). We continue tests with more complex flight examples, and are studying associated research issues such as imposing time bounds on CIRCA's planner to guarantee timely responses to unhandled states.

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References
