robot's task. This description is given in the AL robot programming language, but any other manipulator-level language should work as well. The system assumes that this task description is accurate and correct in the sense that a robot simulator will execute it reliably. Thus, the only errors the system should expect will be introduced by real-world uncertainties.

There are three major system components: the preprocessor, which creates a task description adequate for handling error analysis and recovery; the AP processor, which tracks the robot's activities during execution to detect errors if they occur; and the recoverer, which collects the facts to plan recovery and alter the existing task.

Description. First, the system analyzes the robot's task program off-line to generate a specialized description. This task description has two parts: the program describing the robot's task and additional facts about task intent and physical objects (such as robots, parts, and tools).

The first part, referred to as the augmented program or AP, describes the sequence of actions the robot must perform, the sensor readings necessary to verify performance, and how the robot’s actions affect objects in the its work cell. The second part of the task description, called the task knowledge base, contains detailed information about the work-cell layout and about robot and parts attributes.

Next, the AP processor executes the task as specified by its augmented program. The system monitors program execution and maintains a history of the robot's activities called the event trace. Sensors verify proper operation and detect errors. Information in the augmented program about sensor usage sifts through sensor input and extracts relevant data. Relevant sensor data invokes subsequent robot actions and traces robot activities.

Once an error has been detected, the recovery system uses the event trace and task information to determine error causes and effects. This information is then used to build an appropriate recovery procedure. Steps are appended to the existing augmented program, and the AP processor is restarted with the first step of the recovery procedure.

Status. We have developed prototype system components in Franz Lisp on the Unix timesharing system at the University of Minnesota's Artificial Intelligence Laboratory. This system includes a robot simulator for testing purposes.

We are developing a working implementation at the university’s Robotics Laboratory. This implementation uses a LMI Lambda processor for automated reasoning applications and a separate, stand-alone microcomputer to host the AP processor. The robots controlled include an Adept and several smaller educational robots.


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