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EXTRACTING INFORMATION FROM PROBLEM SOLVING EXPERIENCE

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Much of the problem solving which is performed involves consideration of previous similar situations. Access to previous experience keeps the problem solver from avoiding past mistakes, and aids in the derivation of shortcuts for reasoning. This ~~research~~ note outlines the research studying the processes that comprise this problem solving style. Topics outlined include: organization of cases and generalized knowledge in memory, knowledge structures, the evolution of knowledge structures, analogical problem solving, and failure-driven learning.

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Extracting Information from Problem Solving Experience*

Janet L. Kolodner

Much of the problem solving people do from day to day involves consideration of previous similar situations. In doing this kind of natural problem solving, they integrate learning and analogical reasoning into their problem solving. Access to previous experiences keeps the problem solver from avoiding past mistakes and aids in the derivation of reasoning shortcuts. Our research group at Georgia Tech is studying the processes that comprise this problem solving style (see Kolodner, 1985, Kolodner, et al., 1985). Topics we are investigating include the organization of cases and generalized knowledge in memory that facilitates both analogical reasoning and the integration of cases and newly-derived (i.e., learned) knowledge structures, the evolution of those knowledge structures as the reasoner gains experience, analogical problem solving processes, the integration of analogical problem solving processes with from-scratch problem solving methods, explanatory generalization methods that are guided by problem solving experience, and failure-driven learning. We are studying these topics across a variety of task domains, both expert and common-sense: Labor mediation, meal planning, car mechanics (troubleshooting), and diagnosis of pulmonary disorders are our current ones.

A generalized description of our research program can be found in the proceedings of last year's workshop. In the past year, we have concentrated on four topics (Kolodner, 1986, 1987): avoiding mistakes, deciding between making a transformational or derivational case-based inference, representational support for case-based inference, and integrating case-based reasoning with from-scratch problem solving methods (including problem reduction, constraint propagation and satisfaction, and causal reasoning). We discuss avoiding mistakes and representational support for case-based inference very briefly below.

When a problem solver is reminded of a previous case that resulted in a failed problem solving attempt, that case can serve a variety of functions for the problem solver. First, it provides a warning of the potential for failure in the current case. Second, it directs reasoning effort towards consideration in the new problem of whatever caused the failure in the previous one. Third, it may provide an explanation of why the previous failure occurred which can be used to analyze the potential for failure in the new problem. Fourth, if the previous case was finally solved correctly, it may provide a suggestion for avoiding the potential problem that it warns about.

In short, the steps that must be followed to capitalize on a previous failure are*: (1) determine what was responsible for the previous failure, if possible (this may already be recorded, and if not, some short amount of time is spent attempting to derive it), (2) direct reasoning focus to the decision in the new problem that is analogous to the one that caused the failure in the previous one (this may be the one currently being focussed on or one that its correct solution is dependant on), (3) check for the potential for the same failure in the new case, either by seeing if the explanation of the previous failure holds in the new case or by checking the reasons why the previous decision was made and seeing if the same justifications might apply in the new case (this step may require additional information gathering), (4) if not, potential for error is not there, so return to the interrupted step and keep going, (5) if so, rule out the previous errorful decision as a possibility for the current case, and if the previous case was finally resolved correctly, determine if the decision made when it was resolved correctly is applicable to the new case, (6) if so, use it as a suggestion for a case-based inference, (7) if step 2 redirected focus, then redo whatever decisions must be redone as a result (i.e., follow dependencies) and return to the reasoning step that was interrupted.

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*Of course, it is more complex than the set of steps shown here, but these steps form the core of the processing. See Kolodner (1987) for more detail.

Because this processing requires knowing why previous decisions were made, what other decisions previous decisions were dependent on, and what was responsible for previous failures, there must be both a representational system and a bookkeeping system that keep track of this knowledge. Our solution to the representational problem is to have "value frames" (Kolodner, 1986) associated with each value recorded by the system*. Each time the problem solver makes a decision, it records its decision in the appropriate place and also records what led it to that decision. Value frames include facets for a value, other values that were suggested as alternatives, ruled out values, conditions that were considered in choosing the value, and the inference rule or method or set of steps used to make the decision. Each inference rule that is recorded has three parts to it: the rule body, the bindings that were used in this instance, and the source of those bindings (i.e., where in the problem description can the values used in the bindings be found). In addition to supporting the processing described above, the knowledge found in value frames also supports case-based inference in general.

While value frames keep the justifications for each decision, pointers in the other direction are needed when the problem solver needs to retract an already-made decision. Our solution has been to integrate a truth-maintenance type system with our problem solver.

The processes and representations described above are implemented in our JULIA system (Cullingford & Kolodner, 1986, Kolodner, 1987), a system designed to interact cooperatively as a colleague assisting a caterer in planning a meal. The problem solving components of the system include a case-based reasoner, a problem reduction problem solver, a constraint propagator, and a truth-maintenance system. Together they allow the problem solver to enhance its performance by recall of previous cases. Currently previous cases help the problem solver to avoid mistakes and also direct it towards decisions that have been known to work previously. We are just beginning to look at the problems involved in generalizing new plans from cases so that it can take shortcuts in its problem solving.

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*Value frames hold essentially the same things Carbonell (1986) claims are necessary for derivational analogies.