Fast, Frequent, and Flexible Retrieval in Case-based Planning

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When given a new planning problem to solve, a case-based planning (CBP) system can make use of plans previously generated to solve similar problems. Generative planning systems, in contrast, must solve new planning problems from scratch. CBP systems can thus produce new plans more efficiently, which is particularly desirable in domains for which plans must be produced for quick action in a dynamic world. CBP systems can also use stored planning experiences to avoid repeating previous planning failures.

To realize these and other benefits, a CBP system must employ efficient methods for retrieving cases (plans) analogous to the target problem from a casebase of sufficient size and coverage to yield useful analogies. Many "traditional" CBP systems have employed serial case retrieval methods to retrieve cases from *pre-indexed* casebases of modest size (i.e., usually only tens of cases). In such systems the indices of a case are fixed at case storage time. The kinds of features the system will use as indices, as well as the supporting memory organization, must be engineered a priori. Such engineering becomes more difficult in situations where the case memory is to be used for multiple tasks or multiple domains. Pre-indexing hinders retrieval flexibility since a case can only be efficiently retrieved through its indices, the number of which must be kept small. Flexibility in retrieval is desired so that cases may be retrieved that better match the target problem and that thus require less adaptation. The use of fixed indices is also contraindicated by results from psychology showing the fast, associative character of human analogue recall.

Unlike traditional CBP systems, the CaPER case-based planner[1] uses massively parallel retrieval methods to retrieve cases very quickly from an *unindexed* casebase. This casebase is implemented using the PARKA parallel, frame-based knowledge representation system[2]. When run on the 16K processor Connection Machine, these parallel procedures yield plan retrieval times on the order of tenths of a second for a casebase of 100 cases containing 1200 transport logistics plans (and subplans). Furthermore, while case retrieval times for serial procedures typically grow worse than linearly in the size of the casebase, CaPER's parallel procedures have exhibited retrieval times growing only logarithmically in the size of the casebase. Thus CaPER can support efficient retrieval from casebases in the thousands of cases.

CaPER is designed to exploit this fast case retrieval ability. Because serial methods are not used, cases do not have to be pre-indexed. A case can efficiently be retrieved through any of combination of its features. Thus the retrieval probe can contain any features of the target problem including surface, structural, or pragmatic ones and can be of varying specificity. By retrieving analogues better matched to the target problem, less adaptation work will be necessary.

A CaPER case describes a previous planning problem and its solution — a plan which is itself composed of subplans, each of which can be retrieved independently. Cases are represented as collections of frames in a single semantic network. No special-purpose structures (discrimination networks, etc.) are required. Given its fast retrieval methods, CaPER can inexpensively go to memory often to retrieve multiple plans. It will then merge these plans into a new plan for the target problem. Many traditional CBP systems can only afford to retrieve a single old plan to adapt. The advantage of merging multiple (sub)plans is that more of the target goals are likely to be covered by one of plans retrieved. Thus less adaptation work will be required than when a single case's entire plan is retrieved monolithically.

Other implications of fast, frequent, and flexible case retrieval are currently being investigated in CaPER. The prototype system is being tested in the domains of (simplified) car assembly, transport logistics planning, and protein sequencing experiment planning.

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[1]Kettler, B.P., Andersen, W.A., Hendler, J.A., and Evett, M.P. "Massively Parallel Support for Case-based Planning." *Proceedings of the Ninth Conference on Artificial Intelligence Applications* (IEEE). Held March 1-5, 1993 in Orlando, FL. IEEE Computer Society Press, 1993. (An extended version is to appear in *IEEE Expert*).

[2]Evett, M.P, Hendler, J.A., and Spector, L. "Parallel Knowledge Representation on the Connection Machine." *Journal of Parallel and Distributed Computing*, 1993 (forthcoming).