A LOOK ON THE ISSUE OF BUILDING REAL-TIME KNOWLEDGE BASED SYSTEMS : RESEARCH SUMMARY

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My research is focused in developing reasoning and knowledge representation technology designed to the development of real-time applications including the design of real-time architectures, the design of resource-Bounded Knowledge Based Systems and design of anytime algorithms. The applications I am concerned with involve resource allocation and scheduling, process control, robotics and signal processing.

Real-time architectures

Among the most popular AI architectures, the Blackboard model has attracted our attention. Indeed, the main characteristics of Blackboard systems (independence of agents, strong centralized control, event-driven behavior) make them relatively close to classical real-time architectures. However, the design of real-time Blackboard systems usually requires the introduction of concurrent agent execution, which raises a number of important consistency problems. Aspects such as data access serialization and delays experienced by agents waiting for locked resources become fundamental in such systems. Several models (RT-SOS, ATOME-TR and REAKT) have been developed and experimented in real applications by our group. Applications concern process monitoring and control, decision making assistance for aircraft pilots, etc.

References

A. Mensch, D. Kersual, A. Crespo, F. Charpillet and E. Pessi. REAKT: real-time architecture for time-critical knowledge-based systems. Intelligent Systems Engineering Journal, Autumn 94, pp 153-167.

A.I. Mouaddib, F.Charpillet, Y. Gong and J.P. Haton. " Real-Time Specialist Society". Proc. IEEE conference SICICI, Singapore, 1992, 751-754.

S. Brunessaux, F. Charpillet, J. -P. Haton and J. -C. Le Mentec. Une architecture à bases de connaissances multiples et orientée temps réel. Génie Logiciel et Systems Experts, (28):36--47, septembre 1992.

F. Charpillet, Y. Gong, J. -P. Haton, D. Fohr and D. Dobbeni. AITRAS : A Real Time Expert System for Signal Understanding. Proceedings The World Congress on Expert Systems, Orlando (Florida, USA), décembre 1991.

Design of resource-Bounded Knowledge Based Systems

The second important line of my research work has been the design of new resource-Bounded Knowledge based systems. We have developed two models GREAT(Guaranteed REAsoning Time) and Progress (Progressive reasoning system). Both rely on a trade-off between runtime and result quality. This enables a system to operate under bounded resources while using unbounded AI methods. We have also developed a specific anytime algorithm for scheduling problem based on Hopfield neural networks.

Great

Great model provides a framework to develop anytime knowledge based systems. The problem solving process within Great is organised iteratively so that a first solution is quickly available and then refined step by step until either the quality of the result reaches an acceptable value or the deadline is met. The distinctive feature of this approach results from the combination of a generic knowledge representation language able to organize the problem solving process in a progressive way, and a control mechanism which progressively feeds data and knowledge into the inference engine using a preference criterion. In GREAT, knowledge representation is supported by a rule-based language and a hierarchical organisation of factual information represented by attributes. A preference criterion is used to define an ordering relation. This data criterion that we call granularity is based on the expertise given by the designer. The order relation resulting from the granularity is used to classify knowledge into rule packages and data into regions. The classification is assured by the control module. The rule packages and data regions are considered progressively in the order defined in this hierarchy. The association of a rule package with a data region defines a reasoning level. Each reasoning level returns a solution that is then refined by the next reasoning levels in the hierarchy. A reasoning level is executed by running a set of reasoning cycles.

References

Mouaddib, Charpillet, Haton. "GREAT: a Model of Progressive Reasoning for Real-Time Systems", in IEEE International Conference on Tools for AI. 1994

AI Mouaddib and S. Zilberstein "Knowledge-Based Anytime Computation". Proc. IJCAI-95, 775-781.

A.I. Mouaddib, F. Charpillet and J.P. Haton. "Approximations and Progressive reasoning". Proc. AAAI Workshop on approximation and abstraction of computational theories. 1992, 166-170.

Progress

In the framework of the ESPRIT project n° 5146 and 7805 REAKT (REAl time Knowledge Tool), we have developed such a model called PROGRESS (PROGressive REasoning SyStem). This approach makes it possible to manage AI tasks with hard and soft deadlines, provided that multiple methods are available for the tasks the system has to solve. Thus, PROGRESS is closed to design-to-time real-time scheduling but it extend this approach for harder real-time constraints such that the system has the ability to react, meet hard and soft deadlines, stay alert to incoming events and reset task priorities according to changes in workload or resource availability. For this purpose, we have defined a new task model such that a task is not *a priori* defined at the time of its activation but step by step in the course of its execution. It is conceived as a process that gradually integrates changes and developments in the situation and in availability of resources. When unforeseen tasks have to be included in the schedule because of the occurrence of a unexpected event, the resulting overhead is dynamically accounted for an adaptation of on-going tasks. An on-going task can be reactively adapted as the subtasks composing the task are interruptible (as anytime algorithm can do). A task being constructed dynamically by composing design-to-time methods chosen in a library, we have developed a new deliberative scheduling algorithm which allocates to each component of the task the computation time which maximizes the output quality of the task

References

Lalanda, Charpillet and Haton."A Real Time Blackboard Based Architecture", proc. 10th ECAI, Vienna, Austria, August, 1992.

Charpillet, F., Boyer, A. "Incorporating AI Techniques into Predictable Real-Time Systems: REAKT Outcome," Proc. 14th International Avignon Conference, vol. 1, pp. 121-134, Paris, 1994.

Mensch and F. Charpillet. "Scheduling in the REAKT kernel: combining predictable and unbounded computations for maximizing solution quality in real-time knowledge based systems", To be published in proc. of RTS&ES'96, Paris, 10-12 Janvier 1996.

Charpillet, F., Boyer, A. "Incorporating AI Techniques into Predictable Real-Time Systems: REAKT Outcome," Proc. 14th International Avignon Conference, vol. 1, pp. 121-134, Paris, 1994

Anytime algorithms for scheduling problems

Scheduling techniques have been intensively studied by several research communities and have been applied to a wide range of applications in computer and manufacturing environments. Most of the scheduling problems are NP-Hard, which is why heuristics and approximation algorithms must be used for large problems. Obviously these methods are of interest when they provide near optimal solutions if computational complexity can be controlled. For this purpose, we are developing a method based on Hopfield neural network model and anytime algorithms for general scheduling problems. The Hopfield approach permit to solve in an iterative way, a scheduling problems, i.e. finding a global solution trough the minimisation of an energy function. However, this approach does not guarantee to find an optimal solution and more seriously it could take an exponential number of steps. To address the computational complexity of this approach we have mapped this approach to the anytime paradigm which permit to get a first solution very quickly but with a bad quality and then to enhance the quality of the first result over time. In our case the quality stands for both the number of constraints that are satisfied and the distance with respect the optimal solution when optimisation criteria are used. Encouraging primary results have been obtained and we have to develop now a decision-theoretic monitoring technique that maximizes the probability to get a near optimal solution when this solution exists.

References

Jean-Michel Gallone, Francois Charpillet, Frederic Alexandre. "Anytime scheduling with Neural Networks" IEEE International Conference on Emerging Technologies and Factory Automation, October 10-13, 1995, Paris.

J.-M. Gallone and F. Charpillet. Hopfield Neural Network for Scheduling non Preemptive Tasks. in proc. of 12th European Conference on Artificial Intelligence (ECAI'96). Budapest, Aout 96.

J.-M. Gallone and F. Charpillet. Composing Approximated Algorithms Based on Hopfield Neural Network for Building a Resource-Bounded Scheduler. In Proc.IEEE International Conference on Tools with Artificial Intelligence- November 16-19, 1996.

F. Alexandre, C. Cardeira, F. Charpillet, Z. Mammeri, M-C. Portmann. COMPU-SEARCH METHODOLOGIES II, Scheduling Using Genetic Algorithms and Artificial Neural Networks, editors ARTIBA A., Elmaghraby, S. E., Chapman & Hall, 1997.