A Parallel Blackboard Generic Tool for Intelligent Robotics

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Abstract

In order to specify intelligent control for robotic systems, a generic blackboard based methodology is proposed. It is based on a functional analysis of the problem of control. The control is viewed as a "distributed multi-shapes blackboards" decomposition. Specific functionalities of blackboard architectures are specialized for each of the aspects of control: a graphical blackboard for interaction, a classical one for reasoning, and a parallel real time one for control.

We present an original parallel blackboard architecture which integrates the whole system. A model is supplied to express activity and genericity of this tool.

1 A Distributed Blackboards Architecture for Intelligent Robotics

This paper proposes blackboard architecture as a generic tool for the design of dynamic systems control softwares. The methodology is based on a functional analysis of the problem of control [1]. The proposed decomposition (figure 1) supports an advanced real time control system, allowing both supervisory control and autonomous modes. It consists of three main parts: the "User control module", the "Dynamic Reasoning Module" and the "Execution Control Module".

Each module is based on an adapted blackboard architecture. The first has a graphical interactive aspect, the second may appear to perform reactive reasoning, while the third is concerned with real time execution. We name such an architecture a "Distributed Multi-Shapes Blackboards Architecture". This decomposition allows an easy specification of software for many kinds of robotic applications.

The use of distributed blackboards is well suited for remote control while parallel blackboard is more adapted to multi-processors on-board systems.

The User Control Module is in charge of supervision and interaction with the operator. The blackboard (BB) structure of this module contains a symbolic description of the world (robot, environment). An object oriented implantation of this structure allows a graphical representation (supervisory screen). The control of this BB is integrated to BB objects through the semantic of methods and reactive message passing. Two kinds of events are taken into account, internal events (from local agents) or External events (from other modules or User interventions).

The operator is considered as an agent modifying the objects of the BB. Practically, this constitutes the management mechanism of the graphical supervisory screen representing the environment and the robot, and proposing all tasks available to perform missions.

The Dynamic Reasoning Module is the center of the intelligent control system. Missions are received from the user control module. The BB structure chosen for this module consists of three abstraction levels: Mission, Objective, Action. A mission is decomposed by agents into Objectives and then Actions (last level of abstraction before the robot's low level control routines). Agents are specialists in dynamic planning. Decompositions are model based. Some agents are dedicated to recovery.

Logical or physical failures are processed from more local to more global levels. The propagation of failures, if no intermediate solution is found, can imply that the hand returns to the operator.

The user can specify the autonomy he wants to give to the intelligent system through the control of the activating mechanism of the recovery agents.

The Execution Control Module is responsible for the execution of actions specified by the dynamic reasoning module. It connects the other modules to the low level control routines (thus, the robot). In order to re-
alise this module, an original parallel BB architecture is proposed in the next chapter.

2 A parallel blackboard tool

The Execution Control module represents the essential part of the system. It can be considered as a reactive system, which has to manage cooperation between agents. This module is based on a parallel blackboard model, which can be used in various ways.

We propose a dynamic systems control design approach based on parallel blackboard model. A Petri network allows an evaluation of the activity of such a system and shows its genericity. It can be used to express the load in order to optimize the mapping on a hardware target.

Synchronous and Asynchronous Languages (ESTEREL and ADA) are used to validate this model. This study aims naturally for the realization of an automatic tool for the development of generic parallel blackboard, especially adapted to Dynamic Systems Control specification. A prototype is operational using C++ object oriented language. Otherwise, this blackboard model is implemented in simulation on a Sun network and a Transputer Meiko Computer Surface. We now study how to generate hardware dependant systems (adapted to robots hardware configurations) from this generic specification tool.

3 Conclusion

We proposed a dynamic systems control design approach based on parallel blackboard model. A Petri network allows an evaluation of the activity of such a system and shows its genericity. It can be used to express the load in order to optimize the mapping on a hardware target.

References