A Robotic Soccer Passing Task Using Petri Net Plans

(Demo Paper)

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1. INTRODUCTION

The Petri Net Plans framework (PNPs [2]) allows the representation of high level programs for robotic behavior, providing all the action features needed to describe complex plans in dynamic, partially observable and unpredictable environments. The multi-robot extension of PNPs allows the synchronization of actions among different robots, the performance of deliberate cooperation and the cooperative handling of local failures in a multi-robot system. A multi-robot PNP is automatically divided by each single robot of the system for the individual execution. The robots perform their actions relying on their individual knowledge base, and during the plan execution they are able to communicate through a reliable channel, to attain synchronization and sharing of information.

This demonstration shows the use of multi-robot PNPs for the implementation of a robotic-soccer task. Two Sony AIBO quadruped robots are placed on a soccer field with the task of passing a ball (Figure 1). Before the execution of each pass the robots dynamically assign the roles for the execution of the task ($Passer$, $Receiver$) according to the information that is exchanged during a synchronization action. The passing robot reaches and grabs the ball, waiting for its partner to be ready for receiving the pass. At the reception of an acknowledgement the ball is kicked. At the end of the pass the robots perform a new synchronization and the procedure is iterated. The case of two robots is described for simplicity, but more robots may participate to the passing task.

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Figure 1: a picture of the pass task executed by two Sony AIBO robots

2. SYNCHRONIZATION AND ROLES ASSIGNMENT

As a first step for the performance of the pass, the two robots have to coordinate on the assignment of the roles $Passer$ and $Receiver$. The required coordination is accomplished in the multi-robot plan through a *hard synchronization* operator, followed by two concurrent sensing actions, as shown in figure 2. The h_sync operator is used to synchronize the execution and to exchange information about the individual distance from the ball, ensuring that both robots share the same set of beliefs that are required for coordination. The assignment is then consistently performed through the sensing of the condition $closestToBall$. In case $Robot1$ is the closest to the ball ($R1.closestToBall$ is $true$), the robot will grab it and perform a pass towards $Robot2$. The pass and receive procedures are encoded in the remaining branches of the plan, not shown in the figure. The h_sync operator relies on the single-robot $sync$ primitives, that make use of the underlying network protocol to achieve communication. The presence of a token in the place p_{w1} causes $Robot1$ to send its unique id_1 through the network. The transition t_{s1} fires at the reception of id_2, sent by $Robot2$. A token in the execution places p_{e1} and p_{e2} denotes that the robots are performing the communication. When the information about the distance from the ball has been successfully sent, the transitions t_{e1} and t_{e2} fire.

Synchronization is not only needed in this task for assigning the two roles. The execution of the pass behavior requires the robots to

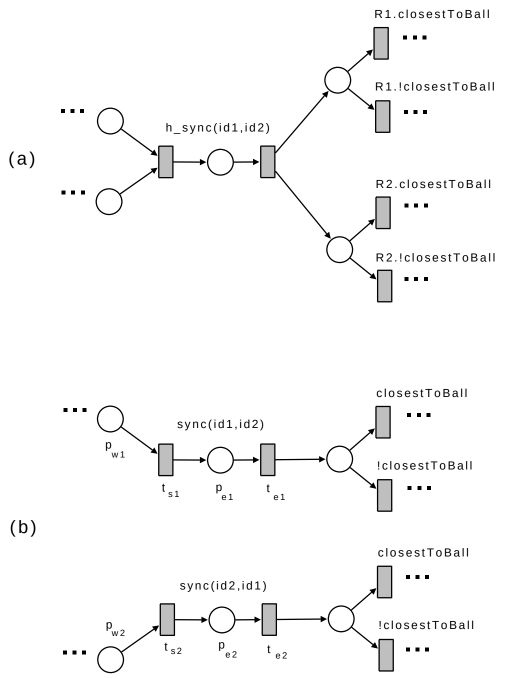

Figure 2: Portion of Multi-robot PNP used for task assignment: (a) multi-robot plan (b) single-robot plans

synchronously perform their actions. When the $Passer$ robot terminates its rotation towards the $Receiver$, and when the $Receiver$ reaches a desired position, a synchronization is performed in order to simultaneously start the passing and the interception of the ball. A final synchronization has been inserted after these actions, allowing the robots to exchange useful information about the outcome of the performed task (e.g. success or failure of the ball interception). Figure 3 shows the use of the h_sync operator in the multi-robot plan at the end of the preparation phase.

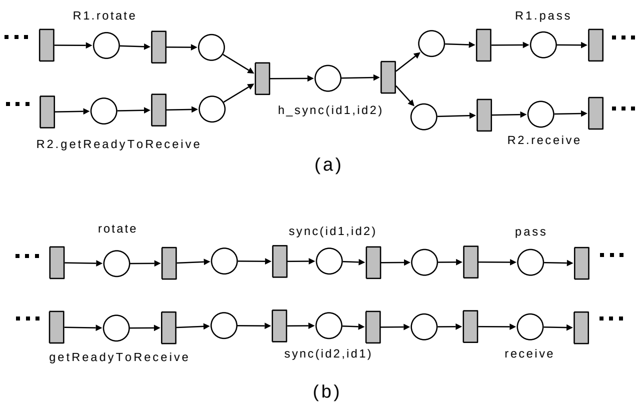

Figure 3: synchronization operator used after the preparation phase: (a) multi-robot plan (b) single-robot plans

3. FAILURE HANDLING

The execution of the multi-robot plan for the passing task is subject to failures, as unpredictable events may occur during the performance of the actions. Indeed, the implementation of effective passing primitives on AIBO robots is a complicated task, and the multi-robot plan must allow the detection of action failures at execution time. Detected local action failures must be communicated and cooperatively handled. In this passing task, if the $Passer$ robot loses control of the ball while rotating towards the $Receiver$, the execution of the pass must be interrupted. The designed multi-robot plan allows the $Passer$ robot to detect this failure situation, through a multi-robot interrupt operator, shown in figure 4. When

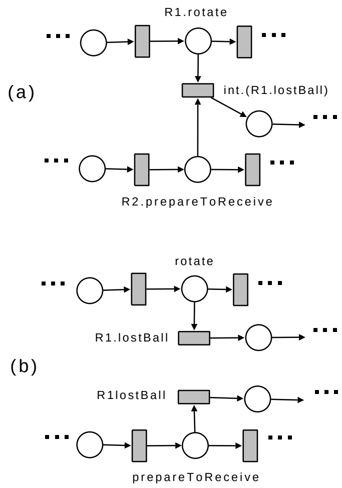

Figure 4: Portion of Multi-robot PNP used for action interruption: (a) multi-robot plan (b) single-robot plans

rotating towards the partner, the $Passer$ robot grabs the ball between its front legs. In case the ball is seen in the field (the $lostBall$ condition becomes $true$), the $Receiver$ robot is notified and the execution is interrupted. The multi-robot interrupt operator makes use of the underlying communication protocol. As for the case of the $sync$ primitives, the firing of the interrupt transitions in the single-robot plans is caused by the communication of a unique interrupt id, sent by the $Passer$ robot in case the $lostBall$ condition is verified. The structure shown in figure 4 is merged in the final plan with the one shown in figure 3, where the interrupt operator was not included for readability.

4. DISCUSSION

Through the implementation of the described robotic-soccer task we have shown the effectiveness of multi-robot Petri Net Plans for the definition complex plans in dynamic, partially observable and unpredictable environments. The complete multi-robot plans, derived single robot plans and videos showing the execution of this task are available at [1]. As a future work we are planning to implement a more structured approach for the characterization of cooperation within the PNP framework.

5. REFERENCES

[1] Extra Material Web Page. `www.dis.uniroma1.it/~ziparo/pnp_extras.html`.

[2] V. Ziparo, L. Iocchi, D. Nardi, P. Palamara, and H. Costelha. Pnp: A formal model for representation and execution of multi-robot plans. In M. Padgham, Parkes and Parsons, editors, *Proc. of 7th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2008)*, Estoril, Portugal, May 2008. IFAAMAS Press. to appear.