Rogi Team Real: Dynamical Physical Agents

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Abstract. Research in dynamical physical agents, consensus of proper physical decisions among physical agents, and an example of passing is shown. The interest is to introduce introspection of the dynamical behavior of each physical body so that every agent has better knowledge. This has to lead to better passes.

1 Introduction

The Rogi Team started in 1996 as the result of a doctorate course in multiagent systems in the University of Girona. The main goal of the team has always been the experimentation of *dynamical* physical agents and autonomous systems. Here, *dynamical* is understood from the automatic control background. It means dynamic temporal evolution of continuous variables of robots' physical body, which can be described by transfer functions or continuous state representation. The aim is to see the impact of dynamics of the physical agent's bodies in the co-operative world.

The micro robots have now clear dynamics for automatic control. There are good transfer functions available to describe the physical bodies of the physical agents.

Our vision hardware, result of our research, is able to process up to 50 frames/sec, locating ten robots and a ball. This sample time is enough for dynamics.

A rational physical agent's approach, result of our research, is operative for robots co-operation. It is here exemplified in terms of passing the ball joint actions.

2 Team's Hardware Description

Our micro-robot team is made up of three parts: robots, vision system, and control system. The vision and control systems are implemented in two PC. The control system is called the host. The host and vision systems are connected by TCP/IP protocol. This allows remote users to do tests on our micro-robots team and permits distant co-operative

M. Veloso, E. Pagello, and H. Kitano (Eds.): RoboCup-99, LNAI 1856, pp. 434–438, 2000.

research [4]. The vision system provides data to the host that takes decisions by an agent oriented approach. The decision is converted into individual tasks for each robot and sent using a FM emitter from the host computer.

We have designed some specific hardware to perform vision, merging specific components for image processing (video converters, analog filters, etc.) with multiple purpose programmable devices (FPGAs) and using multiple color segmentation. This is a real time image-processing tool, which can be reconfigured to implement different algorithms. To locate the robots and the ball, the first step consists in their segmentation from the scene. The discriminatory properties of two color attributes, *hue* and *saturation*, are used so as to segment the objects, and different labels to pixels belonging to different color textures are assigned. Moreover, a more robust behavior under non-uniform lighting of the scenario is achieved, thanks to the stability of hue and saturation under variations on the intensity of the illuminant [2].

3 Taking Dynamics into Account for Decisions

Explicit reasoning on dynamics of the physical body of agents will improve co-operative performance of physical agents. Knowing that controllers modify (controls) dynamics of the physical body of agents, then agents have to be aware (introspection) of the set of controllers their physical body has. Control engineers need tools for developing these agents and their controllers, as stated in [3].

AGENT0 [6] is used as an agent language. In this language an agent's state consists of mental components such us *beliefs, capabilities, choices* and *commitments*. In our point of view, the *capabilities* can represent the dynamics of the agent's body. Some of the agent's capabilities have to be associated to the control of the agent's body and they are proposed as a way for the agent to be aware of what he can or cannot do. *This drives to an extension of the agent concept from physical agents* [1] *to dynamical physical agents* as follows**:** The physical knowledge of the physical agent contains knowledge about dynamics of its physical body, which is supported by further declarative control and supervision levels [5].

As a first example, this approach is applied to a ball passing experiment between two robots. The purpose of the example is to show the utility of inter-agent negotiation with explicit representation of dynamics and to improve the decision of *when* and *how* to do passing with respect to static knowledge. The passing experiment is here simplified as follows (see **Fig. 1**): two robots have an obstacle-free crossing trajectory and have to decide whether to pass the ball and how. The robots have several controllers to move forward in one-dimensional linear movement. The Single Input Single Output transfer functions of the robots and the ball are known. Necessary steps to do the experiment are:

- To find a model that represents dynamics of two mobile robots and a ball.
- To implement several position and speed controllers for passing. Their specification is to reach the set points with precision and stability.
- To inspect untargeted situations: not enough or too much impulse for the ball.

- A negotiation algorithm based on dynamics represented in Agent0 capabilities.

There are passes that are not physically feasible since there are not controllers to execute them. For instance, to do a short pass could be an extremely difficult task if there is no slow speed controller, and the same happens at any required speed set point where no controller exists. The physically unfeasible passes are called undesirable situations, that could be (see **Fig. 1**): (1) the robot 2 has slow dynamics, or (2) the robot 1 does not give the necessary impulse to get ball to the crossing point in some convenient time for dynamics of robot 2. This impulse has to be calculated according to dynamics of the ball.

Both robots have to agree the applicable control and moment for the pass based on the knowledge they have of their dynamics. Since passing between the robots has to be assured by proper physical decisions, then to determine whether a pass is possible or not during a football match, at least Robot 1 has to have a controller to make the ball get through the crossing point.

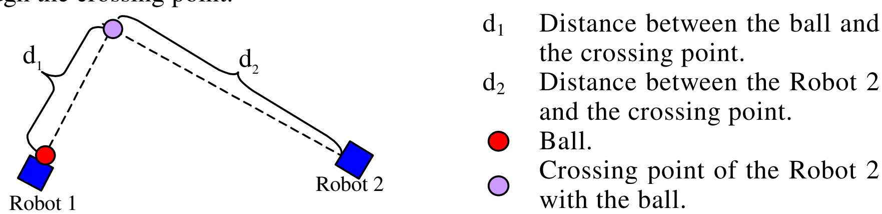

Fig. 1: Simplified *passing experiment*

In this example the transfer functions are:

Dynamics of Each Component

Robot 1:

$$\frac{RealSpeed}{SetPoint\,Speed} = \frac{1}{20s+1}$$

Robot 2:

$$\frac{RealSpeed}{SetPoint\,Speed} = \frac{1}{20s+1}$$

Ball:

$$\frac{RealSpeed}{SetPoint\,Speed} = \frac{21}{0.035s+1}$$

Controllers of Robots

Robot 1:

$$\frac{150s+50}{s}$$

Robot 2:

$$\frac{60s+5}{s}$$

Distance Controller Robot 2:

$$Kp = 1$$

Fig. 3 shows the response of a robot to a speed set point 30 cm/s step (this step is the required speed to kick the ball in the pass). Robot 1 knows that the ball can move 10 cm away from him:

- In 0.285 s with the impulse of 32 cm/s.

- In 0.428 s with the impulse of 45 cm/s.
- And in 1.1 s with the impulse of 60 cm/s.

This knowledge is contained in its base of *capabilities*.

For doing d_1 Robot 1 can provide with three different impulse to kick to the ball as shown in the **Fig. 2**.

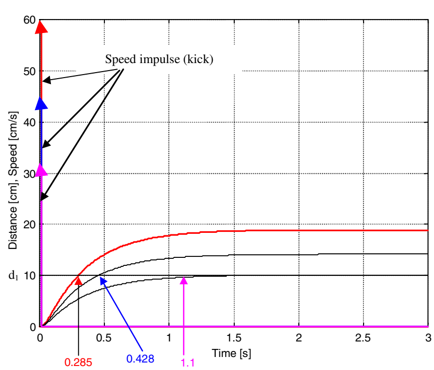

Fig. 2: *Response of the ball to three different kicks (impulses).*

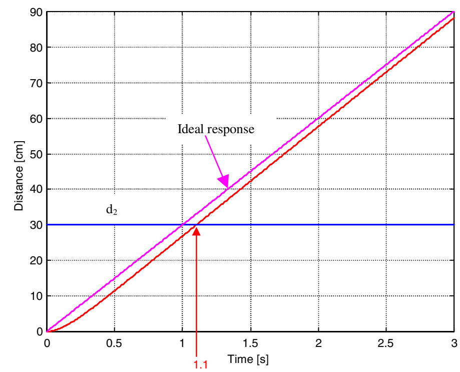

Fig. 3: *Response of Robot 2.*

Consensus Decision Algorithm

- **Step 1:** *Proposition:* With these data, Robot 1 proposes to do the pass in 0.285 seconds to Robot 2.
- **Step 2:** Robot 2 is 30 cm away the crossing point.
- **Step 3:** *Introspection:* Robot 2 looks up its base of capabilities what time is required to be 30 cm far from its actual position. The result is 1.1 s.
- **Step 4:** *Answer:* Robot 2 tells Robot 1 it can move 30 cm in 0.285s, 60% of certainty.
- **Step 5:** *Decision:* Robot 1 considers that this certainty is not enough.
- **Step 6:** *New Proposition:* Robot 1 proposes to do a pass in 0.428 s, impulse 45 cm/s.
- **Step 7:** *Answer:* Robot 2 responds 75% certainty.
- **Step 8:** *Decision:* Robot 1 considers that this certainty is not high enough.
- **Step 9:** *New Proposition:* Robot 1 proposes new time, 1.1 s with impulse 60 cm/s.
- **Step 10:** *Answer:* Robot 2 to Robot 1. It can move 30 cm in 1.1s with 90% certainty.
- **Step 11:** *Decision:* Robot 1 agrees this certainty is big enough and they do the pass.

Fig. 4 shows how the ball and Robot 2 arrive to the crossing point at the time the robots had decided. Robot 2 had to move 30 cm and the ball 10 cm. Note that Figure 3 also shows the difference between the real (dynamical) and the ideal (static) responses of the robot. If agents take decisions considering the ideal case, the decisions may be wrong. Taking into account the dynamics of their bodies in the decision, agents can assure they take the physically proper (and correct) decision.

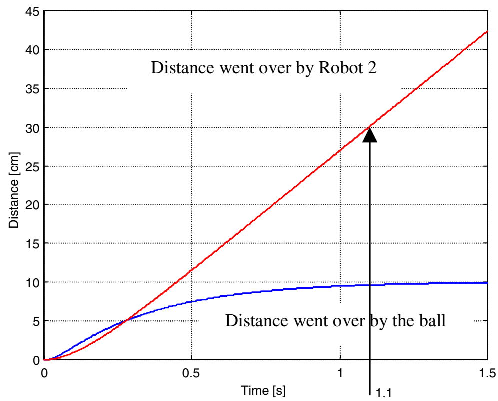

Fig. 4: *Run distances.*

Acknowledgements

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