Middle Robots League, Team *NAIST*, pages 170–174
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# Team Description of the RoboCup-NAIST

**NAIST**

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**Abstract.** *To make a robot team perform a soccer game, various technologies must be developed. To date, we constructed a multi-sensor based mobile robot for robotic soccer research. Based on this platform, we have implemented some behaviors for playing soccer and the vision system with on-line visual learning function. This year, we refine behaviors for playing soccer since we improve a motor control system. Furthermore, we put an omnidirectional camera in addition to an active vision system so as to enlarge view of our soccer robot. This paper presents the design methodology of our robots.*

## 1 Introduction

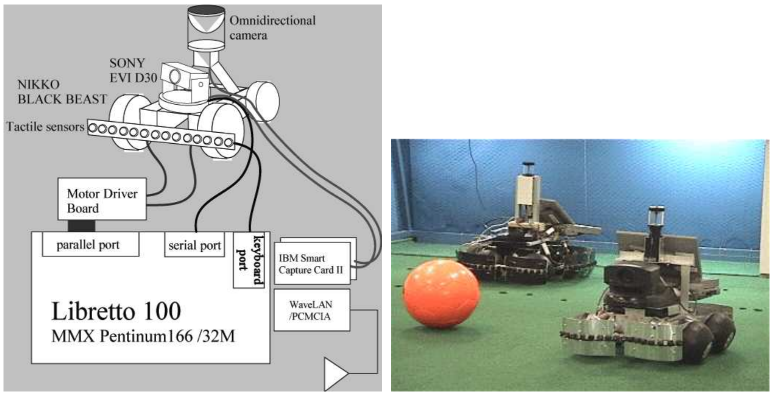
Robotic soccer is a new common task for artificial intelligence (AI) and robotics research[1, 2]. The robotic soccer provides a good test-bed for evaluation of various theories, algorithms, and agent architectures. Through robotic soccer issue, we focus on **"perception"** and **"situation and behavior"** problem among RoboCup physical agent challenges [2]. So far, we have implemented some behaviors for playing soccer by combining four primitive processes (motor control, camera control, vision, and behavior generation processes)[3]. Such behaviors were not sophisticated very much because they were fully implemented by the human programmer. So, a kind of learning algorithm would be useful during off-line skill development phase. We also have developed the vision system with on-line visual learning function [4]. This vision system can adapt to the change of lighting condition in real-time.

This year, we refine some behaviors using a kind of learning algorithm. Furthermore, we put an omnidirectional camera in addition to an active vision system so as to enlarge view of our soccer robot. Using this omnidirectional camera, each robot can recognize its location in the soccer field. We plan to realize cooperative plays between the robots based on such information.

## 2 Our Hardware Architecture

Each soccer robot must have some kinds of behaviors to perform as a soccer player. Therefore, such robot should have a compact and powerful driving system, multiple sensing systems and a communication system.

Currently, we have developed a compact multi-sensor based mobile robot for robotic soccer as shown in **Fig.**1. As a controller of the robot, we have chosen to use a Libretto 100 (Toshiba) which is small and light-weight PC. We set a wireless LAN device for communication on our soccer robot. The wireless LAN device is actually WaveLAN(AT&T) which can be plugged into a portable PC.




(a) (b)

Figure 1: Our soccer robot.

## 2.1 Motor control system

A motor control system is used for driving two DC motors and is actually an interface board between a portable PC and motors on the chassis of our soccer robot. This control board is plugged into a parallel port on the portable PC. The motor speed is controlled by PWM. To generate PWM pulses, we use PIC16C87 micro-controller. A motor control command is actually an 8 bits binary command for one motor. This board can receive control commands from the portable PC and generate PWM signals to right and left motors.

## 2.2 Tactile sensing system

We constructed a cheap tactile sensing system [3] by remodeling a keyboard which is usually used as an input device for PC. Keys which this tactile sensing system is composed of are set around the body of soccer robot.

## 2.3 Visual sensing system

We use an active vision system and an omnidirectional camera system. As an active vision system, we have chosen a color CCD camera (SONY EVI D30, hereafter EVI-D30) which has a motorized pan-tilt unit. An omnidirectional camera system consists of a hyperbolic mirror and a color CCD camera of which optical axis is aligned with the vertical axis of the mirror. In order to capture two images from both vision systems, we use two video capture PCMCIA cards (IBM Smart Capture Card II, hereafter SCCII) which can be easily plugged into a portable PC.

# 3 Our Software Architecture

In order to control our hardware systems, we use a shared memory [5] and 5 software components which are the motor controller, camera controller, tactile sensor module, vision module and behavior generator. **Fig.**2 shows an interactions between these software components. Note that this figure shows the software architecture of our current robotic soccer system. All software components read and write the same shared memory. Using this shared memory, they can communicates each other asynchronously. As shown in **Fig.**2, we define the structure of the shared memory. For example, the behavior generator takes the state of camera, vision, tactile and motor in the shared memory as input vectors. Then, it combines these information with programmer's knowledge and decides the robot's action at next time step. Finally, it writes the motor command for the motor controller on the shared memory. In the same way, other software components read states and write commands in each timing.

## 3.1 Vision Module

The vision module provides some information about the ball, goal and teammates in the image. The teammate will be recognized by a colored marker on each robot. The vision module provides the area of the targets(ball, goal and a colored marker), the coordinates of their center and the both maximum and minimum horizontal coordinates of the goal and so on.

We actually implemented a color image segmentation and object tracking processing in the vision module. Even if surroundings such as lighting condition changes, our vision module can adapt to the change since such vision module with on-line visual learning capability based on fuzzy ART model [4].

## 3.2 Behavior generator

The behavior generator decides the robot's behavior such as avoiding a wall (called avoiding behavior), shooting a ball into a goal (called shooting behavior) and defending own goal (called goalie behavior). Avoiding behavior is implemented in a reflex way based on the tactile information.

### 3.2.1 Shooting behavior

Since we improve the motor control system, we refine a shooting behavior. We make a simple strategy for shooting the ball into the goal. To shoot the ball to the goal, it is important that the robot can see both ball and goal. Therefore, the robot must round the ball until the robot can see both ball and goal with the camera toward the ball. Finally, the robot kicks the ball strongly. The concrete procedure of shooting behavior is follows:

1)Find the ball
2)Approach the ball
 While approaching the ball
 **if** the area of the ball $>$ 20 **then** stop
3)Round the ball
 d $\leftarrow$ the direction of the goal
 **switch(d)**
 right: clockwise round the ball
 with the camera toward the ball
 left: counterclockwise round the ball
 with the camera toward the ball
 **if** the robot can see both ball and goal **then** stop
4)Turn the body of the robot toward the ball
5)Kick the ball strongly

**Fig. 3 (a)** shows the shooting behavior.

### 3.2.2 Goalie behavior

*A word is enough to the wise.* We are pursuing research issues focused on the realization of such learning capability. We're going to develop a robot learning method based on system identification approach. Our method utilizes GMDH algorithm[6] which is a kind of system identification method and expands it so that multiinput-multioutput type system can be applied to. Suppose that a set of visual information is input data and a set of motor commands to the robot is output data, identifying a mapping function between input and output data is equivalent to resolving skill acquisition problem.

Now, our robots succeeds in acquiring a simple strategy for preventing a ball from entering a goal. When a ball is approaching to our goal, our robot can move left/right with the center of robot body toward a ball. The home position of the goalie is the center of a line close to our goal. The goalie only moves along that line. **Fig. 3 (b)** shows the goalie behavior.

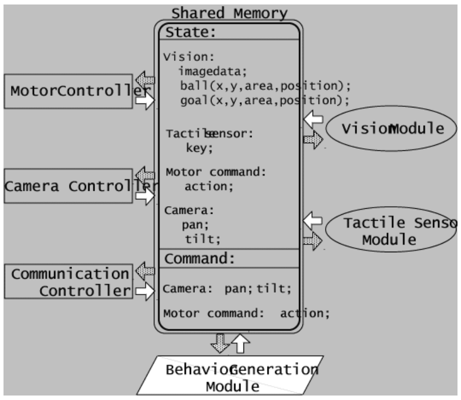
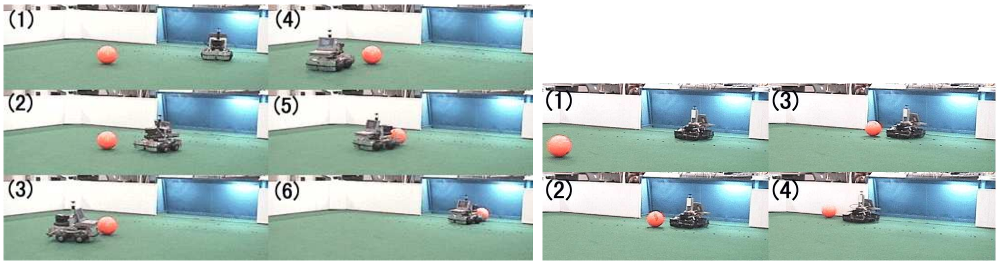



Figure 2: Software architecture.




(a) (b)

Figure 3: Sequences of shooting and goalie behaviors

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