"FC-Soromons" Team Description

Yoichiro Maeda, Wataru Shimizuhira, Satoshi Hanaka and Kensuke Mizutani

Dept. of Human and Artificial Intelligent Systems,
Faculty of Engineering, Univ. of Fukui,
3-9-1, Bunkyo, Fukui 910-8507 Japan.
{maeda, wsimizuhira, shanaka, kmizutani}@ir.his.fukui-u.ac.jp
http://www.ir.his.fukui-u.ac.jp/robocup/index-e.html

Abstract. University of Fukui "FC-Soromons" participates in the RoboCup symposium and middle-size league competition for the first time. The team description of FC-Soromons including the specifications of the robot mechanism and omnidirectional vision system and the outline of the behavior control method is described in this paper.

1 Introduction

RoboCup is the most famous soccer robot competition in the world and was originally established as an international joint project to promote AI, robotics, and related field [1]. The middle-size league competition of RoboCup 2005 is the first trial for FC-Soromons in Univ. of Fukui. "FC-Soromons" means the fuzzy-controlled soccer robot with multiple omnidirectional vision system. Naturally, "FC" and "Soromons" also imply the meaning of a football club in Fukui and an intelligent robot such as sage King Solomon, respectively.

Fig. 1. Appearance of Team FC-Soromons
In our laboratory, the high performance vision system to acquire the surrounding environment information and the flexible behavior control method like human by using soft computing framework are main research topics. The team FC-Soromons is composed of four robots including three field-player and one goalkeeper robots. These robots are used for the subject of our research to confirm the efficiency of the proposed vision system and control method.

Multiple omnidirectional vision system (called MOVIS) with three omnidirectional cameras is built in our field-player robots [2]. MOVIS is able to realize the real-time object position measurement and the self-localization in the field. Furthermore, a multi-layered fuzzy behavior control method for collision avoidance and object chasing motion by using fuzzy reasoning is used in our robots [3, 4]. By combining with MOVIS, it makes possible to realize omnidirectional adaptive behaviors of soccer playing like a skilled human. This paper presents the hardware architecture and the control method of our team robots.

2 Hardware Architecture

Appearance of all robots of FC-Soromons is shown in Fig.1. In the team FC-Soromons, we have four robots including three field-player and one goalkeeper robots. The soccer robot experiment was performed on our own mini-field with half scale of the regular size of the RoboCup middle-size league.

2.1 Robot Hardware

The characteristics of three field-player robots, a goalkeeper robot and a kick device are described in this section.

**Field-Player Robot** The main body and the system architecture of a field-player robot are shown in Fig.2 and 3. Each field-player robot has MOVIS composed of three omnidirectional cameras on the top of its body.

<table>
<thead>
<tr>
<th>Table 1. Specification of Field-Player Robot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot Size</td>
</tr>
<tr>
<td>Total Weight</td>
</tr>
<tr>
<td>Locomotive Speed</td>
</tr>
<tr>
<td>Driving Wheel</td>
</tr>
<tr>
<td>Driving Motor</td>
</tr>
<tr>
<td>Kicking Motor</td>
</tr>
<tr>
<td>Vision Sensor</td>
</tr>
<tr>
<td>Computer</td>
</tr>
<tr>
<td>Battery</td>
</tr>
<tr>
<td>Communication</td>
</tr>
</tbody>
</table>
As shown in Fig.3, two 70W DC motors are controlled by the powerful motor controller according to a control command sent from a notebook PC through USB interface. Images obtained from three omnidirectional cameras are sent to the notebook PC through the daisy-chain IEEE1394 interface. The robot is able to communicate to the local server PC by IEEE802.11b 2.4GHz wireless LAN system. The outline specification of the field-player robot is shown in Table1.

**Goalkeeper Robot** A goalkeeper robot has a single omnidirectional cameras on the center of its body. The appearance of the goalkeeper robot is shown in Fig.4. The specification of the goalkeeper robot is almost as same as that of field-player robots shown in Table1.

**Kick Device** Fig.5 shows the kick device of a field-player robot. All robots have the same kick device in front. Right and left motors of this device are independently controlled by a notebook PC. Therefore, the robot is able to kick a ball toward various directions.

### 2.2 Multiple Omnidirectional Vision System (MOVIS)

We developed the multiple omnidirectional vision system (MOVIS) to acquire the precise distance and direction to an object by only vision sensor without active sensors (for example, sonar, infrared sensor, laser range finder, etc.) [2]. In MOVIS, the three omnidirectional cameras are horizontally arranged in the equilateral triangle on a soccer robot as shown in Fig.6. By the line extended
from the center of gravity of the equilateral triangle to each vertex point, the range of the acquisition of images are divided into three areas which each two cameras perform as the stereo vision within 120 degrees (for example in Fig.7, $M_1 \& M_2$, $M_2 \& M_3$, and $M_3 \& M_1$). Two cameras in each area compose a stereo vision and measure the precise distance information by the principle of triangulation.

We used IEEE1394 digital CCD camera as the omnidirectional vision in MOVIS. Images from this camera are directly sent to PC through Firewire high-speed interface in real time (30fps). In this research, we confirmed that a control sampling time is within 33msec for obtaining the distance and direction information from three cameras and controlling robot by the fuzzy reasoning.

3 Software Architecture

Obtaining the distance and direction information from three cameras and controlling the robot by the fuzzy reasoning are executed by a notebook PC in real
time. In this section, we explain about the measurement process of MOVIS, the multi-layered fuzzy behavior control and the soccer robot simulator. Especially, all robot control programs are described by fuzzy inference rules in our robots. Accordingly, we are able to modify the robot control rule easily and develop software programs efficiently.

3.1 Measurement Process of MOVIS

At first step, the position of an object in the robot coordinates is measured by MOVIS. Next, after corner pole positions in the robot coordinates are measured, a self-localization position of the robot in the absolute coordinates is calculated. Furthermore, the absolute robot position obtained by self-localization is modified by the measurement error in the origin point acquired by the calibration in advance. Finally, by the modified self-localization position of the robot, we can obtain the modified object position in the absolute coordinates. We confirmed that the measurement by MOVIS was more accurate than the measurement by single omnidirectional vision about 63%.

3.2 Multi-Layered Fuzzy Behavior Control

Fuzzy reasoning is the useful method to describe adaptive behaviors for an autonomous mobile robot. However, when we describe the adaptive behavior in the complicated environment with fuzzy rule, we must construct too many rules and take a lot of times to tune them. Accordingly, we developed the multi-layered fuzzy behavior control method that the behavior of the robot is controlled with the lower-layered fuzzy rules and combined them with the higher-layered fuzzy rules [3, 4].

In this method, the behavior of the robot is divided into some sub-tasks and individually controlled with the behavior decision fuzzy rules in lower-layer. Lower-layer fuzzy rules are selected by behavior selection fuzzy rules in higher-layer. The multi-layered control of the robot is able to be realized by combining the lower-layered fuzzy rules with the higher-layer fuzzy rules as shown in Fig.8.

![Fig. 8. Multi-Layered Fuzzy Behavior Control](image1)

![Fig. 9. Soccer Robot Simulator](image2)
3.3 Soccer Robot Simulator

In our laboratory, a soccer robot simulator shown in Fig.9 was developed to confirm the performance of the proposed methods. Now, it is used to simulate the new control and learning method by the fuzzy control, neural networks, reinforcement learning and so on. This simulator was constructed by C++ language with X graphics libraries and Motif widgets on Vine Linux OS. All scales of robots, sensors and the field are equivalent to the real size of them in this simulator. Accordingly, we are able to use for the supervisory monitor program at the real RoboCup competition.

4 Conclusions

We have described the hardware and software architecture for the robots of our team FC-Soromons. Currently, our research interests concentrate on cooperative behavior and strategy learning. We are mainly studying the neural network learning of the characteristics of human operation and the reinforcement learning of the control strategy in the multi-layered fuzzy behavior control.

References