Available online at www.sciencedirect.com
ScienceDirect
Journal of Bionic Engineering Suppl. (2008) 121–129

A System Design Concept Based on Omni-Directional Mobility, Safety and Modularity for an Autonomous Mobile Soccer Robot

Yasunori Takemura[1], Yu Ogawa[1], Amir A. F. Nassiraei[1], Atsushi Sanada[1], Yuichi Kitazumi[1], Ivan Godler[2], Kazuo Ishii[1], Hiroyuki Miyamoto[1]

1. *Kyushu Institute of Technology*, *Kitakyushu*, *Fukuoka* 808–0196, *Japan*
2. *The University of Kitakyushu*, *Kitakyushu*, *Fukuoka* 808–0135, *Japan*

Abstract

In this paper, we describe the concept, design and implementation of a series of autonomous mobile soccer robots, named Musashi robots, which are designed referring ISO safety standards and have mechatronics modular architecture. The robots are designed to participate in the RoboCup Middle Size League. Using a modular design philosophy, we show that the selection of a proper moving mechanism, a suitable vision system and a mechatronics modular architecture design can lead to the realization of a reliable, simple, and low cost robot when compared with most car-like robots that include many kinds of sensors and have a complex design structure.

Keywords: entertainment robotics, mechanism design, wheeled robot

1 Introduction

RoboCup is an international joint project to promote Artificial Intelligence (AI), robotics, and related fields. It attempts to foster AI and robotics research by providing standard problems in which a wide variety of technologies can be integrated and examined. In RoboCup, a soccer game is used as a main topic of research, and the aim is for innovations to be applied to socially significant problems and industries in the future[1].

In the RoboCup Middle Size League (MSL), two teams of mid-sized robots (maximum 50 cm × 50 cm × 80 cm) with all sensors on-board play soccer on a field (12 m × 18 m). Relevant objects (ball, field and line) are distinguished by colors (orange, green and white). Robots communicate with each other by wireless LAN. No external control by humans is allowed, except to bring or remove robots in/from the field. Duration of a game is 15 minutes half, so total 30 minutes. Therefore, the robots should be autonomous and have tough mechanism.

Hibikino-Musashi is a soccer team in the RoboCup MSL[2,3]. Members of the team are from three different research and educational organizations located in the Kitakyushu Science and Research Park, Kitakyushu, Japan.

In this paper, a design methodology to realize a safe, simple, robust, and mobile platform for Musashi robots is presented. Musashi robots are a series of autonomous mobile soccer robots that have modular architecture in their hardware. The robot includes an omni-directional movement mechanism, omni-vision and a novel ball-kicking device, and is developed as a reliable and robust soccer robot with a high degree of simplicity, mobility, and maneuverability.

Therefore, the design concepts of the Musashi robot have two high priority concepts: safety and modularity. Safety concept consists of safety design, safety guarding and safety informing. Modularity concept consists of easy assembling, maintenance, trouble-shooting, reliability and low cost. Modularity concept also helps safety mechanism.

This paper presents details of the current state of hardware architectures. The 2nd section introduces our old robot problems and points of the modification. In the

Corresponding author: Yasunori Takemura
E-mail: takemura-yasunori@edu.brain.kyutech.ac.jp

3rd section, we describe how to design the new Musashi robot by using the omni-directional motion, safety and modularity concepts.

2 Concept of design

Fig. 1 shows the first version of our robot, which was developed in the Fraunhofer AIS as we organized an international joint team GMD Musashi[4]. This robot has a car-like locomotion mechanism that includes two active wheels and two caster wheels at the back and front, respectively. A digital camera with a 70 degree wide-angle lens is mounted on top of the robot. The camera is controlled by a DC motor and an absolute encoder to have 360 degree rotation in the horizontal plane. In order to move in a dynamic environment avoiding obstacles, the robot is also equipped with different kinds of sensors such as two infrared (IR) sensors, two distance sensors, and touch sensors. A pneumatic kicker whose air is supplied by two small air pressure tanks is installed on the robot.

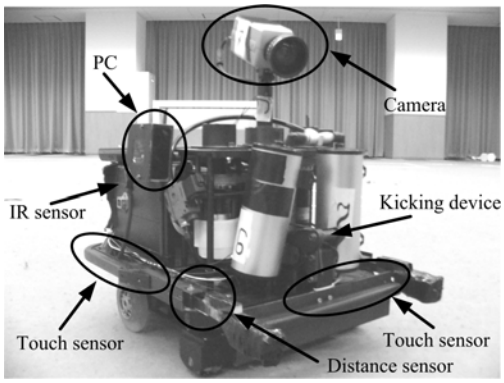

Fig. 1 The first Musashi robot (The first Musashi robot equipped with 11 sensors).

The existing problems of the mechatronics design outlined above are as follows.

(a) Poor mobility functions for performing requested motions such as rotation around the ball and lateral movements.

(b) Complex data processing owing to the wide variety of sensors

(c) Complexity in the development of the hardware and software involved in camera motion control for tracking a ball.

(d) A design that is not compatible or safe for interaction with humans.

(e) Low reliability and insufficient robustness for dynamic environments such as that of RoboCup.

(f) Complex mechatronics from the viewpoints of assembly, maintenance, extendibility, troubleshooting, and transportation.

(g) Low speed in kicking of the ball, in comparison with other teams' robots, which can shoot the ball at high speeds up to 6.0 $m \cdot s^{-1}$[5,6].

To solve the above problems and achieve the required characteristics for a RoboCup scenario, a new mobile robot named "Musashi" is designed and constructed for the Hibikino-Musashi team. In this design approach, we show that selection of a proper moving mechanism, a suitable vision system and mechatronics modular architecture design can lead to the realization of a more reliable, simple, and low cost robot.

3 Musashi architecture

The design of the Musashi robot is based on three significant and fundamental concepts: that the robot must be 1) omni-directional, 2) safe, and 3) modular[7–9].

3.1 Concept of omni-directional mobility

The Musashi robot is an omni-directional mobile platform with omni-vision (Fig. 2). The dynamic and kinematic characteristics of the omni-directional design

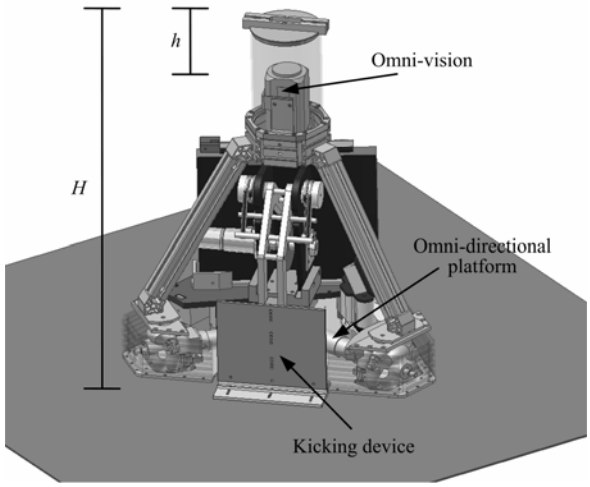

Fig. 2 Three-dimensional computer-aided design of Musashi (Musashi includes an omni-directional platform, omni-vision, and a strong novel ball-kicking device, designed by Autodesk Inventor 3D-CAD.).