Development of "Hibikino-Musashi" omni-directional mobile robot

Yasunori Takemura[a,*], Atsushi Sanada[a], Takaaki Ichinose[a], Yuusuke Nakano [a], Amir A.F. Nassiraei[a,b], Kazuto Azeura [c], Yuichi Kitazumi [c], Yu Ogawa [c], Ivan Godler[c], Kazuo Ishii[a], and Hiroyuki Miyamoto[a]

[a]*Department of Brain Science and Engineering, Kyushu Institute of Technology, Japan*
[b]*Kitakyushu Foundation for the Advancement of Industry Science and Technology, Japan*
[c]*Faculty of Environmental Engineering, The University of Kitakyushu, Japan*

Abstract. Hibikino-Musashi, a middle-size Robocup soccer team, is a joint team of three organizations: Kyushu Institute of Technology, the University of Kitakyushu, and Kitakyushu Foundation for the Advancement of Industry Science and Technology (FAIS). We recently developed a new omni-directional mobile robot platform with an omni-directional vision system. In this paper, our robot platform is presented.

Keywords: omni-directional mobile robot, Robocup, omni-vision, "Hibikino-Musashi"

1. Introduction

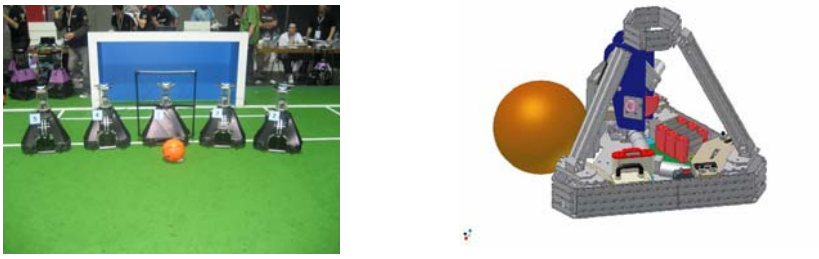
"Hibikino-Musashi" is a joint middle-size league Robocup[1] soccer team. Members of the team are from three different research and educational organizations, all located in the Kitakyushu Science and Research Park, Kitakyushu, Japan. The three organizations are: Kyushu Institute of Technology, the university of Kitakyushu, and Kitakyushu Foundation for the Advancement of Industry Science and Technology. We developed recently a new omni-directional mobile robot platform with omni-directional vision. This paper presents the details on the current state of hardware and software architectures of the "Musashi" robots [2].

2. Omni-directional mobile robot "Musashi"

2.1 Concept of robot

The omni-directional mobile robot "Musashi" series are shown in Fig.1. The design concepts are as follows:

* Corresponding author. Tel: +81-93-695-6102. Fax: +81-93-695-6102.
E-mail address: takemura-yasunori@edu.brain.kyutech.ac.jp (Y.Takemura).



(a) (b)

Fig.1. (a) A series of the “Musashi” omni-direcitonal mobile robot; a goalie and four players (b) 3D-CAD design of “Musashi” robot

(i) Simple modular architecture with a laptop PC for easy assembly and maintenance
(ii) Omni-directional motion
(iii) Omni-vision system
(iv) Strong kicking mechanism
(v) Cable-less system as much as possible

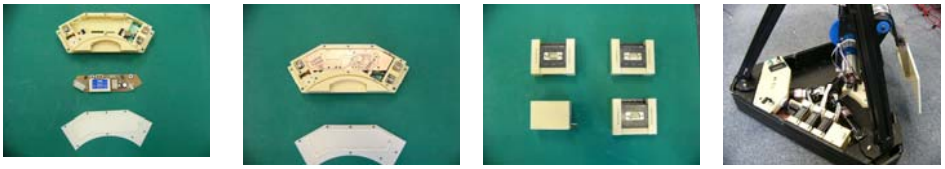
The specifications of the robot are shown in Table 1. The robot has been designed by using a 3D-CAD software (Fig.1-(b)). The driving mechanism consists of 3 sets of a motor, a motor driver, a planetary gear and an omni-directional wheel. The various electric devices and circuits are designed as functional modules. Each function module such as motor drivers and USB serial controllers is developed as a “package” (Fig. 2). Therefore, we can remove a broken part and replace the part easily, and carry and assemble the robot without a large amount of labor.

2.2 System Architecture

The behaviour of the robot is programmed on a laptop PC, and the behavior commands are received by a referee box PC via onboard wireless LAN. The laptop PC, installed on the robot, sends motor control commands (target velocities) to the motor drivers through USB/RS232C serial converters.

Table 1 Specification the robot

Dimensions	Triangle: 500[mm] Height: 500[mm] Weight: 16.0 [kg]		
Actuator	DC-motor x 3 (Maxon, 24.0[V] , 70[W] Motor driver x 3 (Faulhaber, MCDC2805) Omni-wheel x3	Sensor Kicking device	Omni-directional camera DC-motor encoder x 3 DC-motor Torsion spring x 2
Battery	Li-Polymer battery x 7 (3.7[V], 2000[mAh])	Duration	1.2 [h]



(a) (b) (c) (d)

Fig.2. Module system (a) power supply module, (b) assemble power supply module, (c) motor drivers module system, (d) assemble motor drivers system.

The system architecture and the power system are illustrated in Figs.3-(a),(b). The robot has a Li-polymer battery (25.9[V], 2000[mAh]). The voltage is converted to 12.0[V] and 5.0[V] for the camera and the micro computer power supply, respectively. The power consumption of the robot is approximately 40[W], and, the operation duration of the robot is estimated to be 1.2 [h].

2.3 Vision system

The vision system of the "Musashi" robot consists of an omni-directional mirror and an IEEE1394 digital camera. Recent RoboCup robots have strong kicking devices capable of kicking high loop shots, so the distance to the ball is sometimes over estimated than the real distance, which subject is one of future works.

The image from the camera to the laptop PC is obtained in YUV format, then converted into HSV format. In order to detect objects by extracting colors, the images in YUV and HSV are binarized using upper and lower thresholds and the two images are conjugated logically. This method improves robustness and accuracy of the color extractions in various lighting conditions.

The image is used for self-localization by calculating the distances and angles of the robot with respect to the ball, goals, poles and obstacles. To achieve real-time image processing of the vision system the OpenCV library is utilized. The present performance of vision-processing is 15 frames per second [3].

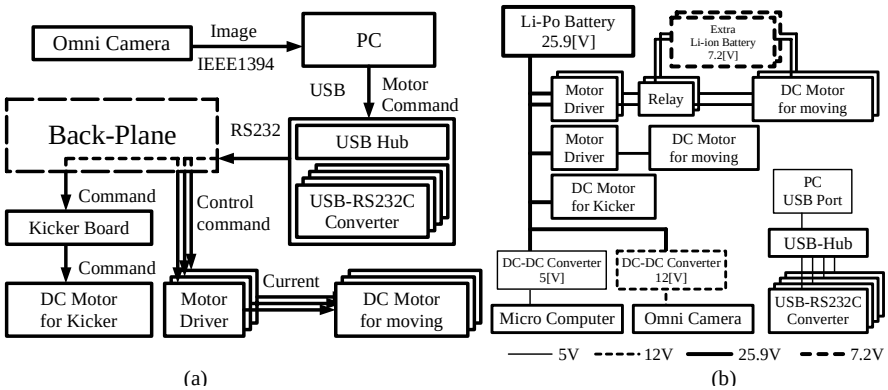


Fig.3 (a) System architecture of "Musashi" mobile robot (b) Power supply diagram of "Musashi" mobile robot

2.4 Behavior of robots

With regard to the team strategy four roles are allotted to the team robots: a forward player, a mid-fielder, a defender and a goalie and three actions are assigned to the robot: attack, support and defence. The forward player attacks the goal and does not join a defence and mid-fielder do the support activities, and the defender does the defence and the attack. The defender attacks only when other robots are far from the ball. The robots autonomously choose to activate one of the roles. The actions are selected reflecting the position of the robots and the ball. If some of the robots are inactive, the remaining robots change their roles automatically.

For example, the attack action is realized through the following process: first, the robot targets and follows the orange ball. The robots continuously face the opponent goal except that the robots are in the collision avoidance mode. Then, the robot dribbles until the position of the robot becomes within 5 [m] distance to the goal, and shoots the ball into the opponent goal. During the dribble, the robot adjusts its direction toward the opponent goal and keeps as high speed as possible. The mid-fielder robot gets the ball only when the distance of the ball is nearer than those of the others. The defending robot doesn't actively approach when the ball is located far away, and keeps his position between the ball and his own goal. The goalie remains in the goal area, and keeps his position between the ball and his own goal.

3. Conclusions

In this paper, we described an approach to realize a simple, robust and reliable hardware for our robot series named "Musashi". In order to make a robot, with capability of robust movement in a dynamic environment such as RoboCup, we introduced and implemented a fully modular architecture for the "Musashi" robots. Using this approach, "Hibikino-Musashi" won the 1st place at RoboCup Japan Open 2006 and was ranked among the best 8 teams at the RoboCup 2006 world championships in Bremen.

The color calibration of our vision system is set manually at present, but we have been developing an auto calibration vision system by using mnSOM [4] that we plan to utilize in the near future.

Acknowledgements

This work was supported by the 21st Century COE program, Ooba sangyou Co., Ltd., and Nippon telephone center corporation Co., Ltd.

References

[1] H.Matsubara, M.Asada, H.Kitano, "History of RoboCup and Prospects of RoboCup-2002", RSJ, Vol.20, No.1, pp.2~6, 2002, In Japanese

[2] T.Ichinose, Y.Takemura, K.Azeura, I.Godler, "HIBIKINO-MUSASHI", RoboCup 2006 Bremen, CD-ROM Proc. Of RoboCup 2006

[3] K.Azeura, I.Godler "Color Sampling with Omni-directional Camera in Robot Soccer", The 24th Annual Conference of the Robotics Society of Japan, 1B25, CD-Proc.

[4] K.Tokunaga, T.Furukawa, S.Yasui, "Modular network SOM: Self-organizing maps in function space", NIPLR, 9(1)(2005), pp.15~22