UChile RoadRunners 2009 Team Description Paper

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Abstract. Our robotics group has teams in three leagues: humanoid, SPL, and @home. Taking advantage of this, we want to contribute to the transfer of relevant developments between the different RoboCup leagues. Our developments for the humanoid league include: (i) the design and construction of a new (hardware) controller to be used in our 3 robots, (ii) the construction of an innovative battery protection hardware, (iii) a new methodology for designing fall sequences that diminish the damage in the robot's joints, and (iv) the proposition of new methodologies to be used in the vision system of our robots (task oriented active vision and context-based perception).

1 Introduction

The UChile robotics team is an effort of the Department of Electrical Engineering of the University of Chile in order to foster research in robotics [1]. The main motivation of the team is the participation in international robotics contests that provide standard problems to be solved, where a wide range of technologies can be integrated and examined. Through the participation in these contests, the team can share knowledge with other research groups, and test the quality of the developed technology. The participation in contests complements other scientific activities of the group (papers' publishing, industrial projects, etc.). The group has also developed several educational programs with children using robots [2].

The UChile team was created in 2002, and it has participated in all RoboCup world-competition with its former four-legged team since 2003. In 2007 and 2008 the group also participated in the humanoid and @home leagues (in the RoboCup world competitions). Among the main scientific achievements of the group, it is worth to mention the obtainment of two important RoboCup awards:

- *RoboCup 2004 Engineering Challenge Award* for the article "UCHILSIM: A dynamically and visually realistic simulator for the RoboCup four legged league", where our realistic simulator of robots was described; and
- *RoboCup 2007 @Home Innovation Award* and *RoboCup 2008 @Home Innovation Award*, which honor outstanding technical and scientific achievements as well as applicable solutions in the RoboCup @Home league, for the development of the personal robot *Bender*.

As a RoboCup research group, we believe that our contribution to the RoboCup community is not restricted to our participation in the RoboCup competitions, but that we should also contribute with new ideas to the community. In this context, our team has been one of the teams that has presented more articles in the RoboCup symposia since our first participation in 2003. Table 1 summarizes the papers that have been accepted for oral and poster presentations in these symposia. In addition, we have presented soccer-related articles in other conferences and journals (some of these works are available in our website [1]). It is our intention to continue contributing to the RoboCup symposia, by reporting our new developments in the humanoid league.

Table 1. UChile articles in RoboCup Symposia.

RoboCup Articles	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
Oral	*1*	*2*	*1*	*1*	*2*	*3*	*2*
Poster	*1*	*1*	*1*	*-*	*3*	*2*	*0*

As a group having teams in both, the humanoid and the SPL league, we can build bridges between both leagues, for transferring some of the developments in distributed control of networked robot from the SPL league to the humanoid league. One of the major ideas behind dividing RoboCup soccer among several leagues was to address specific problems in each league, which later could benefit all leagues. In this line of thought, we intend to integrate some of the solutions already developed in the SPL league with the hardware and robot control developments of the humanoid league. Moreover, in the SPL there are high standards of soccer control software, which can also be transferred into the humanoid league. It is important to mention that our SPL team is one of the 16 that already classified for the RoboCup 2008 world-competitions.

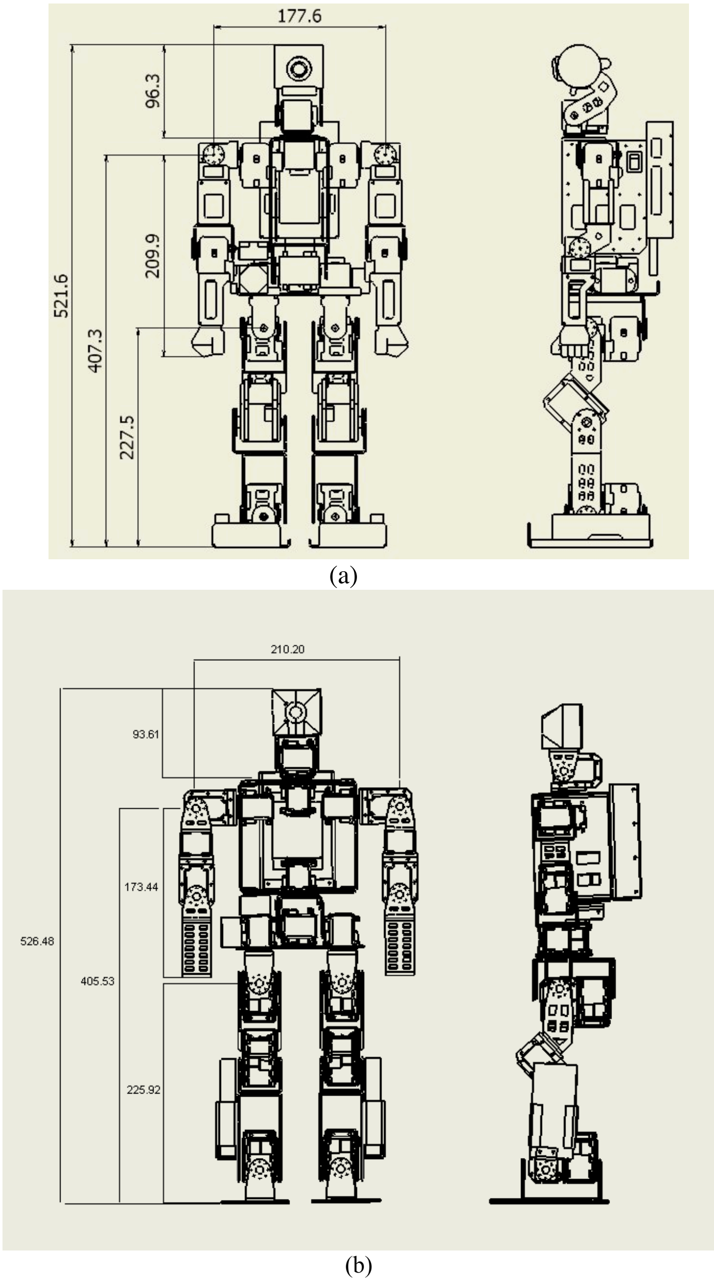
This year our developments include: (i) the design and construction of a new (hardware) controller to be used in our 3 robots, (ii) the construction of an innovative battery protection hardware, (iii) a new methodology for designing fall sequences that diminish the damage in the robot's joints, and (iv) the proposition of new methodologies to be used in the vision system of our robots (task oriented active vision and context-based perception).

This team description paper is organized as follows. In sections 2 and 3 our hardware platform and software library, are described. Finally, in section 4, some new developments of the team that could be of high interest for the humanoid league, are outlined.

2 Hardware

Our team uses two different robot platforms: modified Hajime HR18 robots as field players, and the UCH H1 robot as goalie player. We have made two main modifications to the HR18 robot: (i) we have replaced the original Hajime controller by a controller based on the TMS320F28335 DSP (see figure 2), and (ii) we have included a battery protection and balance circuitry. Both hardware modules have been completely designed and constructed by ourselves. The UCH H1 robot has also been designed and built in our lab. We are using a Fujitsu Siemens n560 Pocket PC running Windows Mobile as main processor, and a Philips ToUCam III - SPC900NC camera as main visual sensors for the robots. The technical specifications of our hardware components are shown in table 2.

The development of an own low-level controller for our robots (see figure 2) was intended to have a more powerful and flexible platform for controlling the motors. Main advantages of this new controller are: higher processing speed than previous platform (150 Mhz), better synchronization between low-level and high-level motion orders, availability of a debugging interface, DSP advantages, and availability of 3 different buses (RS-485 multi-drop) for controlling and reading information from motors.



(b)

Fig. 1. Frontal and lateral view of the (a) Hajime HR18 robot, and (b) UCH H1.

Li-Po battery cells can be easily damaged when used with its internal states with low charge. In addition, when used in serial, they can be damaged by unbalanced discharges of the cells. For this reason, we have built a circuit that: (i) check the voltages in each cell, (ii) protects the battery by turning-off the motors energy when low charge in any of the cells is detected. This protection circuit is used in all our robots.

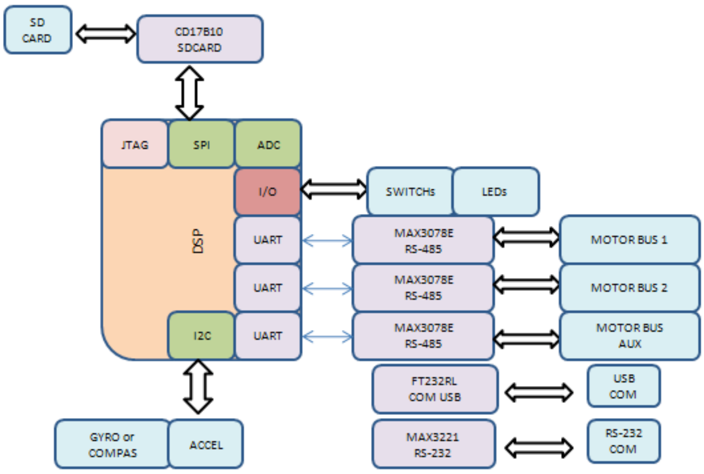


Fig. 2. Block diagram of the developed hardware controller.

Table 2. Hardware specifications.

Player	Field Players (2)	Goalie Player (1)
Robot	Hajime HR18	UCH H1
Height	522 mm	526 mm
Weight	3.3 kg	3.04kg
Servo Motors Dynamixel Robot Actuator	18x DX-117 3x RX-64	22x RX-28
Degrees of freedom	21 leg: 6x2 arm: 3x2 waist: 1 neck: 2	22 leg: 6x2 arm: 3x2 waist: 2 neck: 2
Batteries	2x Li-Po 7.4V, 1500mAh	2x Li-Po 7.4V, 1500mAh
Internal Sensors		
Joint Angle Encoder	21	22
Accelerometer	Crossbow, CXL04LP3, 3 axes, rate 10 ms	Triple Axis Accelerometer - LIS3LV02DQ
Gyroscope	SSSJ, CRS03-04, 3 axes, rate 10 ms	SSSJ, CRS03-04, 3 axes, rate 10 ms
Camera	Philips ToUCam III - SPC900NC	Philips ToUCam III - SPC900NC
Sensor	CCD	CCD
Interpolated snapshot resolution	1.3 Mpixels	1.3 Mpixels
Max. frame rate	90 fps	90 fps
Lens	F2.2, D55°	F2.2, D55°
White balance	2600 – 7600 k	2600 – 7600 k
Min. illuminance	< 1 lux	< 1 lux
Colour depth	24 bit	24 bit
PC Link:	USB 1.1	USB 1.1
Control	Autonomous at frecuency 10 ms	Autonomous at frecuency 10 ms
Internal Controller	32bit DSP TMS320F28335 150MHz	32bit DSP TMS320F28335 150MHz
Pocket PC	Fujitsu Siemens Pocket LOOX N560	Fujitsu Siemens Pocket LOOX N560
Processor	Intel® PXA270 624 MHz based on Intel® XScale™ microarchitecture	Intel® PXA270 624 MHz based on Intel® XScale™ microarchitecture
Memory	System memory (RAM) 64 MB Flash memory (ROM) 128 MB	System memory (RAM) 64 MB Flash memory (ROM) 128 MB
Wireless LAN	Integrated, 802.11 b/g,	Integrated, 802.11 b/g,
Bluetooth V1.2	Integrated	Integrated
Operating system	Microsoft® Windows MobileTM 5.0 Premium Edition	Microsoft® Windows MobileTM 5.0 Premium Edition
Interfaces	1x built-in microphone, 1x speaker USB 1.1 (slave) via sync cable USB 1.1 (host) via sync cable Serial (RS232) via sync cable Stereo Audio Out on cradle connector	1x built-in microphone, 1x speaker USB 1.1 (slave) via sync cable USB 1.1 (host) via sync cable Serial (RS232) via sync cable Stereo Audio Out on cradle connector

3 Software Architecture

As already mentioned, our software architecture is based on the robot control library developed for our four-legged team (see detailed description in [3]), which was ported to Windows Mobile and used in our humanoid robots. The control library is divided into four task-oriented modules: vision, localization, strategy, and motion control (actuation). The vision and motion control modules operate in each robot locally. The localization module is distributed, it operates in each robot, and a global estimate of the overall ball localization is generated in a distributed fashion. The strategy module is also distributed; it allows the sharing of global information among the robots. In our current implementation (Windows Mobile) these four task-oriented modules run, in each robot, in two different processing platforms: the Fujitsu Siemens n560 Pocket PC (vision, localization, and strategy) and our new hardware controller (motion control). The modules running in the pocket PC are implemented using Windows threads. The main features of our software library are described in our 2008's TDP [4].

4 New developments of potential high interest for the Humanoid League

Design of fall sequences for humanoid robots. The management of falls – e.g. how to avoid an unintentional fall, how to fall without damaging the body, how to achieve fast recovering of the standing position after a fall - is an essential ability of good soccer players. Given the fact that one of the RoboCup main goals is allowing robots to play soccer as humans do, the correct management of falls in legged robots, especially in biped humanoid robots, which are highly unstable systems, is a very relevant matter. However, to the best of our knowledge this issue has almost not been addressed in the RoboCup community. Having this motivation, we have developed a methodology for the analysis and design of fall sequences of robots that minimize joint/articulation injuries, as well as the damage of valuable body parts (cameras and processing units). These fall sequences can be activated/triggered by the robot in case of a detected unintentional fall or an intentional fall, which are common events in humanoid soccer environments. The idea is to take control of the fall, as soon as the robot detects it. The proposed methodology is human-based and requires the use of a realistic simulator, as a development tool. This methodology has been validated in simulated and real humanoid robots [5][6].

Probabilistic Task Oriented Active Vision. A mobile robot has always some degree of uncertainty about its world model. The reduction of this uncertainty is very hard, and depends on the tasks that the robot is accomplishing. This is especially true in robot soccer where the robot must pay attention to landmarks in order to self-localize, and at the same time to the ball and robots in order to follow the status of the game. In [7], an explicitly task oriented probabilistic active vision system is proposed. The system tries to minimize the most relevant components of the uncertainty for the task that is been performed and it is explicitly task oriented in the sense that it explicitly considers a task specific value function. As a result, the system estimates the convenience of looking towards each of the available objects. As a test-bed for the presented active vision approach, we selected a robot-soccer attention problem: goal covering by a goalie player.

Bayesian Context-based vision for soccer environments. Robust vision in dynamic environments using limited processing power is one of the main challenges in humanoid robot vision. This is especially true in the case of biped humanoids that use low-end computers (e.g. Pocket PCs). Techniques such as active vision, context-based vision, multiresolution and sampling are currently in use to deal with these high-demanding requirements. Thus, having as a main motivation the development of robust and high performing robot vision systems that can operate in dynamic environments, we have proposed a spatial-temporal context integration framework that improves the visual perception of a mobile robot [8][9]. This framework considers the coherence between current detections and (i) past detections, (ii) the physical context, (iii) a holistic characterization of the image, and (iv) a so-called situation context. In addition a bayesian model that integrates all these information sources is included. We have chosen as a first application of this context integration framework the detection of static objects in the RoboCup SPL and Humanoid leagues. The proposed system has been validated using real video sequences.

Acknowledgements

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