The GEAR Tucano Project

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Abstract— **This paper presents the RoboCup SSL team GEAR Tucano, developed during 2010 by the GEAR (from Portuguese Grupo de Estudos Avançados em Robótica, "Advanced Robotics Studies Group") from the Department of Electrical Engineering of the University of São Paulo at São Carlos. This project brings many improvements in all areas, including a fully-controlled 4-wheel omnidirectional locomotion system, a new mechanical structure fully built with the resistant and light ABS thermoplastic and an advanced strategy system that combines a multi agent role-based decision module with the potential fields and A* navigation algorithms.**

I. INTRODUCTION

The GEAR Tucano Project has been being developed since the end of 2009 at the Department of Electrical Engineering of the São Carlos School of Engineering of the University of São Paulo (USP) by the Advanced Robotics Studies Group (GEAR).

The group was created in 2003 with the intention of studying and developing new technologies in robotics in order to apply them at the robot soccer. Nowadays it counts with about 25 members, students of Computer, Electrical and Mechatronic Engineering at the USP at São Carlos.

The 2010 version of the project, which will be used at the Latin American Robotics Competition (LARC) 2010, brings many improvements over the previous one, including its fabrication process, electronic components and circuits and integration and strategy systems.

The next sections present some GEAR Tucano 2010 features details, namely the physical structure, electronic devices and computer systems.

II. PHYSICAL STRUCTURE

The robot physical structure is divided in three parts: base, upper and cover, that can be easily detached and reassembled in another robot if needed.

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The base was designed to accomodate the locomotion system, with its four Faulhaber 2342 DC motors, gearboxes of 15:1 ratio and omnidirectional wheels, capable of providing a maximum speed of 1.7 m/s; the kicking device, consisting of two 2200 μF and 200 V capacitors and a custom solenoid with a concave plate attached to its axis, that can kick up to 5 m/s fast; and the dribble device that counts with a specific shape-roller coated with an viscoelastic material, mounted on a suspension with shock absorber system and linked to a Microred A DC motor by a 3:1 gearbox.

The upper part houses the two electronic boards and the battery. Besides that, it contains ducts for wiring and columns for cover attachment.

The cover follows the classic design of the category: a cylinder linearly cut off to a distance of 79 mm from the center with opening for the wheels and the kicking and dribble devices, resulting in a robot with 148 mm height and 179 mm diameter.

All mechanical structure was made by the rapid manufacturing process using ABS, a rigid and light thermoplastic that offers impact resistance and some flexibility as showed in [1] and [2].

III. ELECTRONIC DEVICES

In order to fulfill the essential requirements of locomotion, kicking and dribbling, two electronic devices were developed: MainBoard and KickBoard.

A. MainBoard

The MainBoard is responsible for receiving commands from the artificial intelligence, decoding them and activating the requested actuators (motors, dribble device and kick board). Moreover, it measures information as battery and kick capacitors voltages and sends them back to the telemetry system.

A dsPIC 33F running at 40 MIPS is used as the main controller: capturing the sensors, controlling the motors speeds, choosing the radio frequencies and activating the kicking and dribbling devices.

The communication is done by the transceiver LAIPAC TRF-2.4G, a cheap but high reliable module that runs at 2.4 GHz and implements features as address attribution, ShockBurst transmition mode and error detection via CRC [3].

The control system must assure the proper functioning of the Faulhaber 2342 DC motors, therefore it counts with 512 lines per revolution Faulhaber IE-2 enconders to measure their real speeds, that act as the feedback of a classic PID controller. The driving is done by the IC L298 –a H-brigde that amplifies the signals that will be sent to the motors–, activated by Pulse Width Modulation (PWM), for that is an easy to implement solution and, according to [4], ensures that "the global efficiency of the system, even when taking the losses due to harmonics into account, is much larger than the one provided by linear amplifiers".

B. KickBoard

The KickBoard controls the kicking device, charging two 2200 μF capacitors to 200 V and discharging them in a custom solenoid when requested.
The charging module follows the boost topology with an analogic control system. A principle of the boost converter is the switching, in other words, there must be voltage/current pulses at the transistor gate, as described in [5], [6] and [7], hence a PWM signal is generated by a LM555 IC-based circuit. Furthermore, an automatic stop system ceases the charging when the capacitors reach the wanted voltage and reactivates it when they fall under a certain value.
The shooting module consists of capacitor discharge and control module protection circuits. When shooting, the protection circuit stops the charging and isolates both modules to avoid components damages, and the discharge circuit triggers a power transistor that lets the capacitors charge pass almost instantaneously to the solenoid.
Both boards are powered from a LiPo battery of 14.8 V and 2200 mAh, that provides an autonomy of about 40 minutes to robot in a game-like ambient: with dashs, stops, kicks and dribbles.

IV. COMPUTER SYSTEMS

The GEAR Tucano Project softwares are based on two subprojects developed by the group: the GEARSystem library and the GEARCoach application.

A. GEARSystem

The GEARSystem is a distributed system library that provides communication among all system modules. It was built over CORBA, a classic standard for this kind of application, and allows the execution of the AI application in one machine and the telemetry system in another one, for example.
The library architecture is minimalist, with four basic elements: Server, Sensor, Controller and Actuator. The sensors can create teams, players and balls and set their information (position, orientation, velocity, etc). Controllers may read these information and send commands to the actuators (move, kick, dribble, etc.). Actuators read and decode these commands.

B. GEARCoach

Acting as a Controller, the GEARCoach application is the main artificial intelligence module, it reads game information, decides which actions each player must take and sends these commands. Its archtecture divides it in three subsystems: MapManager, Strategy and Naviagtion.
The MapManager is responsible for reading and storing game information. It implements three extended Kalman filters to correct the poses read by the vision system.
The Strategy subsystem is based on a multiagent approach, where each robot is an agent with a role (goalkeeper, defender, midfielder, forward) and a playbook, from where the decisions are taken according to the game status. The agents do not communicate among them, choosing their actions to improve their own gain.
The Navigation allows the robot to move from one position to another avoiding obstacles. Therefore, it implements two navigation algorithms, A* and Potential Fields, that can be chosen from an user interface.
The A* was implemented following the tradicional approach of dividing the ambient in smaller parts and verifying to which ones the robot can move. A graph is created with the parts on the vertices and the paths on the edges, then the best path is calculated.
On the other hand, the Potential Fields module uses an slightly different approach: as in the traditional implementation the force that attracts or repels the robot is proportional only to the distance between it and the destination or the obstacle, in this method the force is related to the distance and the relative speed between the robot and the destination.

V. CONCLUSION AND FUTURE WORKS

The presented project brings a whole set of improvements, taking the group to a high competitive level. The developed hardware is robust, reliable and provides an excelent plataform to the strategy systems. The implemented navigation algorithms allow the robot to move fast and softly in the field, permitting the execution of all desired strategies.
Until the end of 2010, the computer systems shall be tested harder and some new features may be available either on naviagation and strategies or on integration systems, improving the ability of the team.

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