Description of the Warthog Robotics 2014 project

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Abstract. This paper presents the RoboCup SSL team WR Magic, developed from 2011 until 2013 by the Warthog Robotics group from the University of São Paulo at São Carlos. This project merges the best features from older projects developed by the groups GEAR and USPDroids. Besides that, it brings a new aluminum mechanical structure with a 4-wheel omnidirectional robust control system, an efficient kicking device, a potential fields-based navigation module and a fuzzy strategy system. The team presents full game capability with accurate and fast responses to strategy and referee commands.

Keywords: RoboCup Small Size League, Robotics, Embedded Electronics, Artificial Intelligence.

1 Introduction

At the beginning of 2011 the groups GEAR and USPDroids merged creating the Warthog Robotics, a group of the departments of Electrical Engineering of the São Carlos School of Engineering and the Computer Sciences of the Institute of Mathematics and Computer Science of the University of São Paulo at São Carlos.

The group counts with about 50 members students of Computer, Electrical and Mechatronic Engineering and Computer Science and develops robotics technologies, applying most of them at the robot soccer. This first project of the group brings features from older projects of GEAR and USPDroids and implements them together with some improvements in a new mechanical structure. The next sections present some WR Magic features details, including the mechanical structure, electronic devices and computer systems.

2 Mechanical Structure

The mechanical structure was designed to accommodate the locomotion system, with its four Faulhaber 2342 DC motors, gearboxes of 6:1 ratio and omnidirectional wheels, capable of providing a maximum speed of 3.8 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 7 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 maximum ball coverage when dribbling is 18%. The upper part houses the three 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 with opening for the wheels and the kicking and dribble devices, resulting in a robot with 150 mm height and 179 mm diameter. All mechanical structure is made of aluminum and was machined by the group members, offering a robust, yet light, robot.

3 Electronic Devices

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

3.1 MainBoard

The MainBoard is responsible for receiving commands from the artificial intelligence, decoding them and sending commands with SPI to 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 with the strategy 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 [1].

3.2 DriverBoard

The DriverBoard receives commands from the MainBoard and activates the motors. 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 encoders 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-bridge 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 [2], 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”.

3.3 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 a digital 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 [3], [4] and [5], hence a PWM signal is generated by a PIC 18F circuit.

Furthermore, an automatic stop system ceases the charging when the capacitors reach the wanted voltage and re-activates 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.

All boards are powered by a LiPo battery of 14.8V and 2.1 Ah, that provides an autonomy of about 40 minutes to robot in a game-like ambient: with dashes, stops, kicks and dribbles.

4 Computer Systems

The WR Magic Project software is based on two sub-projects developed by the group: the GEARSystem library and the strategy application.

4.1 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, ...). Controllers may read these information and send commands to the actuators (move, kick, dribble, ...). Actuators read, decode these commands and execute them.

4.2 Strategy and Artificial Intelligence

The strategy is responsible for setting behaviors to the players and planning paths. Some behaviors were defined: defend, intercept, pass and kick. Defend is performed only by the goalkeeper and consists in standing still in front of the goal, protecting it. Intercept shall prevent the ball from going towards the goal. The passing behavior consists in conducting the ball towards the opponent area, preferentially towards a team mate that is close to the area. Finally, kick behavior pulls the ball to the goal. The attribution is flexible: during the game, the coach can choose the best set of behaviors for the game situation using a fuzzy control logic.

The path planning uses the orientated potential fields technique. This technique uses solutions of the elliptic partial differential equations contour value problem to create the potential fields. The Dirichlet contour condition was used [6], where the goals have potential 0 and obstacles, 1. This technique represents an evolution to the old USPDroids strategy system [7], because it allows the definition of behaviors at the generated trajectories. This is possible due to the definition of a influence vector to the potential field [6].

The utilization of this kind of equations also solves another conventional potential fields problem: the existence of local minimums.

5 Conclusion and Future Work

The presented project brings a whole set of improvements, taking the group to a highly competitive level. The developed hardware is robust, reliable and provides an excellent platform 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 mid-2014 the computer systems shall be tested harder and some new features may be available either on navigation and strategies or on integration systems, improving the ability of the team.

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