Khainui Team Description for Robocup 2008

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Abstract. This paper describes the current state of development and future plans for Robocup 2008 of the Khainui team. Existing systems will be documented and future systems will be outlined. Khainui team was developed based on minimalist and low-cost concepts. We achieved a low-cost design of our robots using surplus motors and gearboxes, and a simple back-EMF feedback control system. Our vision system consists of two IEEE1394 web cameras. The entire software systems can run on only one PC.

1. Introduction

Building a team of soccer playing robots for Robocup small-size league is one of the most challenging engineering tasks, because it concerns mechanical, electrical and software design. To build a high performance robot, we need precise mechanical parts, carefully-chosen electronics components, and efficient software coding. Every team needs fast, accurate, and reliable robots. These objectives can be achieved with high cost. A high performance robot can cost more than 2,000 US$. Each team needs 5 robots and vision hardware. This would be difficult for a low-budget team to establish a competitive Robocup team.

Khainui is a Robocup team from Prince of Songkla University, Thailand. Its first appearance was in Robocup Thailand Champion 2006. Khainui team was able to win the 3rd place, among other 12 competing teams [1].

In Robocup Thailand Champion 2007, we won the 2nd place and also won the Best Technical Team and The Popular Vote award.

Recently, in Robocup Thailand Championship 2008, the team won the 3rd place and the Best Technical award.

Our main goal was to build a robot using low-cost hardware. The robots should have all necessary capabilities, such as omni-directional drive, chip kicker or straight kicker, and a closed-loop motor speed control. We have successfully built 5 robots which met all of our requirements and each robot costs less than 200 US$. By keeping our cost down, we can maintain our team for many years to come. The detail description of our robot design is presented in the following sections.

2. Mechanical design

The robot was constructed with 2 pieces of 2.5 mm aluminum sheet. Both pieces (top and bottom plates) were connected to the top part and the bottom part of the gearbox. Electrical components were assembled on a PCB. The PCB and the kick solenoid are mounted on the top plate. Figure 1 shows our current robots.

Figure 1. The current Khainui robots.

2.1 Motor and gearbox

Many teams have used high performance motors and gearboxes. A set of such motor, gearbox, and rotary encoder can cost over 200 US$ and is hard to buy locally. Our team utilized surplus DC motors (Namiki 22CL-3501PG80:1) which are available locally. The motor comes with an 80:1 gearbox, which is too slow for our application. We modified the gearbox by cutting it short and remove one stage of its gear train. Finally, we achieved a gear ratio of 1:16.5, which give us enough torque and speed. Figure 2 shows the motor and gearbox, before and after modification.

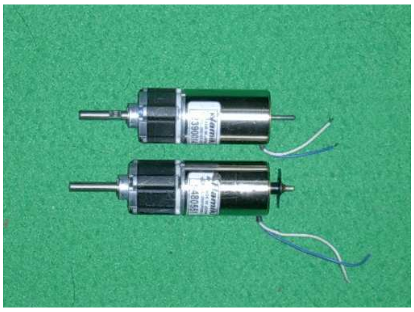

Figure 2. Motor and its modified gearbox.

2.2 Omni-directional wheels

Our current version of the omni-directional wheels were made of acrylic which can be broken during play. Our future version of the wheels will be machined from a 6 mm polycarbonate sheet.

2.3 Kickers

The kicker is powered by a pull-type solenoid, which can also be found locally. Depending on the angle of the kicking plate, each of our robots can be configured for straight kick or chip kick. Figure 3 shows a close look at robots with straight kicker, and chip kicker.

Figure 3. The robot with a straight kicker (left), and the robot with a chip kicker (right).

The solenoid was energized by high voltage charge stored in capacitors. The capacitors were pre-charged by a DC-to-DC conversion circuit.

Each of our robots can kick at 2 different speeds. We used a small capacitor and a large capacitor to hold the high voltage charge. If we want to perform passing kick, we will command the robot to discharge from the small capacitor, and if we want to shoot at the goal, the large capacitor will be used.

3. Electrical design

The main goal for our electrical design was to achieve high performance robots using minimal circuitry. Complicated electrical design can bring the cost up and prone to failures.

3.1 Microprocessor

The Philips LPC2139 ARM 7 processor was used to control all functions of the robot. This microcontroller has an internal 10-bit, 16-channel ADC’s, and 6-channel PWM generators. The followings are main functions of the microprocessor:

1. receive commands from the wireless module
2. activate/deactivate the kicking solenoid
3. closed-loop control the speed of all drive motors, as follows:
    i. perform analog-to-digital conversion
    ii. compute control value for each motor using the PI control algorithm
    iii. convert control values to PWM values
    iv. generate PWM signals to drive the motors

3.2 Speed sensor

Rotary encoders are a perfect speed sensor, and have been used in most teams. However we think that they are too costly for our team. Our previous robots used a small DC motor as a speed sensor. Our current robots achieved speed control by using the back-EMF speed control technique. The voltage across the DC motor terminals is measured, using the ADC's. This voltage is proportional to the speed of the motor. We, then, close-loop control the motor speed using the PI control algorithm. Since we can not measure the back-EMF voltage across the motor terminals while the motor is being energized, then we need to turn of the PWM for a short period of time before making the measurement.

3.3 Battery

Each robot was powered by twelve 2700 mAh Ni-MH batteries. Fully-charged batteries can run the robot for about 45 minutes.

3.4 Wireless receiver

To receive commands from the AI system, the ET-TF2.4G wireless module from ETT Company, [2], was used. The module is easy to configure and interface. It can communicate with the host computer at a baud rate as high as 19200 bps. For our application, we configured the module to communicate at its highest speed.

The data transmitted from the PC to the robots are formatted into a 26-byte packet. The first byte in the packet represents the packet start byte (the value was 0x6A). The next 5 bytes are commands for Robot 0, the next 5 bytes are for Robot 1, and so on. The last byte was used for sum check.

The 5-byte commands can be interpreted as follows:

Byte 1: speed of wheel 1
Byte 2: speed of wheel 2
Byte 3: speed of wheel 3
Byte 4: speed of wheel 4

Byte 5: kick command

4. The Vision System

We used OpenCV [3] for image capture and CMVision [4] for color segmentation. Both run on low budget imaging devices consisting of a pair of IEEE1394 web cameras. These cameras are manufactured by Unibrain [5]. The camera gives a 640x480 image at 30 fps in Bayer color format.

The captured image is converted in to RBG color format before any further processing. The lens distortion is corrected using the Tsi's algorithm.

5. The AI Module

The AI module was a modified version of the Cornell's Robocup 2002 AI program [6]. We chose this program because it has source code, runs very fast, well structured and well documented. The code was written in C++ language and was developed under Microsoft Visual C++ 6.0.

We had put significant efforts to understand the Cornell's code. It has been modified to suit our vision module and our robots. We mainly modified 2 parts. The first part was on the building wireless packet and wheel conversion. The second part was on the skills and plays.

Currently we utilize only the main structure and main loop of Cornell's code. Skills and plays have been developed to suit our needs. Mainly, we have developed move-to-ball skill, ball-passing skill, ball-intercept skill, goalie skill, defender skill, and all necessary plays. Our AI system runs entirely on our Skills and Plays.

6. Future plan for Robocup 2008

So far, we have explained the current state of our team. In order to upgrade our team to be competitive in world Robocup tournament, we need to improve many components our system. Here is the list of things to do:

1. Redesign our robots. The new robots must be more reliable mechanically and electrically and have more capabilities.
2. Use higher frame rate cameras (>50 fps) to improve prediction accuracy. The new camera should also use larger CCD. Our current cameras use a ¼" sensor, which makes it difficult to find a decent lens that matches the sensor and fully covers the 2008 playing field.
3. Our current vision software can not adapt to light change very well and it can not effectively reject false objects on the field. This part of software needs to be improved.
4. Develop more game plays. Our current system is very good at defending but not offending. We need more plays to improve our game.

7. Conclusions

We have successfully built a Robocup team. Our team performed very well in Robocup Thailand Championship over the past 3 years. There are many components of our current system that can be and must be improved.

8. References

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