OMID 2015 Team Description

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Abstract. This paper is a curt explanation of OMID 2015, Robocop small size team, technical estate and robots technical improvement which generally divided into three part: Mechanical part, Electronic part and Software part.

1. Introduction

Omid Robotics Team began small size league activities in summer of 2007, as a branch of robotics society of ECE department of Shahed university. Omid robotics team endeavor to confirm new member's substitution as a custom due to create propitious situation for talented and enthusiastic students. Now 3rd generation of Omid robotics team working hard to achieve more glory.

According to last competition (Iran Open 2014) and the problems we faced, some improvements done:

- Communication module data rate problem solved.
- Improving robot's inner controlling system.
- Optimizing robot's FPGA codes.
- Changing Batteries.
- Design and setting new boards.

More details added in related part.

2. Mechanical Design

As we have in Small-Size League rolls the robots must have specific dimension, our robots have 178mm of diameter and 148mm of height and also each robot covers less than 20% of ball. The whole robot is about 2 kilograms weight. 3D simulation models shown in Fig.2 are created with SolidWorks.

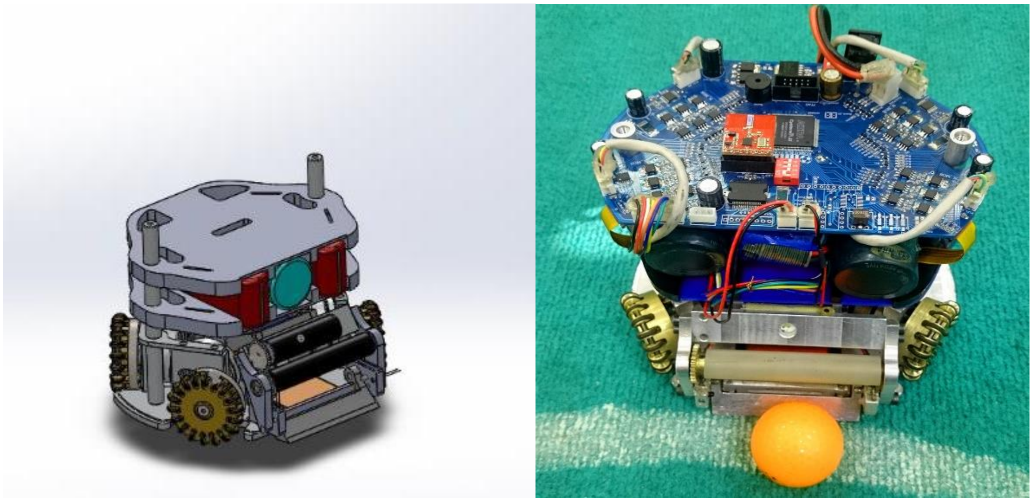

Fig1. Robot's mechanical plan design

2.1. Driving System

The main chassis of robot is made of Aluminum. 4 Omni-directional carry the main body, each wheel is coupled to an EC-45-Flat brushless 30 watt motor via an inverse gear with a transmission ratio of 1:5. These Wheels are fully designed in one piece and no screw has been used in the structure of wheels. This feature causes more efficiency, more wheel life time and simplicity in design.

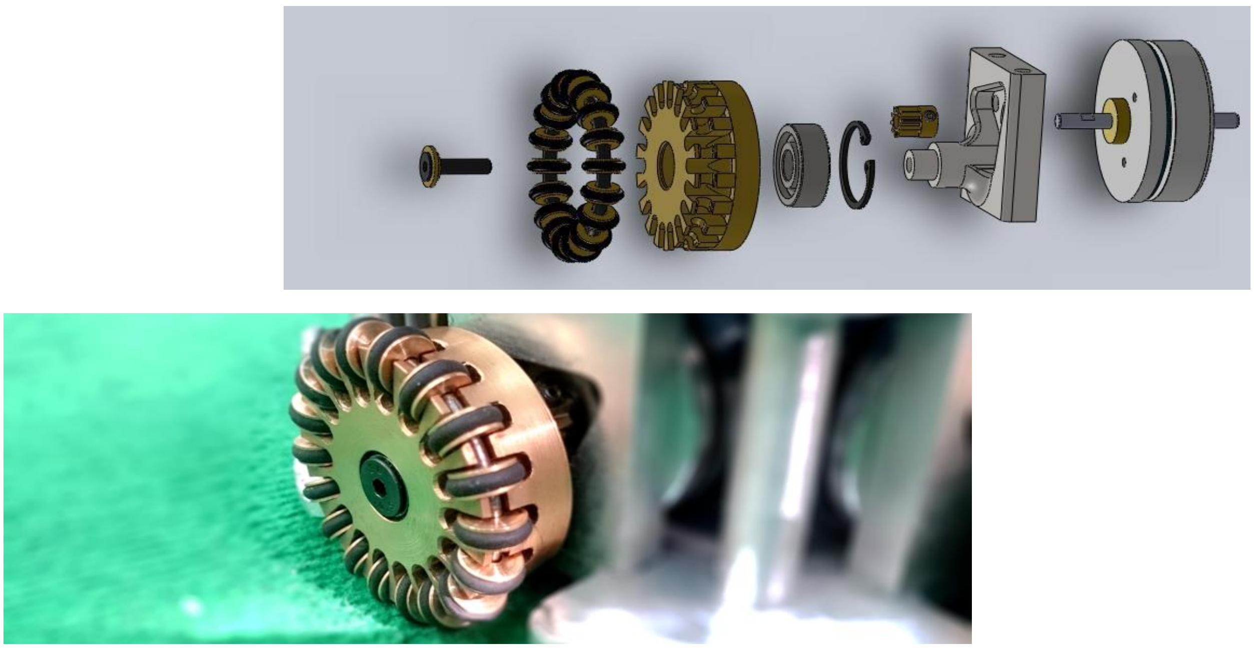

Fig2. Omni-directional wheel structure.

2.2. Kicking System

There are two solenoids that help to kick the ball, both for direct and chip kick. A flat plunger is made of steel, 4mm thickness. Direct kick plunger is made of two materials. The first part material is magnet which is steel, and the second part is made of a material with no magnetic property such as Aluminum. This feature causes a powerful kicking system.

2.3. Dribbling System

The Spin-Back module is driven by 15 watt Maxon EC16 with a transmission ratio of 2:1.

3. Electrical System

Robots consist of three general part: Communication, main board and shoot board. In the main board we have FPGA Cyclone II [1], motor drivers and etc. A 4-cell li-polymer battery (1500 mAh) used as power supply. Block diagram of robot's electrical hardware and software show in Fig3.

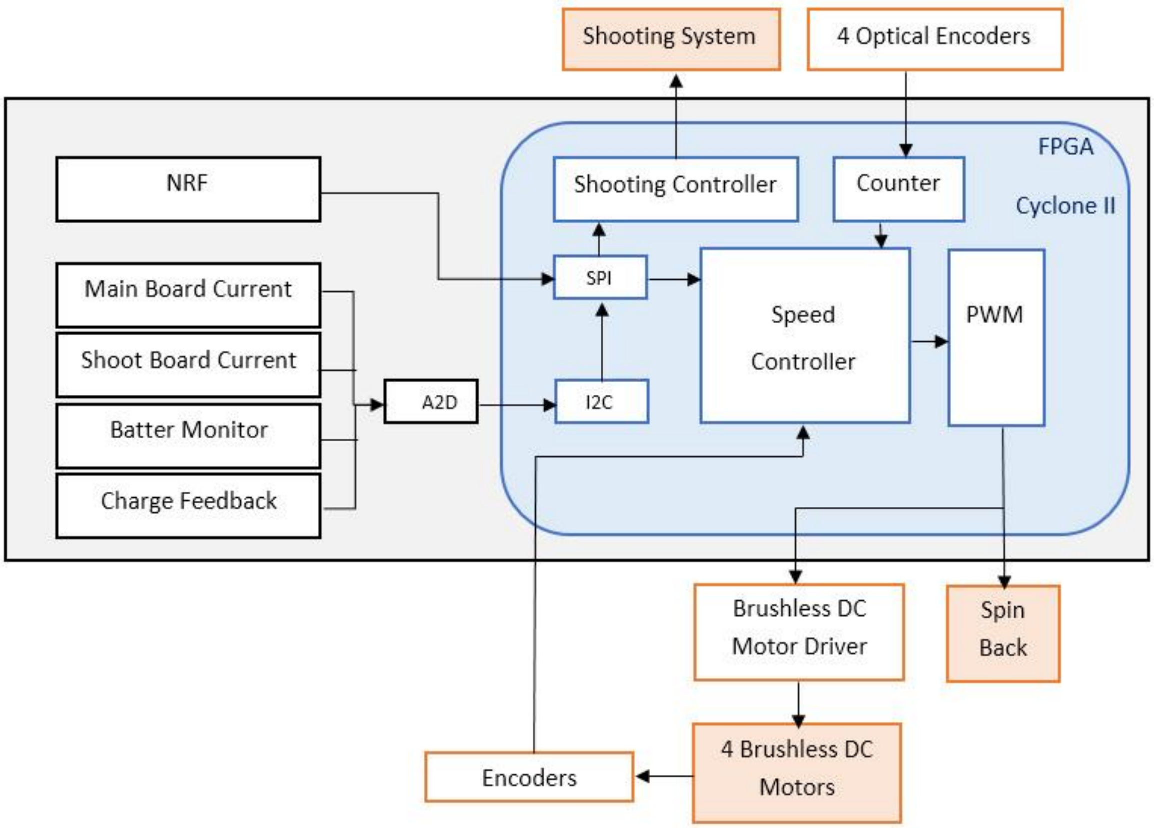

Fig3. Robots Hardware Block Diagram.

3.1. Communication module

The communication between robots and computer performed with nRF24L01+ module [2]. The nRF24L01+ is a single chip 2.4GHz transceiver with an embedded baseband protocol engine, suitable for ultra-low power wireless applications. The nRF24L01+ is designed for operation in the world wide ISM frequency band at 2.400 - 2.4835GHz.

3.2. Main Board

In the main board we use FPGA (cyclone II) as central controller that control motors and shooting system by producing PWM. New board doesn't have much difference from the previous one in schematic design but the appearance of the board changed and some PCB designing points applied.

In FPGA we do some code optimization and change velocity controller [3] with a torque controller [6] for each wheel.

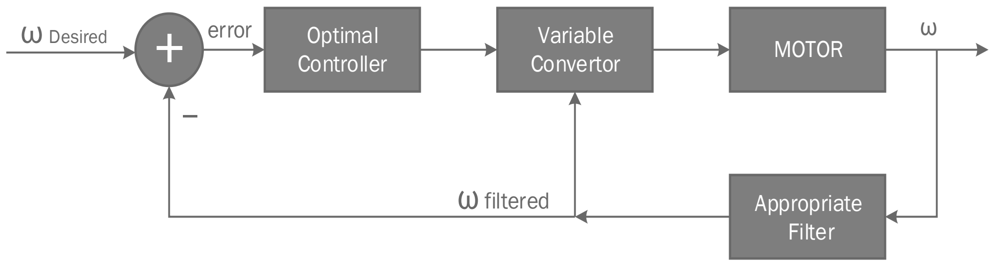

Fig4. Torque controller [6] block diagram

3.3. Shooting System

Because of free space limitation on robot we compelled to design new shooting board. Which is smaller and efficient than then previous.

There are two kickers, a direct kicker and a chip kicker. We developed the flat kick system to kick in maximum velocity, approximately 8 m/s. The kicker board can charge two 2200µF capacitors from 0V to 250V in about 10 seconds with 1A average current. For controlling input current and shooting board current we used ACS712 current sensor. In charging moment a PWM used, that PWM and Duty Cycle change proportional with capacitor voltage's percentage. In order to avoid IGBTs break down in shooting moment, RCD-SNUBBER [5] as secondary Circuit used, that damping extra current.

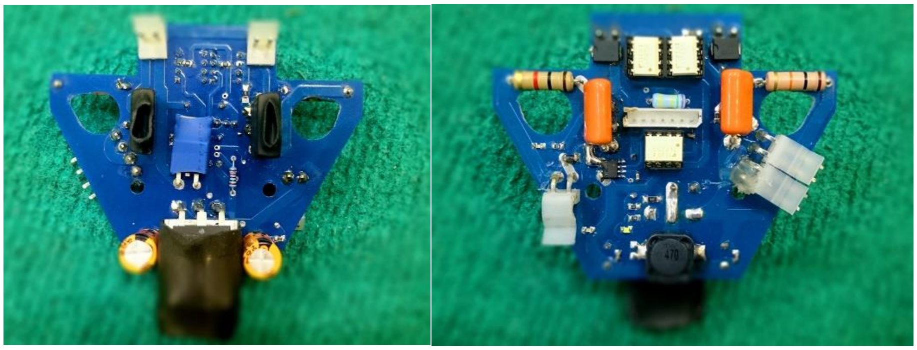

Fig5. New shooting board

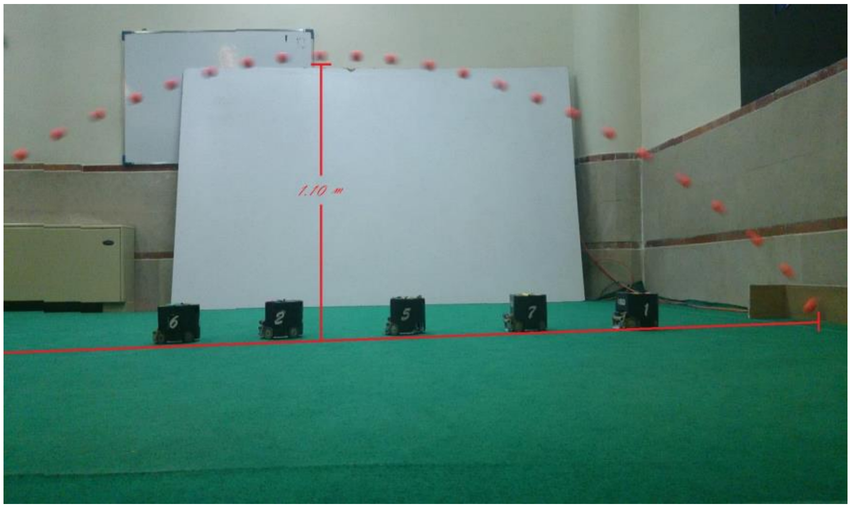

Fig6. Chip kick test in laboratory

4. Computer Software

The computer software is separated to two main sections. Algorithms & User Interface and controlling system.

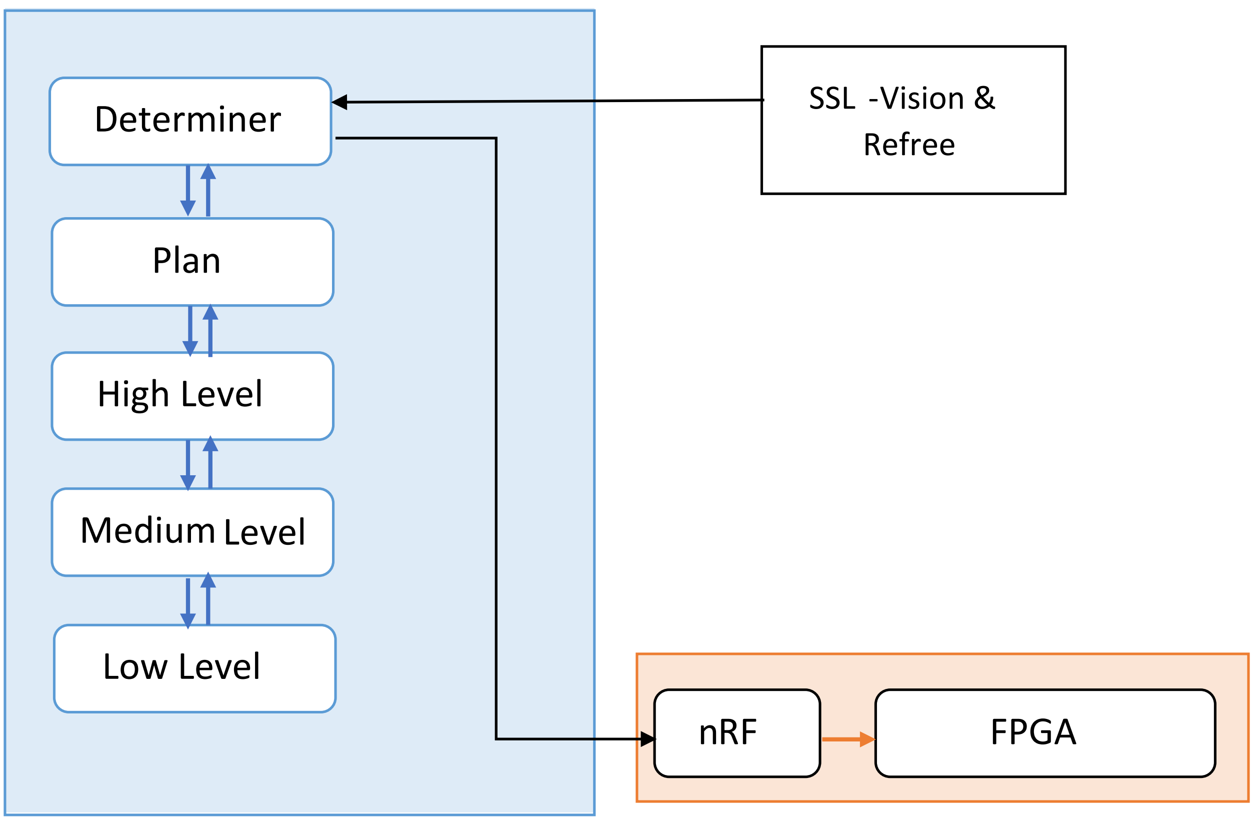

Fig7. Block diagram of computer software

4.1. Algorithms & User Interface

Algorithms structure contain four basic part: 1) Plans 2) High Level 3) Medium Level 4) Low Level

Entirely we classify functions in these four part in order to making program more simple & flexible.

To monitor the status of each robots and control all robots in the game field, Monitoring Software is programmed that will be installed on the off board controlling system. The robots location and ID on the play field is received from the visioning software and simulated. In other word this software manages the game play.

In Algorithms part we suffice to code optimization in order to reduce calculation loops and keeping old algorithms and layer structure of software. And in the same way for user interface, we just fix some problems.

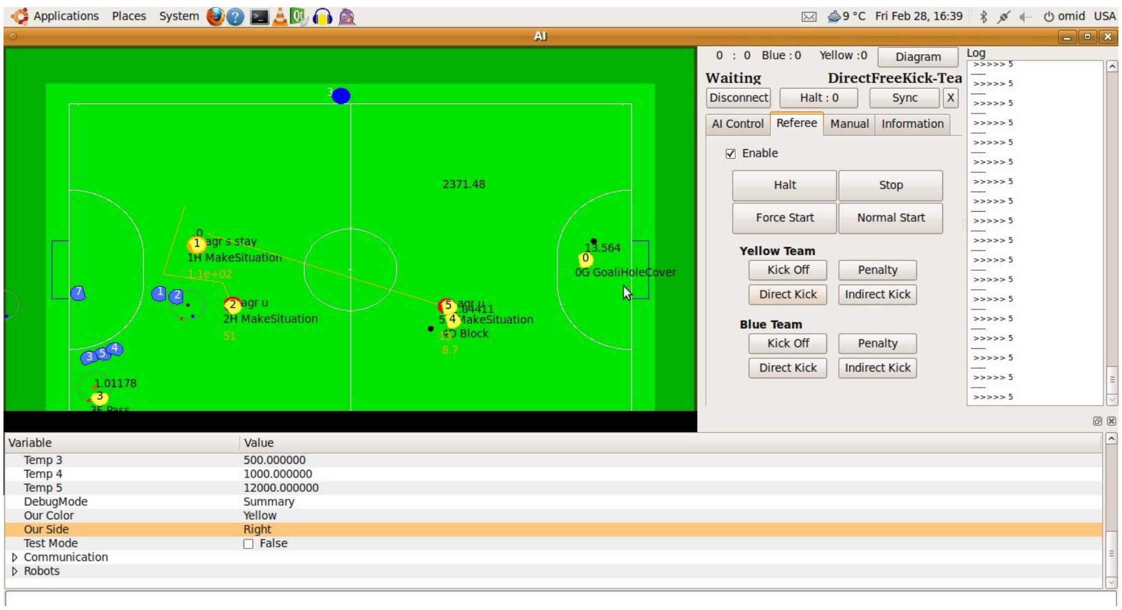

Fig8. Screenshot of AI Software

4.2. Navigation

For navigation of robots we use random rapidly tree (RRT) as a path planning with some customization that limit random trees in order to reduce calculation time.
In time optimization part we use Bang-Bang trajectory and PI coefficient in some cases (when high accuracy is needed like direct kick or penalty).
Nevertheless, observation results wasn't eligible so we revision whole system and system's delays. We find out important delay which not covered (around 0.3s). This delay cause our AI software observe the game 0.3s later than real-time. To cover this delay and put AI system in real-time we chose to add robot's position (ΔX) to their observed position (X) by each wheel velocity feedback from robots to AI

4.3. Motor Controller tuner

Due to important problems in controlling robots we spend more time on it and re-design this part.
For make this part better than before we program a software in MATLAB to receive, save and analyze motor velocity. With the velocity of motor which transfer by nRF, transfer function of each motor will be available.
With this function we will be able to find and set the best controlling coefficient. But obviously for effete motors the best transfer function (optimized for time rise) is different and cause an error in robots global movement. So we need that motors have same closed loop transfer function, when motors have the same functions they behave Same together, therefore we add this ability to the software.
With this ability we reduce most of the global movement errors in the robot.

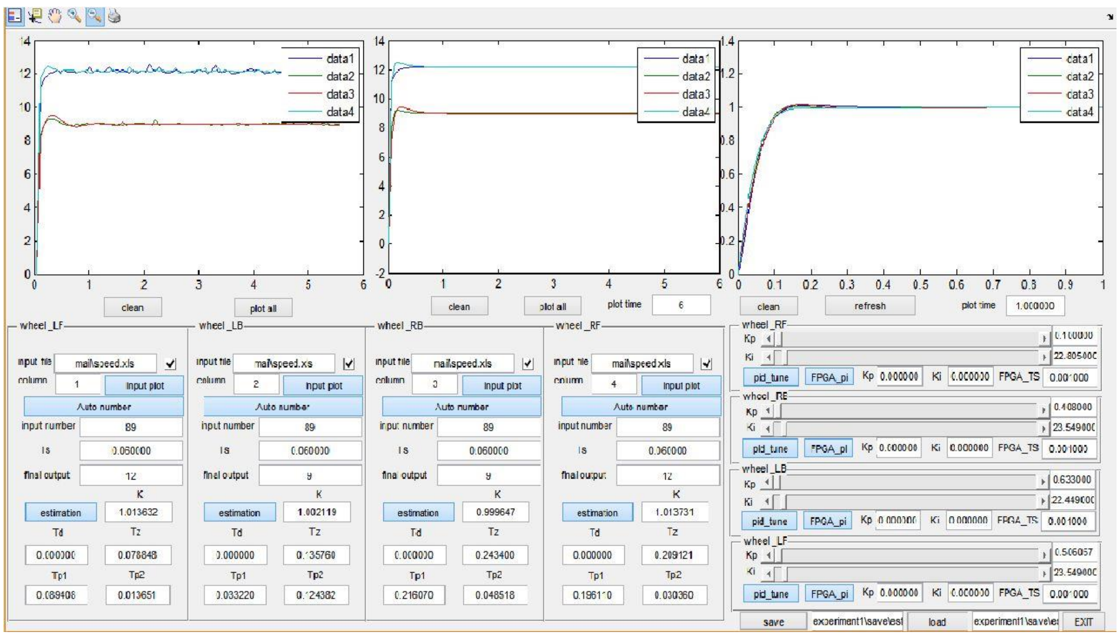

Fig9. Screen shot of Motor sampler software in MATLAB

References:

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