NuBot Mechanical and Electrical Description 2017

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Abstract. The software structure, mechanical and electrical system of the robot from NuBot team is described in this material. The size of the current robot is 50cm × 50cm, and the weight is about 35 kg.

1 Mechanical

This section describes the mechanical design of our soccer robots. Currently the regular robot and the goalie robot are heterogeneous due to their different tasks. The mechanical platform is composed of five main parts: the base frame, the ball handling mechanism, the electromagnet shooting system, the omnidirectional vision system and the Kinect sensor, as illustrated in Fig. 1. For the goalie robot, the ball handling mechanism and the electromagnet shooting device are removed; instead two Kinect sensors are integrated as shown in Fig. 1.

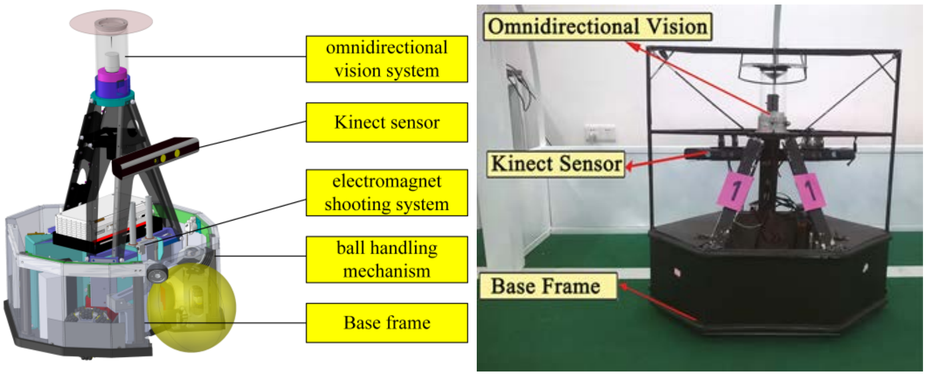

Fig. 1. The NuBot regular robot (left) and the goalie robot (right).

1.1 Base frame

In our omnidirectional wheeled platform, we use custom-designed omnidirectional wheel, which is illustrated in Fig. 2 (left). Three such omnidirectional wheels are uniformly arranged on the base as shown in Fig. 2 (right).

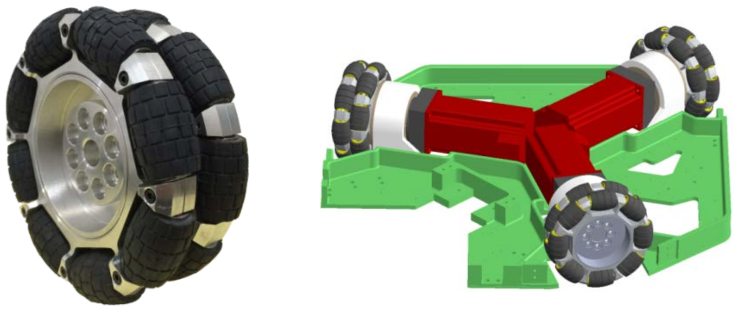

Fig. 2. The omnidirectional wheel and the base frame of the NuBot soccer robot.

1.2 The Active Ball Handling System

The active ball handling system, which is designed for dribbling the ball, is made up of the active ball handling mechanism and its close-loop control system. As illustrated in Fig. 3, there are two symmetrical assemblies, and each contains a wheel, a DC motor, a set of transmission bevel-gear, a linear displacement transducer and a support mechanism. The wheels are driven by the DC motor and are always pressed by the ball, therefore they can generate various frictional force to the ball, making it rotate in desired directions and speeds together with the soccer robot. During dribbling, the robot will constantly adjust the speed of the wheels to maintain a proper distance between the ball and the robot using a closed-loop control system. This control system takes the actual ball distance as the feedback signal, which is measured indirectly by the linear displacement transducers attached to the supporting mechanism. As the ball moves closer to the robot, the supporting mechanism will raise, and then compress the transducer; otherwise, the support mechanism will fall and stretch the transducer. The information obtained from two transducers can be used to calculate the actual ball distance based on a given detailed geometry model and careful calibrations.

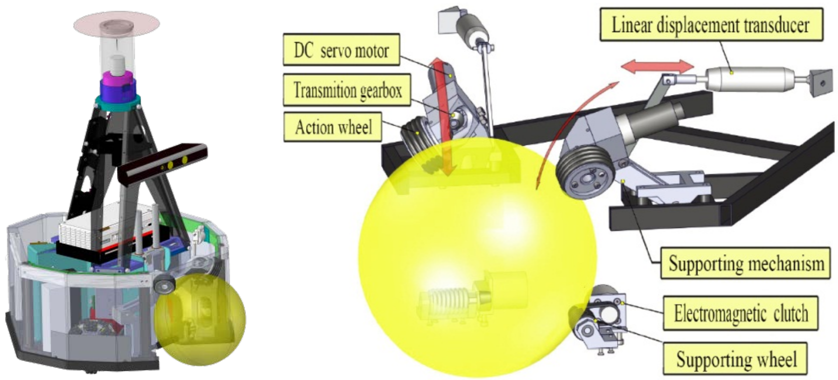

Fig. 3. Our active ball handling system.

1.3 The Electromagnet shooting system

The shooting system is basically a custom-designed electromagnet with a high impulsive force. As depicted in Fig. 4, it consists of a solenoid, an electromagnet core, a shooting rod, a capacitor, and two linear actuators with potentiometer. The shooting rod can be adjusted in height to allow for different shooting modes, namely lob shot and ground pass. Two modes are realized using two linear actuators to move the hinge of the shooting rod to different positions. Firstly, the electromagnet core is rearward located within the solenoid and the capacitor is charged. When the shooting action is activated, the rod will be adjusted according to the selected mode. Then the control circuit board will switch on the solenoid by discharging the capacitor, thus producing a strong electromagnetic force to push forward the rod. The rod then strikes the ball and delivers momentum to it. After the shooting is finished, the core will be pulled back to its initial position by an elastic string, and the capacitor will be recharged again and wait for the next shooting action. Therefore, this system is simple yet capable of various shooting angles.

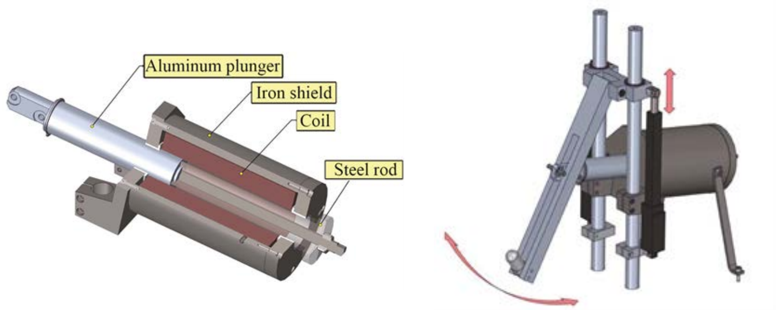

Fig. 4. The electromagnet shooting system of the NuBot soccer robot. Left: The Electromagnet; right: The Shooting System.

2 Industrial electrical system

The schematic diagram of the NuBot control system is shown in Fig. 5. All vision and control algorithms are processed on the industrial PC. The industrial PC communicates with the EtherCAT system via Ethernet. The Elmo Motion Control (SOL-WHI 20/60) is the intelligent miniature digital servo drive for the 150W DC brushless motor. The CANopen modular EL751 embedded in the EtherCAT is used to realize communication between the industrial PC and the Elmo Motion Controls. Our shooting module, also named as kicker driver, is mainly composed of a relay and an IGBT FGA25N120ANTD. The PC can send control signals to the kicker driver for shooting or passing via the EtherCAT.

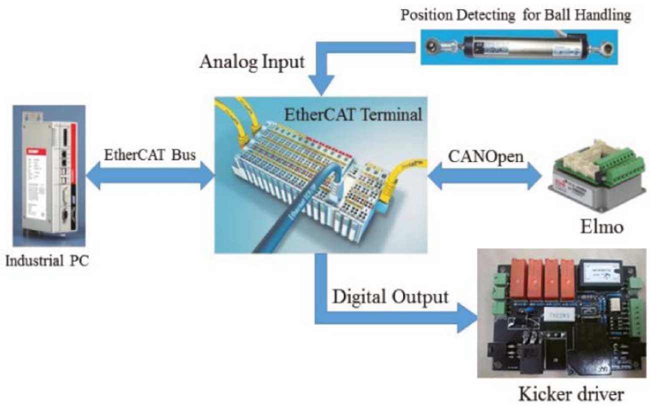

Fig. 5. The NuBot electrical system.

3 Software based on ROS

We have built our software based on ROS for our new robots. The operating system is Ubuntu 12.04, and the version of ROS is groovy. The software framework, as shown in Fig. 6, is divided into 5 main parts: the Prosilica Camera node and the OmniVision node; the UVC Camera node, the FrontVision node and the Kinect node; the NuBot Control node; the NuBot HWControl node; the RTDB and the WorldModel node. Two Kinect nodes replace the FrontVision node and the UVC Camera node for the goalie.

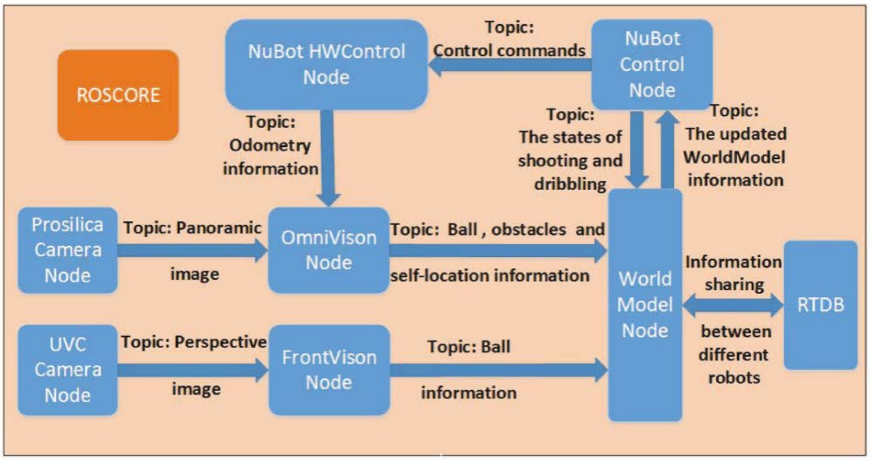

Fig. 6. The software framework based on ROS.

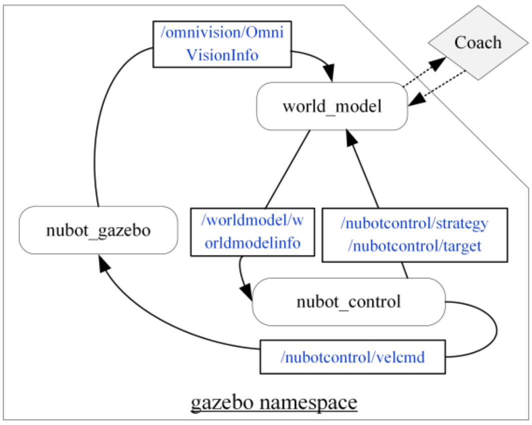

Fig. 7. The data flow graph of the integration of the real robot code and model plugin.

A simulation system[1] is developed based on ROS and the open source simulator Gazebo. The open source simulator Gazebo is adopted to simulate the motions of a soccer robot. The main reason we use Gazebo as the simulator is that Gazebo offers a convenient interface with ROS. In addition, Gazebo also features 3D simulation, multiple physics engines, high fidelity models, huge user base and etc. Therefore, the simulation system based on ROS and Gazebo can take advantage of many state-of-the-art robotics algorithms and useful debugging tools built in ROS. It can also benefit from or contribute to the active development communities of ROS and Gazebo in terms of code reuse and project co-development.

[1] https://github.com/nubot-nudt/gazebo_visual

To integrate the real robot code with the simulation model, those nodes related directly to hardware should be replaced with model plugins. This replacement requires an appropriate communication interface. For this reason, ROS messages-passing and services-calling mechanisms are employed. Finally, the data flow of the integration of the real robot code and the model plugin is shown in Fig. 7.

The simulation system can be used for designing single robot behaviors and multi-robot cooperation strategies. Furthermore, it can be employed to simulate a match between two teams, as shown in Fig. 8.

Fig. 8. Two sides of robot models compete in a soccer game. (a) The initial state of the robot models (black) and the rival robot models (red); (b) three robots on the right side of the soccer field are chasing the soccer ball; (c) Black robots shoot the goal.