NuBot Mechanical and Electrical Description 2021

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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

After RoboCup 2017 in Japan, we developed a new generation of robot platform as shown in Fig. 1. We re-designed the external frame of it to better adapt to the competition environment with huge impact. And it is proved that the generation of robot has a more reasonable layout and more stable performance. The rest of this part only details the active ball handling system and shooting system.

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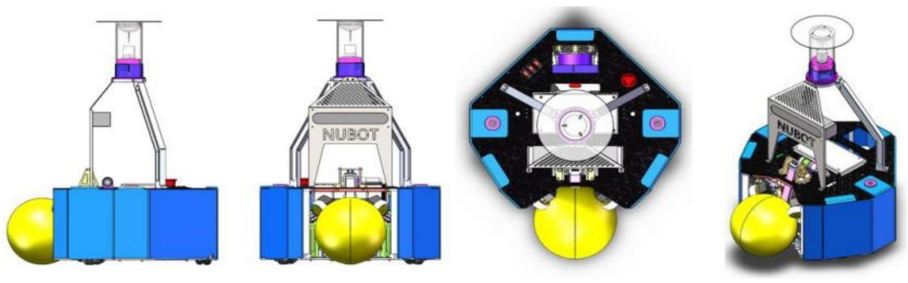


Fig. 1. The NuBot robots.

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).

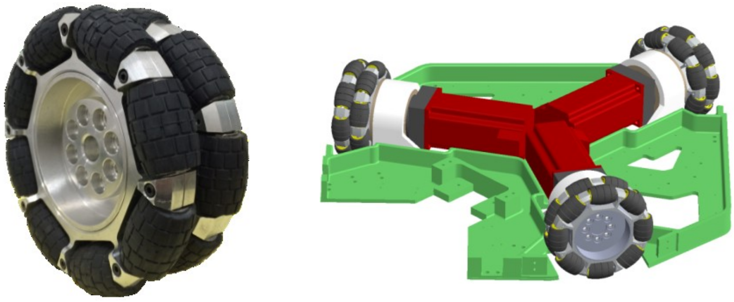


Fig. 2. The omnidirectional wheel and the base frame of the NuBot soccer robot.

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 with a right angle reducer, 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 stretch the transducer; otherwise, the support mechanism will fall and compress 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. This system effectively solves the ball handling control problem.

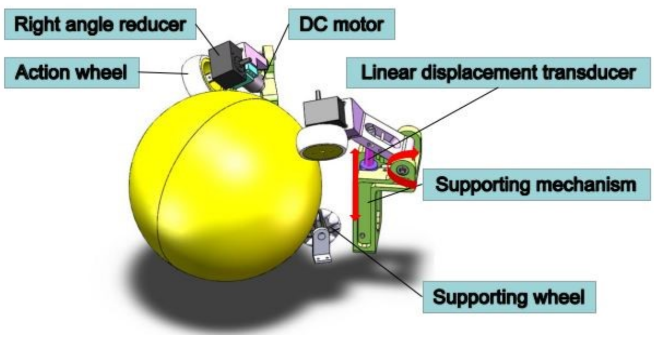
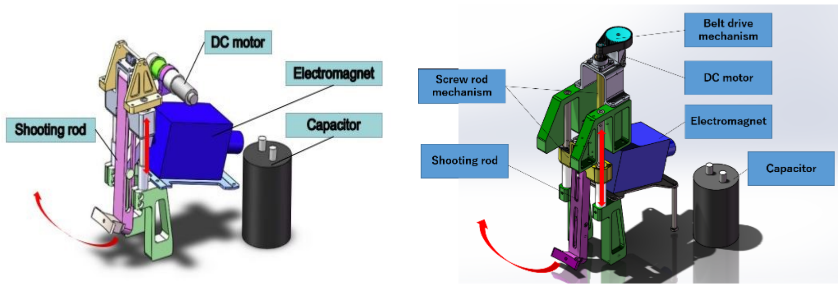


Fig. 3. Our active ball handling system.

1.3 The Electromagnet shooting system

After 2019 RoboCup Sydney, we improve the shooting system of NuBot. The shooting system is still based on an 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 a DC motor. The shooting rod can be adjusted in height to allow for two different shooting modes, namely lob shot and ground pass. In order to control the angle of the shooting more accurately, we use the screw rod mechanism to replace the previous design. Through a screw rod mechanism and belt driving mechanism, two modes can be realized by using the DC motor to pull the hinge of the shooting rod to different positions. Compared with the former system, the ground pass mode has a higher shooting rod position, resulting in a faster ground pass without jumps. The shooting procedure remains the same. 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 slide back to its initial position, and the capacitor will be recharged again for the next shooting action.



(a) (b)

Fig. 4. The former(a) and current(b) electromagnet shooting system of the NuBot soccer robot.

2 Industrial electrical system

In recent years, the risk of the fierce collision between robots increased in the highly dynamic MSL competition. To improve the real-time performance and robustness of our robot control system, we design our current electrical system using PC-based control technology as shown in Fig. 5. Due to steadily growing processing power, PC can work as an ideal platform for automation. It enables automation tasks to be performed through software without the dedicated hardware. All control system and visualization tasks can be carried out by a powerful central CPU and decentralized I/Os, thus the electrical system is highly scalable. For example, the limitations on the number of I/O modules, sensor modules and actuator modules are only dependent on the CPU processing power. In addition, the system employs the Ethernet-based fieldbus system EtherCAT and the TwinCAT system to realize high speed communication between industrial PC and the connected modules. Furthermore, the electrical system also realizes the effective utilization of high-performance multi-core processors.

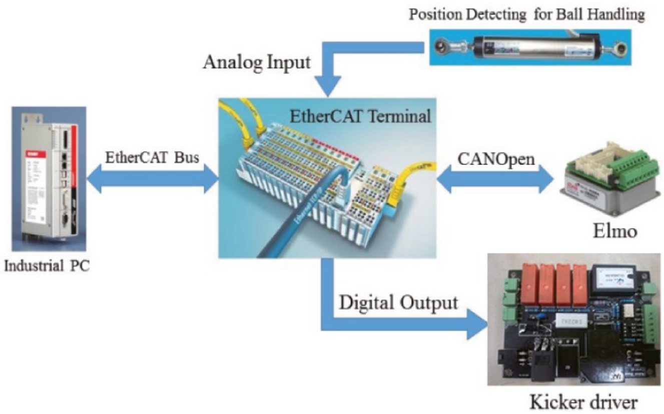


Fig. 5. The NuBot electrical system.