Mechanism and System Design of Linkage Driven Humanoid Robot

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***Abstract*— In this study, we present the design and implementation of a new humanoid robot lower body hardware structure. A four-bar linkage mechanism is used for the transmission to mimic the human leg muscles. The foot sole is designed to mimic the human arch, so that the robot can walk similar to the human gait. In addition, a comprehensive system architecture is established to control the robot.**

I. Introduction

The humanoid robot has achieved a new milestone with the launch of the Tesla Optimus Gen 2 prototype [1]. In this paper, a new humanoid robot is proposed to mimic the human leg structure and the arch of the foot through a four-bar linkage mechanism [2] and foot soles design [3]. On the basis of high extendibility and maintenance, deep learning and algorithms are implemented to optimize and improve the robot system, ensuring that the robot can perform a variety of human actions and solving the phenomenon of labor shortage in modern industries.

II. Methods and Results

The goals of robot's leg design are to achieve light-weighting and mimic the structure of human legs which allows the center of mass of the bipedal robot to move upward, thus decreasing rotational inertia. In Fig. 1, Four-bar linkage mechanism is used for driving robot's legs. This mechanism mimics the muscles contraction of human legs. All of four-bar linkages are parallel equal crank linkages. Except for the robot's driving links, which are made of high stiffness metal, lightweight materials are used. Carbon fiber tubes are used to connect the joints in the legs.

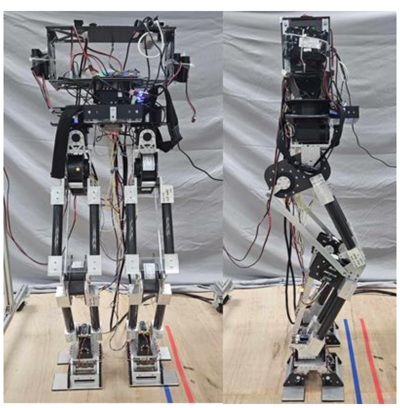

Figure. 1. The mechanism of the robot.

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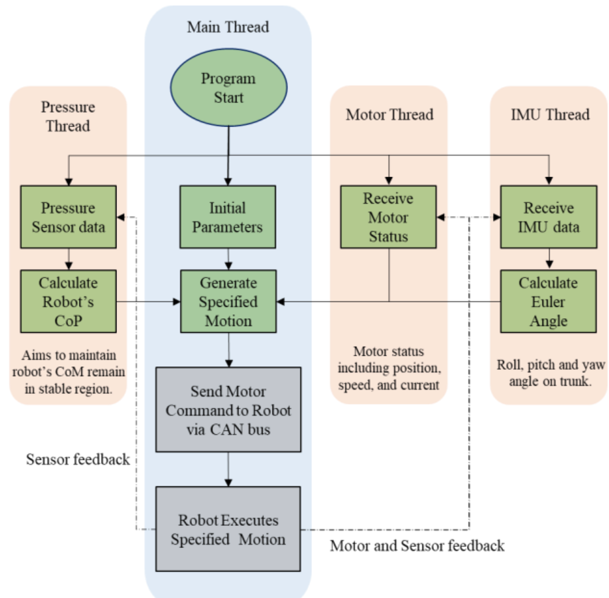

Figure. 2. The system architecture of the robot.

Regarding the design of foot soles, in order to reduce vibration during interaction with the environment, the mechanism mimics the arch of the human foot. Additionally, passive, rotatable joints are used at the front toe and rear heel sections as shown in Fig. 1.

The system architecture of this robot is shown in the Fig. 2. The control program consists of four threads, including the main thread and three others dedicated to receiving sensor data. The main thread is responsible for controlling the start and stop of each thread, receiving sensor data to generate appropriate motion commands, and transmitting them to the motors via the CAN bus. The other three threads are used to receive IMU data and compute Euler angles, receive motor angles and speeds, as well as receive pressure sensor data from the foot soles and calculate the robot's center of pressure.

III. Conclusion

This paper presents an innovative design for a humanoid robot's lower body mechanism and system architecture, as well as the physical assembly and testing. In future work, we will finish the upper body of the robot and operate it to complete the walking and other dynamic testing so that it can be used in an actual-life situation.

References

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