Structural Design and Simulation Analysis of Wheel and Leg Compound Robot

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Abstract

Aiming at the movement requirements of mobile robots in complex environments, a six-legged robot is proposed. First, a robot structure with front and rear leg expansion and contraction functions is designed and the characteristics of the structure are described. Because the robot is not affected by the environment, it can be detected by the search and rescue personnel before entering the underground, and the real-time situation of the underground is uploaded to the ground search and rescue headquarters, which is conducive to the rescue experts to develop a reasonable rescue plan, which is extremely important for the scrambled rescue work. Therefore, research on coal mine underground detection robots is an urgent task to ensure the safety of coal production in China, reduce accidents and reduce economic losses.

Keywords

Six-legged robot; obstacle negotiation;structural design.

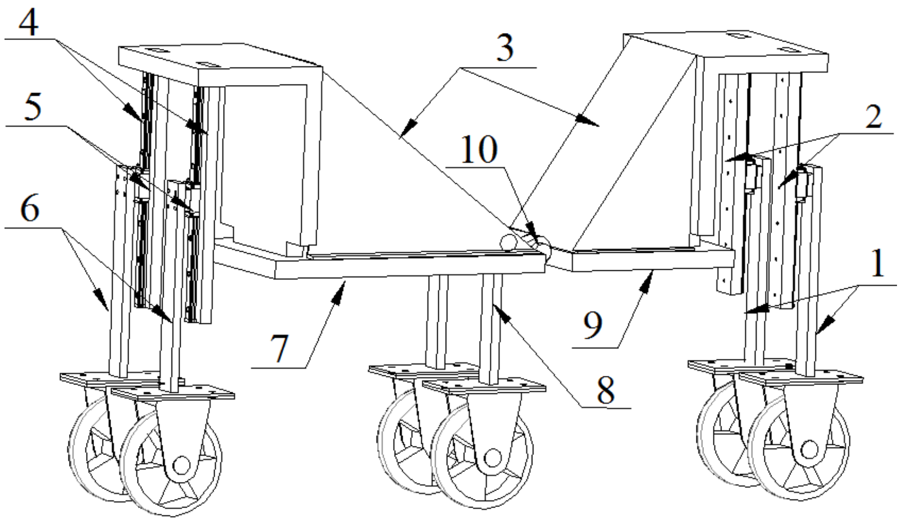
1. Introduction

Debris flow, typhoon and coal mine accidents have occurred in China, and it is a country with frequent social accidents and natural disasters. All these disasters pose a great threat to the life safety of rescue workers. The unknown and complex nature of the site environment and the potential secondary disasters such as secondary collapse and secondary explosion have brought great difficulties to the rescue work. Therefore, a rescue robot is needed instead of the staff to carry out rescue work. In the first time, the disaster information is detected on the scene of the disaster to provide a basis for the rescue personnel in the well to make the next decision.

Because the mine may contain smog dust and explosive gas, the air may also contain toxic gases. The environmental information is more complicated. The in-situ rescue personnel need to know the specific conditions of the well, including the humidity and temperature of the well and the environmental structure. In time to see, the rescue robot must also have strong road adaptability and passability to ensure its normal work in a complex unstructured environment. Currently, rescue robots mainly include multi-modality, bionic search and rescue robots, and traditional crawler styles.

2. Robot structure design

The structural design is a fusion of the quadrilateral mechanism and the telescopic leg structure, so that the wheel-leg composite robot has a waist rotation and a leg telescopic function, mainly by the front wheel leg, the front car body, the rear car body, and the rear wheel. The legs, the middle wheel legs, etc., as shown in Figure 1.



1. Front wheel movable leg 2. Front wheel fixed leg 3. Protective cover
4. Rear wheel fixed leg 5. Slider guide6. Rear wheel movable leg 7. Rear body
8. Intermediate wheel leg 9. Front body 10. Car body rotating drive shaft

Figure 1 Wheel-leg composite robot structure

The characteristics of the wheel-leg composite robot are as follows:

1) The front and rear body are designed as a Z-shaped structure, which greatly improves the overall obstacle resistance of the robot.

2) The corresponding wheel legs are not in contact with obstacles during the obstacle crossing process, which reduces the impact of the obstacles on the robot during the obstacle crossing process and improves the obstacle stability of the robot.

3) The front and rear wheel legs adopt the linear motion of the slider guide rail to make it have the telescopic function, which greatly increases the obstacle-obstacle ability of the robot, which not only ensures high positioning accuracy and good stability during the telescopic process of the wheel leg. The characteristics, but also able to withstand the up and down load caused by a certain body.

4) For the convenience of control, the middle wheel leg is selected as the auxiliary wheel, and the front and rear four wheel legs are separately driven and controlled, and the universal wheel is used for convenient steering. The front and rear bodies are driven by the drive motor to complete the robot, and obstacles such as stepped vertical obstacles are completed.

5) The six-wheel mobile system has strong adaptability and obstacle-tolerance.

6) The sliding steering mode of the front and rear wheels is adopted as a whole.

7) When the road condition is good and the ground is flat, the front and rear universal wheels and the auxiliary wheels are in contact with the ground at the same time. When the obstacles need to be crossed, the cooperation of the six wheel legs is completed, and the driving and steering modes of the mobile robot determine the robot. Stability, flexibility and other performance.

3. Simulation

The following is a verification of the robot obstacles under three different obstacles.The 3D model of the robot is built by Solidworks.The file is saved in parasolid (*x_t) format, and then imported into the ADAMS virtual prototype to establish the corresponding constraints and then simulate.

3.1 Step obstacle obstacle verification process verification

The robot's entire obstacle-obscuring process time is set to 12s. Through simulation and post-processing, the simulation animation and curve of the corresponding step obstacle are obtained. The obstacle process simulation is shown in Figure 2. In order to simplify the observation of the simulation model and the simulation process, the front and rear protective covers are removed during the simulation, and the steering problem of the vehicle body is not considered, and only the linear motion is analyzed, so parallel constraints are added to the vehicle body and the ground simulation.

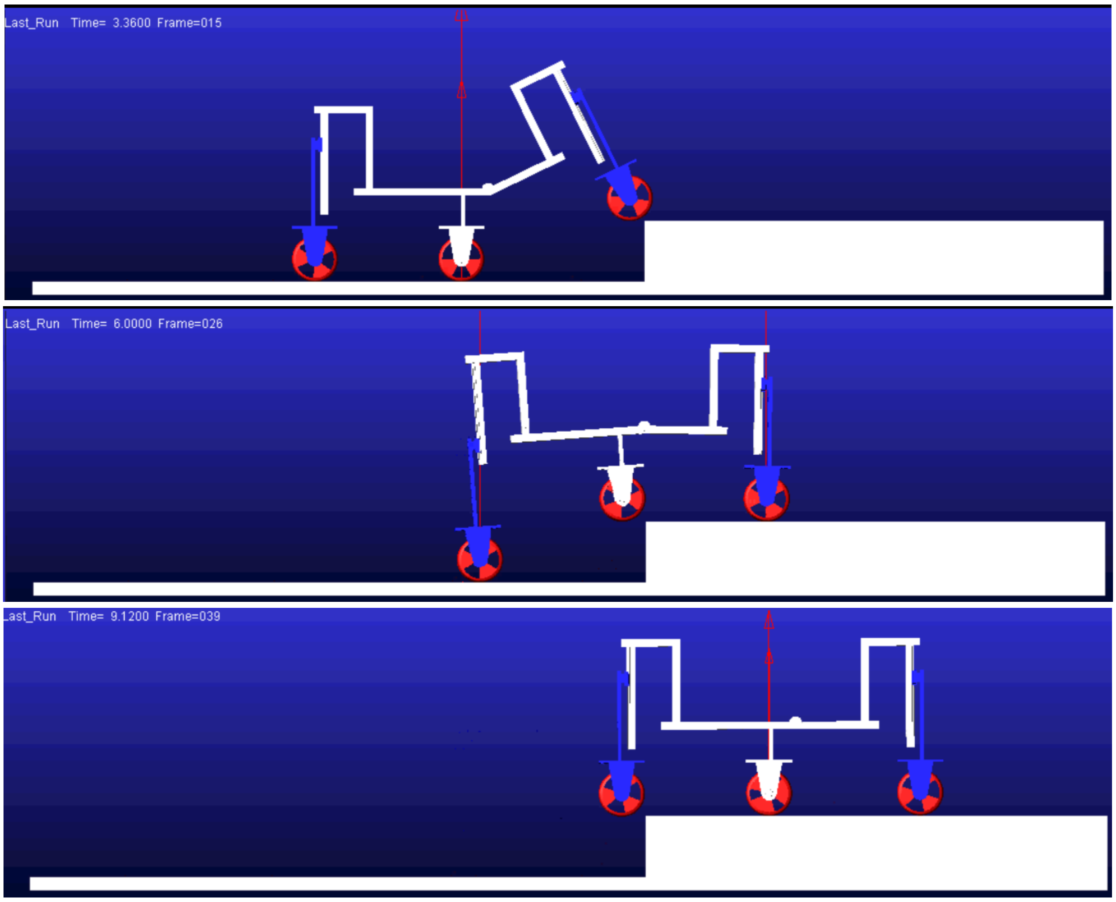
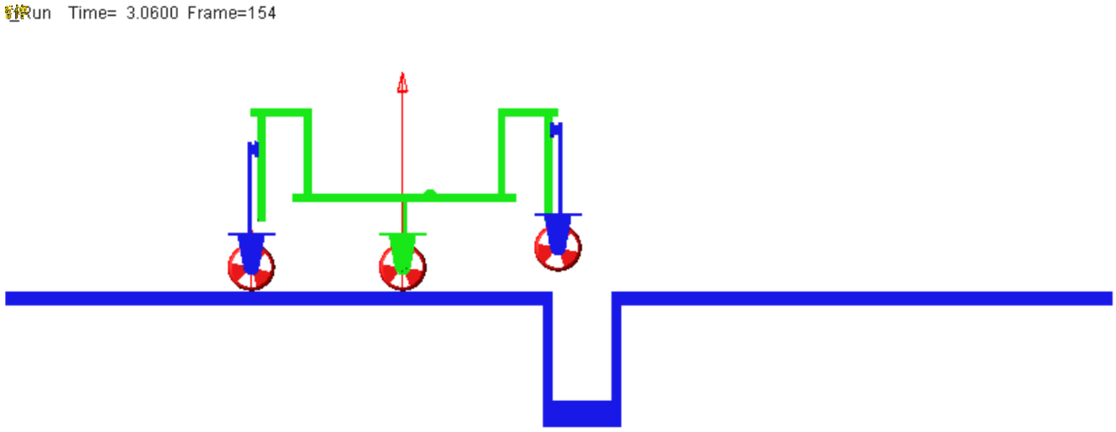


Figure 2 Stepped obstacle process simulation

3.2 Trench obstacle obstacle verification process verification

The robot's entire grooved obstacle crossing process time is set to 10s, and the simulation animation of the corresponding groove obstacle is obtained through simulation. The obstacle process simulation is shown in Fig. 3. In order to simplify the observation of the simulation model and the simulation process, the front and rear protective covers are removed during the simulation, and the steering problem of the vehicle body is not considered, and only the linear motion is analyzed, so parallel constraints are added to the vehicle body and the ground simulation.



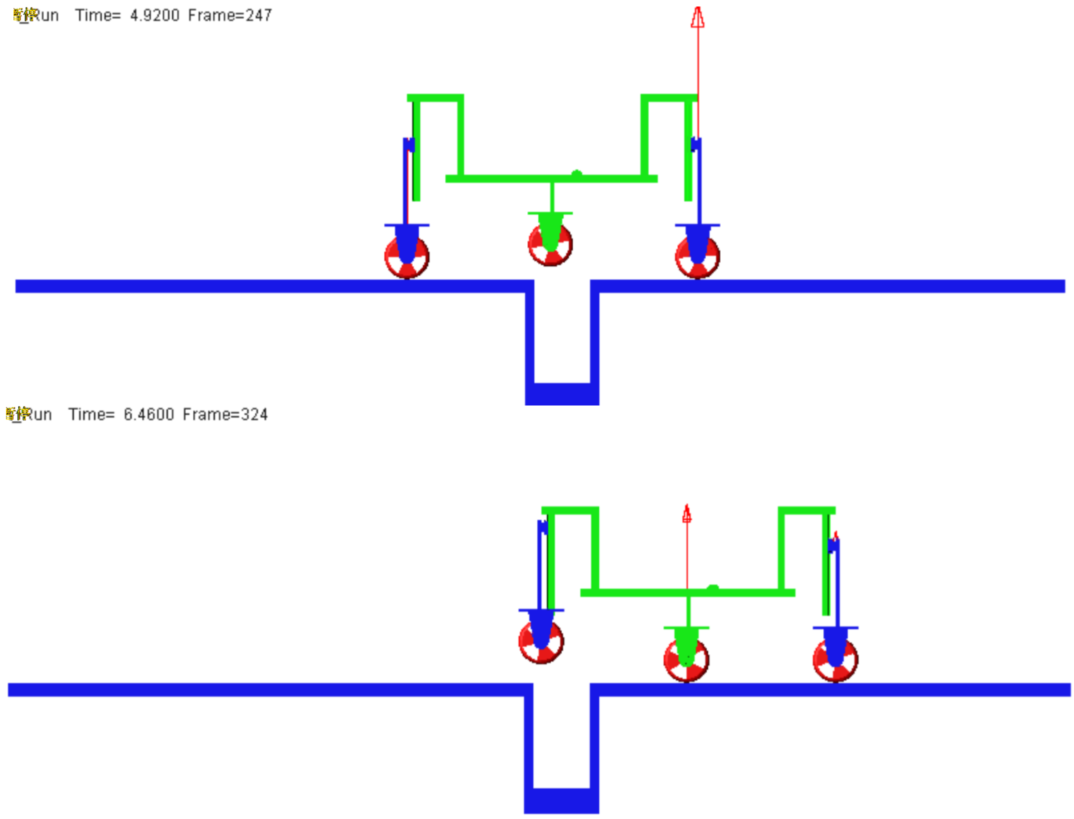
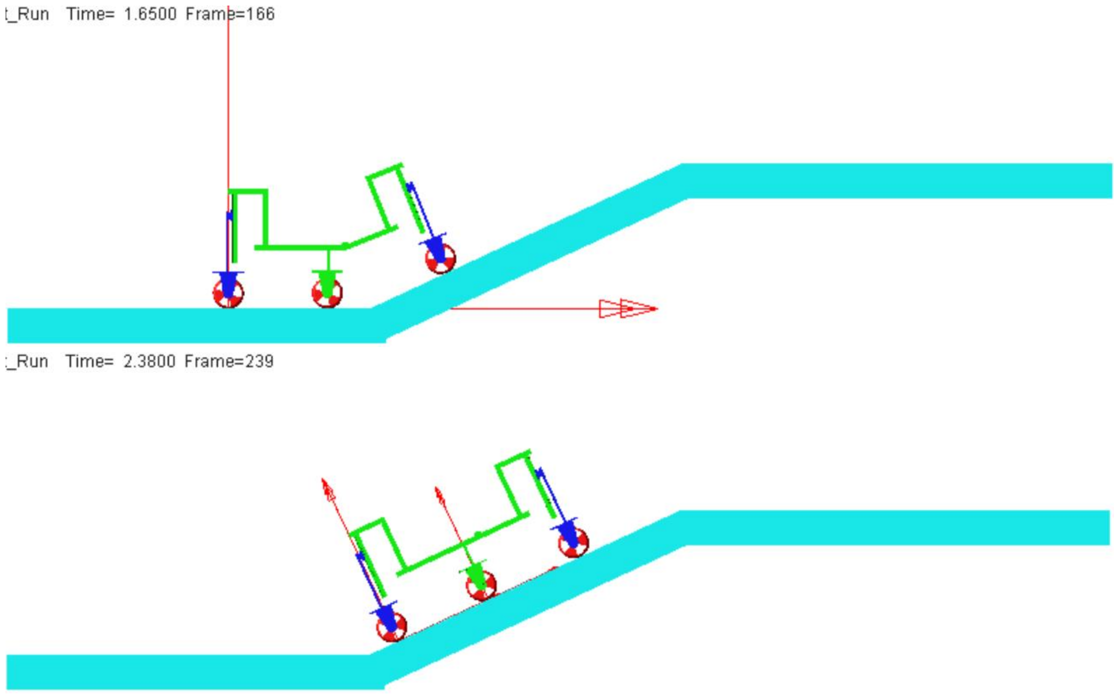


Figure 3 Groove obstacle crossing process simulation

3.3 Slope obstacle obstacle verification process verification

The robot's entire ramp-type obstacle crossing process time is set to 5s, and the simulation animation of the corresponding slope obstacle is obtained through simulation. The obstacle process simulation is shown in Fig. 4. In order to simplify the observation of the simulation model and the simulation process, the front and rear protective covers are removed during the simulation, and the steering problem of the vehicle body is not considered, and only the linear motion is analyzed, so parallel constraints are added to the vehicle body and the ground simulation.



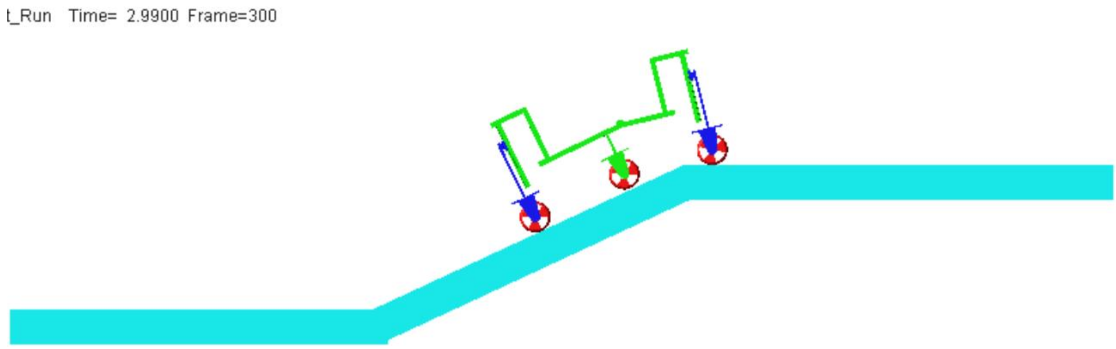


Figure 4 Ramp-type obstacle crossing process simulation

4. Conclusion

According to the structural characteristics of the robot and the characteristics of the three types of obstacles, a detailed description of the obstacle crossing process is made. By establishing a combination of 3D models and virtual prototypes, the feasibility of the robot's obstacles to three obstacles is verified.

Based on the previous work, the follow-up will be based on the real-time contact control of the wheel and the ground and the control of the entire obstacle-obscuring process.

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