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RoboCupRescue - Robot League Team ROBHAZ-DT3, Korea

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Abstract. In this paper, design and integration of the ROBHAZ-DT3 are introduced which is a newly developed mobile robot system with double tracks. It is designed to carry out military and civilian missions in various hazardous environments. The rotational passive adaptation mechanism equipped between the front and rear body enables the ROBHAZ-DT3 to have good adaptability to uneven terrain including stairways. The passive adaptation mechanism reduces energy consumption in moving on uneven terrain as well as it offers simplicity in design and teleoperation. Based on this new design concept, dynamic simulation was conducted to determine the significant parameters such as optimal track size and allowable attack angle. Also dynamic effects in vehicle turning are investigated to assess proper load torque. The ROBHAZ-DT3 system developed was successfully experimented in stair-climbing case.

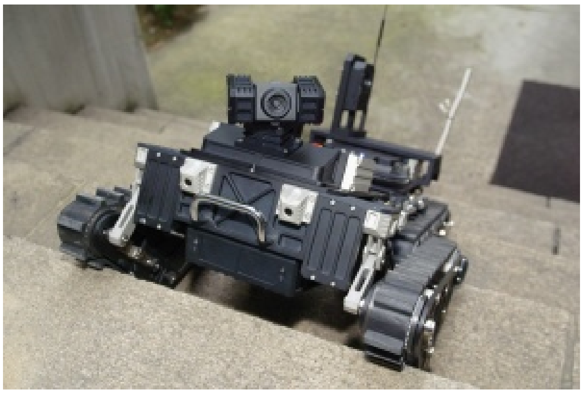


Fig. 1. Pan-Tilt Camera

Fig. 2 ROBHAZ-DT3

Introduction

In the 21st century, robots will take the place of human labor in many areas. In the near future they will perform various hazardous duties like fire fighting, rescuing people, demining, suppressing terrorist outrage, and scouting enemy territory. To make use of robots in these various circumstances, robots should have the ability of passing through rough terrain such as steps. There are three types of moving mechanisms for this kind of robots in general : wheel type, track type and walking type mechanism. Robots with wheel mechanism are inferior to robots with track when they are to move on rough terrain. Walking robots have complex structures so that they are usually difficult to control and slower in speed. In that sense, the track mechanism has advantages in high speed driving and mobility under severe conditions [1]. In spite of these merits, it consumes more energy than the others. Therefore it is needed to design a robot to overcome this drawback. Some recent researches are to develop a novel track mechanism with flexible configurations adaptive to various ground conditions.

Kohler, et. al. suggested a moving mechanism with 4 flexible tracks [2] and Maeda, et. al. proposed a moving mechanism that combines merits of wheel and track type robots [3]. Iwamoto and Yamamoto developed a moving mechanism that shows superior ability on going up steps with track that changes its configuration while moving [4]. Yoneda, et. al. suggested a track type moving mechanism that uses a track with a material having higher coefficient friction and wider contact area between the track and steps [5]. Schempf, et. al. suggested a robot with flexible track that has a similar structure to the robot proposed in this paper, but this robot must change the shape actively to adapt to the ground condition [6].

As result of investigation of other researches and upgrade of our previous work[7], a simple and compact double-track mechanism is proposed and realized in this work in Figure 1& 2

1. Team Members and Their Contributions

- Woosub Lee — Controller development & Mechanical dedign & Operator
- Changwoo Park — Controller development & Mechanical dedign
- Sungchul Kang — Advisor
- Seungkook Yun — Advisor

2. Operator Station Set-up and Break-Down (10 minutes)

In many of real situations of hazardous duty, the robot should be deployed into the site as soon as possible. It requires minimum setup time and simple and intuitive user interface. Thus the tele-operator station with small size and light weight for easy operation, as shown in the Figure 3, is necessary for practical use.

Fig. 3. Operator Station

3. Communications

We'll use 802.11A access point for data communication but we don't choose the channel number. And We also use 2.4GHz frequency for VIDIO & AUDIO RF communication.

4. Control Method and Human-Robot Interface

We will use remote teleoperation method for moving contol. Figure 4 shown the block diagram of integrated control system of the robot.

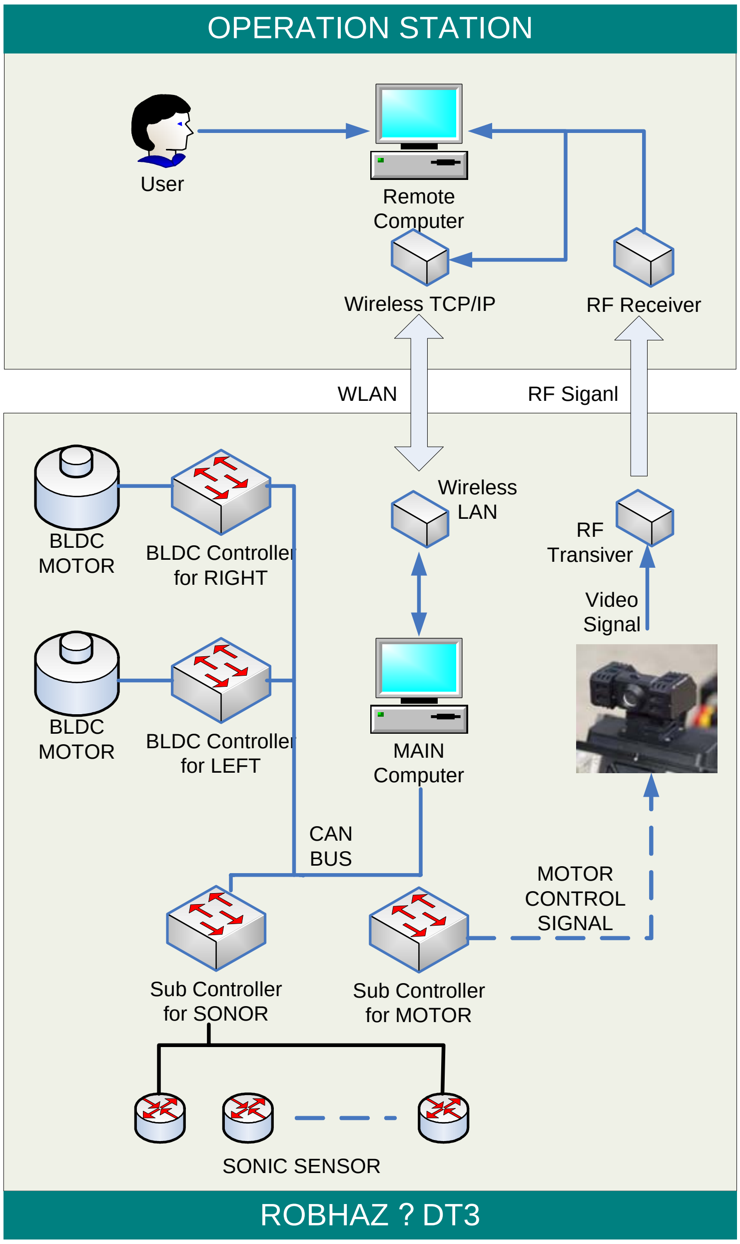


Fig. 4. A block diagram of integrated control system of the robot

5. Map generation/printing

We will use ICP method for map generation. By using the algorithm, we can build the map if short computing time. Also the map will be printed automatically after mission, but we don't decide the format of report which include the victim location, victim condition and map of the environments.

6. Sensors for Navigation and Localization

We will use 2D-Laser sensor like SICK laser. We can obtain the information of the environment data from 2D-Laser sensor. We can solve the position of robot and the map data.

7. Sensors for Victim Identification

We will use several sensor for victim identification.

1) CO2 measure sensor – We can measure the value of CO2 quantity.
2) Non-Contact Temp. sensor
   - We can measure the value of victim's body temp.
3) Pan-Tilt Camera – We can see the number of victim.
4) Microphone - We can detect the sound of victim.

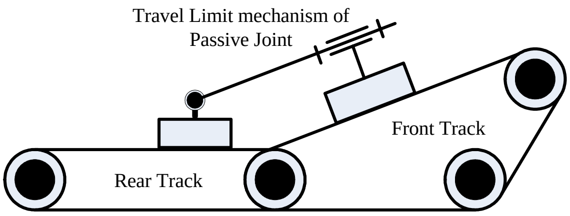
8. Robot Locomotion

A new track mechanism, which can give a passive adaptability based on a unique link mechanism, is exploited for the ROBHAZ–DT3 to increase its mobility on rough landform. Figure 5 shows a recently upgraded design of the double track mechanism of the ROBHAZ-DT3. The double track mechanism is composed of two tracks driven by single motor for each side. The ROBHAZ-DT3 consists of three parts : the front body with track, rear body with track, and travel limit mechanism of passive joint. The front-left and rear–left track (or the front-right and rear–left track) in Figure 5(b) have the common driving shaft and each motor is equipped for actuating the shaft. Thus, the two tracks at each side rotate in the same direction as that of the driving shaft as illustrated in Figure 5(a).

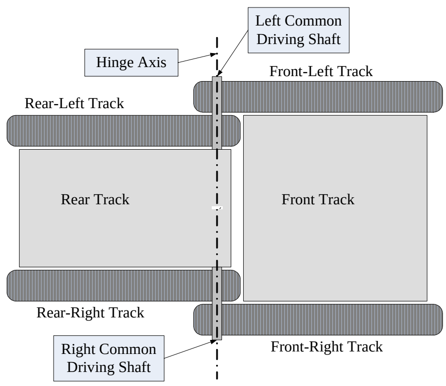
The passivity applied to the ROBHAZ-DT3 is simply acquired by attaching the front and rear body through a hinge joint without any actuator. The hinge axis is marked in Figure 5(b) and is coincided with the axis of the driving shaft. Figure 6 illustrates a passive relative motion between the front and rear bodies. As the front track rotates in the angle of β as marked in Figure 4 from the initial state *F* to the arbitrary final state *F'*.

Changing configuration will give alteration of the weight center or ZMP (Zero

Moment Position), which gives influence on stability of a vehicle in rough terrains. It is generally known that single-track mechanisms have limitation in rugged terrain due to a fixed weight center in the local frame, which greatly affects a stability margin (the minimum length between weight center and edges of a supporting area). The stability margin in the case of single- track vehicle is only determined by the other factor such as the inclination of landform. Therefore, it is needed to design to have chained mechanism with multiple track bodies to overcome this limitation. This is a main reason that we developed the double track mechanism. In case of the double-track mechanism, the center of mass varies and the supporting area is also altered by the passive motion when traveling over the landform.



(a) Side View



(b) Top View

Fig. 5. Design of passive double-track mechanism (patent pending)

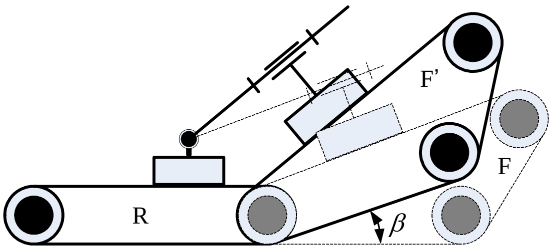
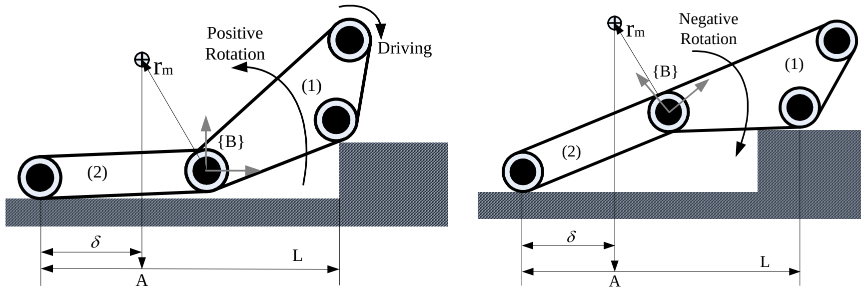


Fig. 6. Relative motion on the hinge axis



(a) Case of Positive Deflection (b) Case of Negative Deflection
Fig. 7. Passivity in stairway climbing

Effect of the passivity is investigated in an example of stairway climbing as shown in Figure 7. Stairway is one of the good landform to verify the mobile capability of a vehicle, and it is widely used among many researches related in developing a vehicle for such irregular terrain. For simplicity, the example is drawn in 2D vertical plane. {B} is a body fixed coordinate frame and $\mathbf{r}_m$ is a position vector of center of weight. L is a projected line representing the supporting area as depicted in Figure 7(a). The point A is a center of weight projected on a supporting area, and δ is a stability margin.

During climbing the stairs, both the positive and negative rotations are observed in Figure 7. In the situation of Figure 7(b), for instance, a supporting area is increased compared with that of Figure 7(a). The L would be shorter in case of single track. It means that the double-track design has advantage in low gravity center and large stability margin. Note that no actuator is used to generate the rotation and the rotation is only produced by gravity on the given landform. Thus the passivity can improve adaptability to a rough terrain and the motion (i.e., the positive and negative deflection) occurs successively during stairway climbing.

9. Other Mechanisms

Nothing

10. Team Training for Operation (Human Factors)

We carried out many demonstrations already in several environment like stairs and rough terrain. Also the operation of ROBHAZ-DT3 is very easy.

11. Possibility for Practical Application to Real Disaster Site

Figure 8 shows a demonstration of shooting a 29 mm diameter water-bullet from a water disrupter mounted on the ROBHAZ-DT3. This demonstration was conducted in cooperation with Seoul Police SWAT team of Korea in November 2003. In this demonstration, we examined whether the shooting accuracy of the water-bullet after firing is feasible for real use because the firing impact is so large compared with the weight of the ROBHAZ-DT3 light(39kg).

Fig. 8. ROBHAZ-DT3 with Water Disrupter for EOD Mission

ROBHAZ-DT3 has good mobile ability and high-payload. So the robot can be use for several purpose. (fire fighting, rescuing people, demining, suppressing terrorist outrage, and scouting enemy territory)

12. System Cost

I'm sorry, I can't tell the prime cost of ROBHAZ-DT3. Because, the robot is developed for commercial product. But selling price is $60,000.

References

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