Design Concepts of Emergency Response Robot Platform K-R2D2

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1. Introduction

A mobility which is instead of emergency workers is very important in order to quick remote response to the nuclear accident. The current developed robot could not easy to move aisles that human workers are moved during normal operation or preventive maintenance period in the case of nuclear power plants [1], [2].

Especially, in assuming the extreme conditions disasters such as earthquake or hydrogen explosion, migration path that is on the collapse of the obstacles can be interspersed, mobile technology is required to overcome them.

From the analysis for various mobile robots competed in DARPA Robotics Challenge [3], there are some drawbacks in using two or four legs because bipedal locomotion is not yet suitable for maintaining stability and quadrupedal locomotion is difficult to go through narrow aisles as shown in Fig. 1.

Motivated by the above observations, we propose a K-R2D2 robot platform with three legs arranged in the form of a triangle like as R2-D2 robot [4] which is a fictional robot character in the Star Wars movies. This robot has 3 legs with tracks in each sole of the leg. It is statically stable since there are three contact points to ground. In addition, three legs are also possible to design a structure walking stairs that can expand and contract in the vertical direction. It is possible for robot instead of emergency workers to walk or wheel depending on the terrains and move quickly as possible on uneven terrain.

The design concepts are as follows.

a. Achieving stable movement on uneven terrain or walking up stairs.
b. Smaller/lighter size than emergency workers.
c. Moving on the plat terrain of a hybrid structure.
d. Robot stands up on its own and minimizes damage after falling down.
e. Minimizing degree of freedom and modulation.
f. Increasing terrain adaptability by using a passive-dynamic mechanism.

(a)working aisle (c) Narrow aisle (b)uneven aisle

Fig. 1. Emergent workers movement aisle

2. Overview of Conceptual Design

2.1 Walking up stairs

From the analysis for gait locomotion based on walking up stairs as shown in the Table 1, we calculate link length of K-R2D2. It is 0.9m. Walking up stairs is set in a width and height are 0.24~0.4m and 0.18~0.2m.

Table 1: Stairs specification

Width(mm)	Height(mm)	Gradient(degree)
240	180	36.9
300	200	33.7
400	200	26.6

2.2 Size and weight

K-R2D2 is designed smaller size than emergency workers based on the calculated link length. Its height, weight, right/left and front and rear width are 120cm, 86kg, 70cm and 40cm. Fig. 2 shows the size for K-R2D2.

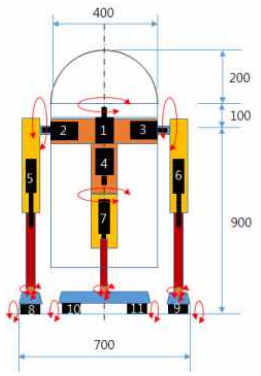

Fig. 2. Schematic of joint and link

2.3 Moving on the plat terrain of a hybrid structure

This robot has 3 legs with tracks in each sole of the leg. So tripod walking and wheeling are possible depending on any environment and terrain

2.4 Robot stands up on its own and minimizes damage after falling down

It is possible to get up by using the left and right leg after fall down which is landing sideways or falling forward/backward because we design body with a cylindrical shape.

2.5 Minimizing degree of freedom and modulation

We tried it to have minimized 11 DOF to mobile monitoring. It has yaw head, left and right pitch shoulder, yaw torso, left and right expand and contract arms and middle leg and 4 track driving. Yaw head, the left and right pitch shoulder and yaw torso use the same rotational drive module. Left and right expand and contract arms and middle leg use the same liner drive module. Four tracks also use the same track drive module.

We simplify the drive unit of a combination of the three drive modules. Three joints connecting the left and right arms and legs to the track module also uses a passive rotary joint module.

2.6 Terrain adaptability by using a passive-dynamic mechanism

We design that is possible for robot to drive by using 3 legs with active-dynamic tracks on plat or uneven slopes. Ankle spherical part which is changed according to depend on the terrain gradient during walking is designed for passive-dynamic mechanism.

2.7 Module specification

Track module, each one attached to left and right arm and only middle leg attached two track modules in order that is statically stable to maintain equilibrium.
Sum of forces for 4 tracks is 30kgf for 30-degree slope climbing. Stroke, movement speed and thrust of the liner drive module are above 300mm, 200mm/s, 60kgf. Rotation speed of the passive rotary joint module is 0.5rev/s and torque is above 60kgfcm.

Fig. 3. Robot platform for K-R2D2

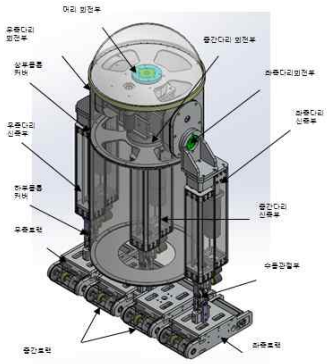

Fig. 4. 3D structure for K-R2D2

Fig. 3 and Fig. 4 show our current research platform and 3D structure as following the proposed design concepts.

3. Conclusions

This paper has presented the conceptual design, it is developed on the purpose of quick response instead of emergent workers to the extreme conditions disasters. This robot is emergency response robot platform K-R2D2 with three legs, which is statically stable to walk or wheel depending on the terrains and move quickly as possible as on uneven terrain or stairs.

In the future work, the K-R2D2 will be considered in addition to the dynamics of their machines for improving an efficiency for their motions.

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