Avatar Robot that Coexists with People

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Abstract

The “Future Theme” program is a company-wide initiative that solicits ideas from within our company with the goal to create businesses and technologies for 10 years from now. The authors are participating in the in-house program as the “Mobile Robot Working Group”. In this activity, we aim to create products and services based on the development concept of “backtracking to the future”. We have developed and prototyped a mobile robot with a new undercarriage system based on the rocker-bogie mechanism. We are working with the following basic principles:
(1) Proposing a replacement for manual labor with “remote-controlled smart robots” that pursue ease of use and safety for various industries and applications.
(2) Looking ahead to the arrival of the metaverse era, we will explore the creation of new value with “avatar robot” that bridges the real world and virtual space.

1 Preface

The Mobile Robot Working Group (hereinafter referred to as “this development project theme” or “this theme”) was launched in 2018. We aimed to develop a platform for the undercarriage of mobile robots by drawing on the technologies cultivated in the field of Automated Guided Vehicles (AGVs). After extensive market research, in 2019 we revised our goal to “Create a mobile robot that is safe for people and can overcome any obstacle!” We are now working on developing a mobile robot that can solve social issues. This paper introduces the prototype mobile robot.

2 Current Social Issues and Approach of this Theme

The impact of the COVID-19 pandemic in 2019 caused major changes in society. Independent of the negative social impact, it also accelerated remote work and Digital transformation (DX). Society now has an environment where people can work and live without having to go to the workplace in person. It is safe to say that this trend will never return to the state it was before 2019.

The vision of the future that this theme aims for is to realize a society in which many people can live more productively. In the near future, people will be able to live diverse lives without being restricted by time, place, body, age, or gender. However, the current society is still far from the ideal society, with issues such as labor shortages, diversity, and LGBTQ.

Therefore, in this theme, we will work on the development of a mobile robot that can move in the same way as a human. We propose the social implementation of an “avatar robot” to realize avatars in the metaverse space in the real world.

3 Features of Avatar Robots

Avatar robots are robots that can work and perform data exchange with people in remote locations. It is said that social activities using the metaverse will become more active in the future. In this context, avatar robots are expected to be used as a tool to connect the metaverse space with the real world. People will use these avatar robots through the metaverse space. They will be able to work directly access various places around the world by gaining a kind of physical body. Furthermore, avatar robots are required to have the ability to overcome steps and move freely in all directions, just like humans.

This is one of the most important things for users to feel immersed when operating them. The rocker bogie + Mecanum omniwheel mechanism we developed can meet this requirement.

In this theme, we created a roadmap for developing a mobile robot that can safely overcome steps. The immediate target is the development of a "walk-around" inspection robot that can be operated by a person from a remote location. The "walk-around" inspection robot has a function for two-way communication connecting remote workers with on-site workers. It can also be used for "walk-around" inspection for maintenance of facilities where there are no people.

4 Production of Prototype

The prototype avatar robot for "walk-around" inspection for maintenance of facility has the following three functions.

4.1 Traveling Function

To achieve rough terrain travel, a rocker-bogie mechanism was adopted. In addition, a combination of mecanum wheels and omni wheels was adopted.

4.1.1 Rocker-Bogie Mechanism

The rocker-bogie mechanism has excellent rough terrain travel performance. It has been used in Mars rovers and other missions. It consists of rocker arms and bogie arms, each of which can move freely. All six wheels are always in contact with the ground. In this theme, a motor was attached to the joint to actively move the bogie arms, adding high step-crossing performance. By leaving the motor output shaft free except when crossing steps, it is possible to demonstrate road surface tracking and vibration absorption during travel.

4.1.2 Combination of Mecanum Wheels and Omni Wheels

Mecanum wheels generate driving force in the axial direction of barrel-shaped rollers that are installed at a 45 degree angle to the wheel mounting angle.

Omni wheels only generate driving force in the direction of wheel rotation. No driving force or resistance is generated in any other direction.

In this theme, four Mecanum wheels are used on the front and rear wheels, and two Omni wheels are used in the middle wheel. The direction of travel is determined by the scalar sum of the driving force generated by each driving wheel. By controlling the rotation speed and direction of each wheel, it can travel freely on a flat surface.

The travel direction is controlled by a combination of "forward/reverse", "traverse" and "spin turn". For example, diagonal travel (diagonal movement) is achieved by "forward/reverse" and "traverse", and curved travel is achieved by "forward/reverse" and "spin turn", or by "traverse" and "spin turn".

In addition, the joystick allows intuitive and easy operation.

4.2 Remote Operation Function

The problem with remote operation is the delay in operation. In order to operate while viewing the image captured by the camera, it is necessary to reduce the data transmission delay.

In this theme, we initially developed a web application that simultaneously transmits the robot's operation commands, voice calls, and camera images. However, depending on the line conditions, delays of more than one second sometimes occurred. Therefore, a significant improvement was required. Therefore, a pre-existing call application was used for voice calls and camera image communication. Rather than insisting on making everything in-house, we changed our policy to actively adopt useful means. As a result, we were able to reduce the delay to less than 0.5 s, achieving a natural remote operation.

4.3 Camera Lift Function

Walk-around inspection for safety or facility maintenance will often include visual inspection of instruments, such as control panels. These are often placed near the line of sight of people. Therefore, the camera needs to be placed at the same height as the instruments. In addition, to communicate two-way with people on-site, it is also necessary to display the operator's image on the walk-around inspection robot. Therefore, we decided to place the tablet with a built-in camera at eye level. However, if the tablet is fixed at eye level, it will not be able to see objects at lower positions. As a countermeasure, we equipped it with a lifter that moves up and down, and added a function to move the tablet to any position between 50 and 170 cm in height. In this way, by equipping an omnidirectional vehicle that can overcome steps with a tablet with a lifter, it can be used as a walk-around inspection robot. It has become a tool that allows inspection

Fig. 1 External Appearance of Prototype Model

Keeping weight reduction, the prototype model has a camera with a function of elevation.

and two-way communication even from a remote location.

5 Verification Test

We conducted a verification test together with the in-house plant construction department. During the test, many issues were identified, such as poor operability due to remote communication delays and the inability to check inspection targets at high positions. We created a prototype of a “walk-around” inspection robot that incorporates these issues and customer requests for improvements. Fig. 1 shows the external appearance of the prototype Model, and Table 1 shows the specifications of each prototype Model. We are working on improving the functions by focusing on the issues identified during the verification test.

Table 1 Specifications of Prototype Model

Specifications of the Prototype Model are shown.

Item	Specifications
Driving system	6-axle driving
Size (mm)	W630 × H430 (1700) × D690
Self-weight (kg)	28 (+4.5 with camera and lifter)
Load capacity (kg)	6
Traveling direction	Omnidirectional traveling, curve, spin turn
Guiding system	Remote control
Step overcoming ability (mm)	100 (High friction road surface)
Wheel diameter (mm)	152
Maximum speed (m/min)	60

6 Postscript

We believe that the mobile robot developed using this technology will be a unique product as an avatar robot.

Going forward, we are considering introducing the results of joint research with other research institutes. We will incorporate customer requests and improve usability. We will evolve the robot into one with even more unique features. At the end of the roadmap, we aim to enter the metaverse market.

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