

Guide Robot Management System

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ABSTRACT

We have developed the guide robot system to help efficiently give directions to people in public spaces. The ‘management system’ for guide robots can facilitate effective collaboration between multiple units and types of robots in operation by using fleet management algorithm and communication channels through clouds and IoT technologies. It would expand the area in which the robots can operate as well as overcoming some restrictions in network availability. We have tested the system with robots in a public facility, simulating a real-life guiding service, and successfully confirmed its functionality.

1. Introduction

Honda makes this statement in its 2030 Vision: “Serve people worldwide with the ‘joy of expanding their life’s potential’: Lead the advancement of mobility and enable people everywhere in the world to improve their daily lives”⁽¹⁾. The company has also been engaged in the development of robotics technology, as exemplified by ASIMO, with the aim of realizing “a robot that coexists and cooperates with people and performs useful functions in society”⁽²⁾.

As one such initiative, the guide robot system was developed for robots moving in a mixed environment with people. Guide services by robots are provided to general guests for the purpose of exploring challenges involved in robot implementation in society. The guide robot system is configured with two types of robot, the reception robot and the guide robot (Fig. 1).

Guide robot management system (management system) was developed together to allow the network of robots to share information and coordinate between multiple units. The system processes the data transmitted by individual robots to allocate tasks for smoother operation. The system uses a cloud and IoT communications to overcome constraints on infrastructure building thus expanding its operational range.

The system approach of the management system is introduced below.

2. Guide Robot System Configuration

The guide robot system provides two types of service. One is the route guide that shows guests how to get to their destination. The other is the guide that accompanies

them to their destination. These services are distributed between the reception robot [Fig. 1(a)] and the guide robot [Fig. 1(b)] respectively, but their execution is coordinated. When guests specify their destination either by voice or touch screen terminal input, the reception robot indicates the route to the destination (route guide function). Then,



Fig. 1 Guide service scenario

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the guide robot directs the way to their destination, while accompanying them along the journey (guide function).

The request for a guide received by the reception robot is allocated to a guide robot by the management system [Fig. 1(c)]. In order for the management system to respond to guide needs as required, it monitors the location and operational status of the guide robots in real time and engages in appropriate fleet management. In this way, the robots of two types and the management system operate in a coordinated manner, passing the task smoothly from the reception robot to the guide robot so that guests can navigate the way to their destination without getting lost even in unfamiliar places.

3. Roles of the Management System

The management system has two main roles to play.

The first role is to engage in appropriate fleet management of guide robots so that the system can respond to guide requests [Fig. 2(a)] from the reception robot. Guide requests include the guest's desired destination and facial recognition data which is acquired by the reception robot, with the guest's permission. It is used by the guide robot when guiding the guest. The management system selects one from among the multiple guide robots on standby near the reception robot, taking their operational status, remaining battery charge, and so on into consideration. In order to guide a guest, the guide robot has autonomous navigation functionality and facial recognition functionality. Autonomous navigation plans a route to the destination and navigate the robot itself and the guest while avoiding obstacles. Facial recognition identifies guests using the camera installed at the rear of the guide robot and recognizing their relational position. It is used to make sure the robot speed matches that of the guest and notice separation from the guest. The management system transmits the data needed for autonomous navigation and facial recognition as a set of commands to the guide robot [Fig. 2(b)], which receives the data and initiates the operation.

The second role is to monitor the operational status of the reception robots and guide robots and notify the system operator of any malfunctions. During guide operations, the management system constantly monitors the progress of

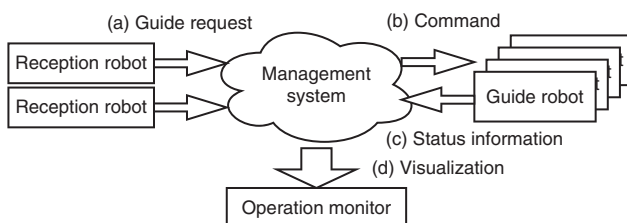


Fig. 2 Guide robot system configuration

tasks [Fig. 2(c)]. When a certain task is completed, the next command is transmitted. The system operator also carries an operation monitoring terminal by which the location and operational status of guide robots can be checked, and when trouble occurs, detailed information regarding the location and nature of the malfunction can be checked through the terminal [Fig. 2(d)].

4. Management System Configuration

The management system is made up of the Honda Robotics as a Service Platform (Honda RaaS) and the guide cloud application (guide cloud). Honda RaaS [Fig. 3(b)] is a platform for development and operation of robotics services, and it is equipped with general purpose functions such as communications, data acquisition, and so on⁽³⁾. In contrast, the guide cloud [Fig. 3(a)] was newly created to realize particular functions specific to guide operation. The guide cloud uses data shared from Honda RaaS as the basis for managing guide jobs and monitoring operational status of the robots. Honda RaaS and the guide cloud are linked by data streaming and the REST API [Fig. 3(c)]. The reception robot, guide robots, and operation monitoring terminal are connected through the Internet using IoT and other such frame of communications. The system operator uses the operation monitoring terminal to check the operational status of the robots, as well as to handle user registration, device registration, and other such configuration work [Fig. 3(d)].

This system configuration has advantages for both development and operation. The advantage in development is that, since it uses the secure communications, device management, data visualization, and other such functions provided by Honda RaaS, resources can be concentrated on application development. The advantage in operation is that, since it does not use dedicated servers and Wi-Fi, it does not have their limitations on robot range of movement or on infrastructure building.

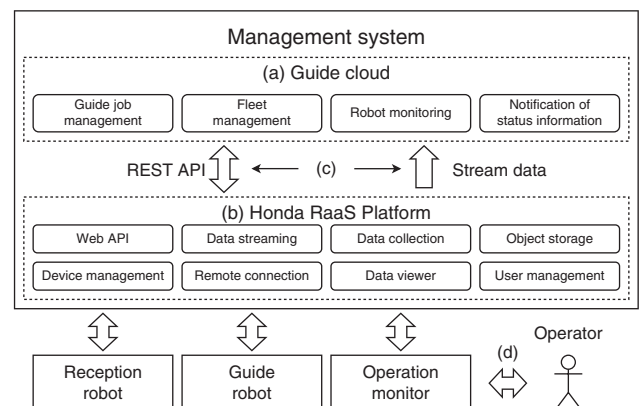


Fig. 3 Management system configuration

5. Guide Cloud Functions

In order to provide guide services, the guide cloud performs guide job management for guide reservations, guide robot selection, and other such functions. It also maintains readiness for contingencies by monitoring the operational status of robots.

5.1. Guide Job Management and Fleet Management

A guide job is one unit of the guide services provided to guests which can have variety of status, reservation in effect, guide job under way, cancelled, and so on. The management system manages the progress of multiple guide jobs simultaneously.

The scenario that precedes the start of a guide service will be described in order here. First, the guest enters the destination by voice or by using the touch screen terminal to search for it, retrieve it, and designate it. Once set of the destination has been completed, the reception robot displays the route to that destination [Fig. 4(a)]. While the guest is operating the reception robot, the management system evaluates the operational status, remaining battery charge, and other such factors of the guide robots, selects one of the robots, and transmits a standby instruction to it. The guide robot enters standby preparatory to performing the guide action [Fig. 4(b)]. At this point, the job may end with just the route guide, depending on the guest's preference, in which case the standby status is cancelled.

When a guide is to be used, the destination information and facial recognition data are transmitted from the reception robot to the management system. The guide robot receives this data from the management system and starts the guide action [Fig. 4(c)].

The system is designed to manage up to several tens each of reception robots and guide robots. Also, in order to make the guide robot selection in accordance with the location information for those guide robots that are on standby near the reception robot, the system was made to allow for flexible replacement of guide robot standby locations during operation.

5.2. Robot Operational Status Monitor and Notification

For a guide action, the guide robot performs the sequence of three tasks of pickup [Fig. 4(d)], navigation [Fig. 4(e)], and return [Fig. 4(f)], in order. The destination and method of operation vary with each task. When performing pickup, the robot moves to where the guest is, greets the guest, and informs the guest of the destination. While navigating, the robot uses the camera to recognize relative position of the guest, adjusting the speed of its autonomous navigation accordingly. The onboard screen displays the direction of turns making it easier for the guest to follow the robot. When the destination is reached, the robot informs of the arrival then greet the guest together with a farewell message. The robot returns to the standby location on its own.

At the point when the guide robot begins to guide a guest, the management system initiates the guide job monitoring sequence (Fig. 5). This monitors the progress of the task, and when execution has been completed, the system transmits the information needed for the next task. Instances of this monitoring sequence are generated only for the guide actions that are executed, so that it can save computing resources.

Contingencies or system trouble may occur during guide operations and prevent the robot from carrying out the operation. In such a case the management system would notify the system operator of the failure via monitoring terminal or email.

Within the management system, tasks are configured as task lists in JSON format. JSON allows for data to be added and expanded flexibly, so in principle, the system can be configured with tasks increased to any number. Each task is configured with the destination name, destination coordinates, task type, and so on (Fig. 6).

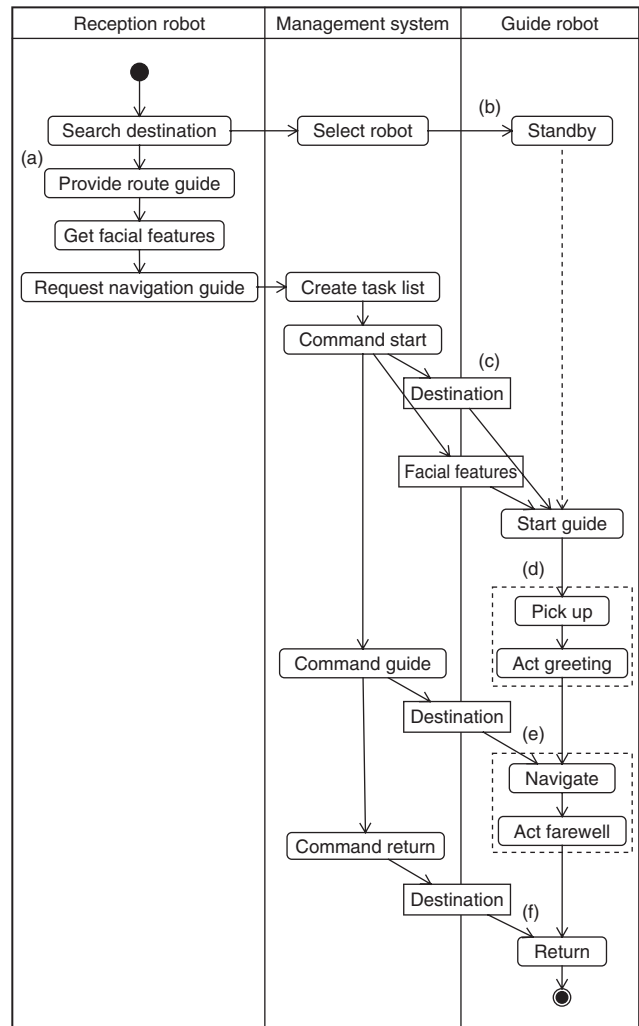


Fig. 4 Guide sequence

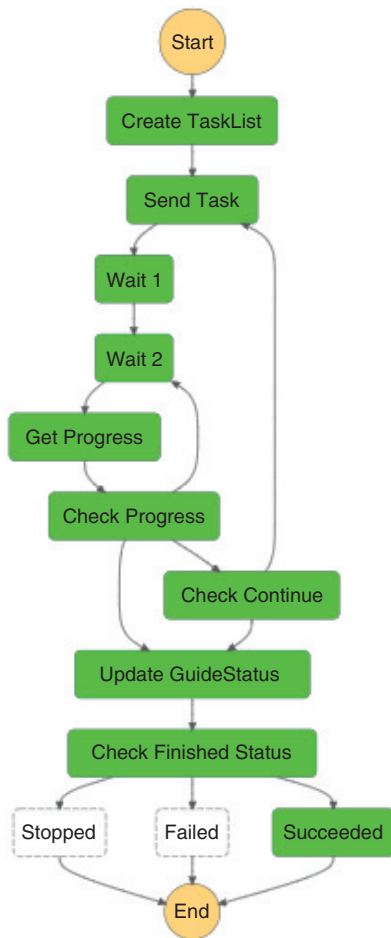


Fig. 5 Guide job monitoring sequence

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{
  "robotId": "xxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx",
  "taskList": {
    "Type": "GUIDE",
    "task": [
      {
        "id": 1,
        "type": "picking_up",
        "goal": {
          "name": "meeting_point1",
          "coordinate": [
            "3.11",
            "-4.67",
            "1.59"
          ]
        }
      },
      {
        "id": 2,
        "type": "guide",
        "goal": {
          "name": "McDonald's",
          "coordinate": [
            "-4.12",
            "6.67",
            "1.59"
          ]
        }
      }
    ]
  }
}

```

Fig. 6 Task list example

6. Results of the Trial with Actual Equipment

Confirmation of service envisioning guide services and using actual equipment was carried out at a certain public indoor facility which extends as far as 500 meters in each direction and include many tenants run businesses. New visitors to the facility may find it challenging to figure out what direction to take to reach their destination. Therefore, we concluded that there would be a demand for guide services provided by robots.

Testing of the management system was carried out to confirm whether the system performs guide job management and fleet management according to the design, whether the operational status of robots can be monitored by means of IoT communication, and so on.

No installation of dedicated server or networking infrastructure was needed to conduct the trial. The number of robots used was limited to one reception robot and two guide robots, since the objective of the trial was a confirmation of the system at the initial stage of operation.

We confirmed that the management system functions in the following manner during the testing.

- One appropriate robot would be selected from the two guide robots in accordance with the conditions for operational status and remaining battery charge.
- The transmission of destination and facial recognition data to the guide robot with appropriate timing and other such matters were confirmed. The guide robot recognized the guest correctly and performed the configured tasks of pickup, guidance, and return.
- Data was transmitted to and from the guide robot as it moved throughout the entire facility, and that the guide robot's movement information was updated without delay. Hence the monitoring of the robot and the transmission of commands could be carried out in a stable manner using IoT communications.

A screen capture from the operation monitoring terminal (Fig. 7) shows an example of how the trial of the management system had been conducted. The terminal displays the location and path of the robots on the floor map, together with the detailed status of the robots, including the battery voltage of each robot, and so on. From the observation, it was confirmed that the management system successfully monitor operational status of the robots. We have also confirmed that the system operator is notified properly whenever a trouble occurred to any robots.

From the above results, it was confirmed that the management system performs guide job management and fleet management according to the design, and that it is capable of monitoring the operational status of the robots by means of IoT communications.

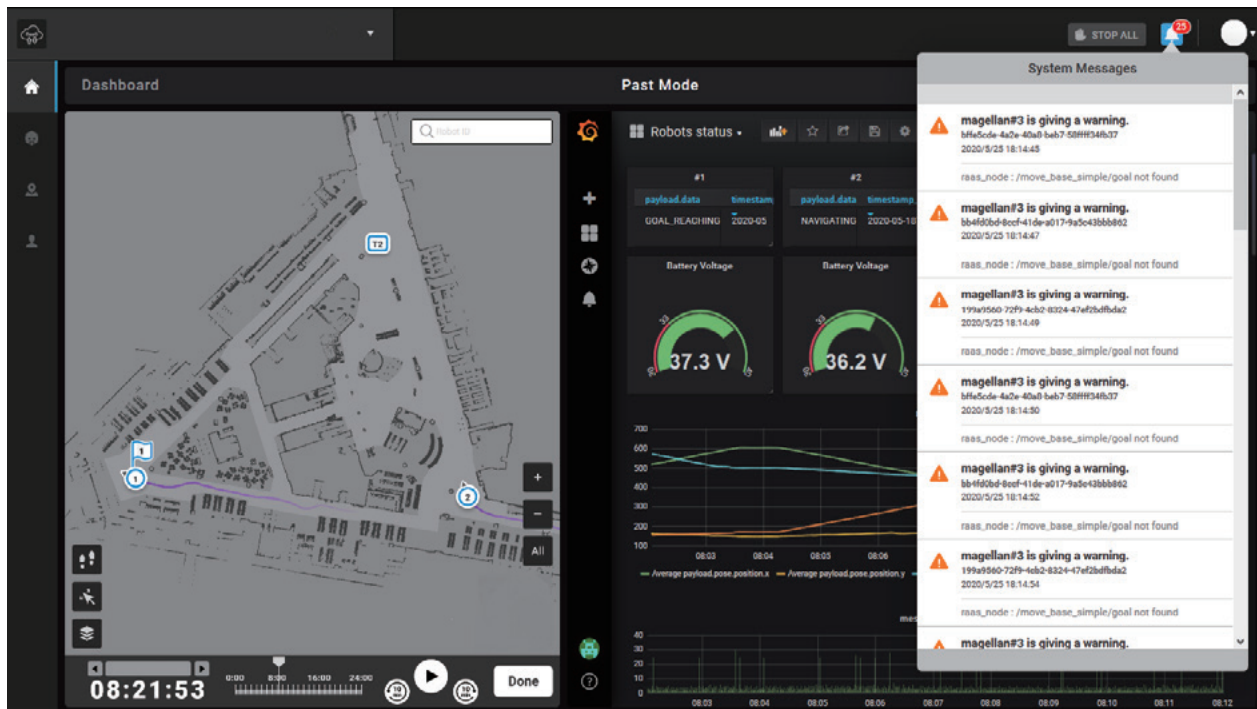


Fig. 7 Operation monitor

7. Conclusion

A guide robot management system was built to use the cloud and IoT communications. In order to realize guide services provided by robots, guide job management, fleet management, robot operational status monitoring, and other such functions were newly implemented, while also using the general-purpose functions of Honda RaaS. Tests were conducted using the actual equipment in a public facility, and it was confirmed that multiple units and types of robots operated appropriately while coordinating information by means of the management system.

Since there is no need to put dedicated servers or networking equipment in place on-site, there is no limitation on the robots' range of movement, and use of the robots can be initiated right away. The system is configured with general-purpose functions using cloud and IoT communications to which specific service functions are added. We believe that this method will be effective for the deployment of various different robotics services.

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