Design and Evaluation of Basic Exercise Environment for Virtual Laboratory

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ABSTRACT

In recent years, the integration of cyberspace and real space has been progressing at a rapid pace, and the benefits that cyberspace brings are extremely significant. It is an urgent issue for engineering education institutions to develop human resources who can play an active role in the era of paradigm shift brought about by cyberspace. In order to develop such human resources, it is most necessary to have educated personnel who can utilize physical space as well as cyberspace without wasting time. In this research, we created some virtual models of experimental equipment that can be used in experiments and practical training remotely as well as locally (CDIO Standard 6). We conducted an evaluation of the models by implementing them in the experimental classes of students of Mechanical Engineering (CDIO Standard 7). We found that majority of the students could learn from that model irrespective of their locations (local or remote) (CDIO Standard 7).

KEYWORDS

Engineering experiments, Digital twin, remote student experiments, Quality assurance in education
CDIO Standards: 6, 7

INTRODUCTION

In recent years, the integration of cyberspace and real space has been progressing at a rapid pace, and the benefits that cyberspace brings are extremely significant. Developing human resources who can play an active role in this era of paradigm shift brought about by cyberspace is an urgent issue for engineering educational institutions. In addition, For the development of such human resources, the most necessary is a person who has received an education that can utilize cyberspace while utilizing physical space without waste. In the industrial automation industry, design development by virtual commissioning based on digital twin models has begun. All this development work is done in virtual space. It is realistic to develop experimental/training teaching materials that apply these technologies and are not bound by time and space, but there are no such teaching materials yet. This teaching material uses a virtual model of the experimental equipment that is actually used in student experiments and training, and builds a remote training environment to play a part in the development of human resources who can respond to the paradigm shift. In the environment built with this teaching material, there are no time or space restrictions, so you can continue learning even in the event of an emergency such as a corona disaster or a natural disaster (CDIO Standard 6). Furthermore, even in normal times, educational institutions that train practical engineers cooperate with each other, making it a tool that can make the most of limited educational facilities.

SYSTEM OVERVIEW

Figure 1 shows the system of the teaching materials developed in the research. The feature is that the digital twin built on the actual machine and the PC can be connected via the Internet, and when connected, the same movement can be performed in real time. In places like college education, there is no need to prepare actual machines for the number of students, and in addition to being able to operate actual machines placed in remote locations, multiple educational institutions can share and use actual machines.

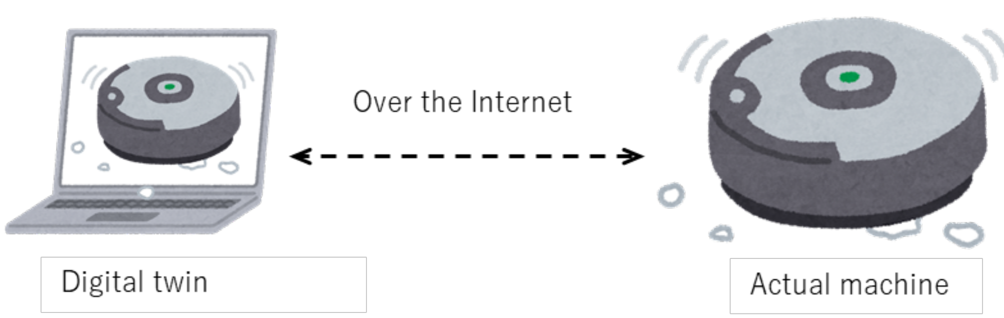

Figure 1. System overview

EQUIPMENT AND SOFTWARE

This teaching material consists of myAVG, an AVG (Automatic Guided Vehicle) manufactured by Elephant Robotics, and a general personal computer. myAVG is controlled by ROS installed on the Raspberry Pi 4 mounted there.

ROS is a distributed computing environment. The ROS Master provides naming and registration services to the rest of the node in the ROS system. A node is a unit of execution programming in Ros. Communication is done in a specific type called message, and communication between nodes is done through ropic. This communication is characterized by the fact that neither the sending side nor the receiving side needs to set the other party's information. Figure 2 shows the settings for a single PC.

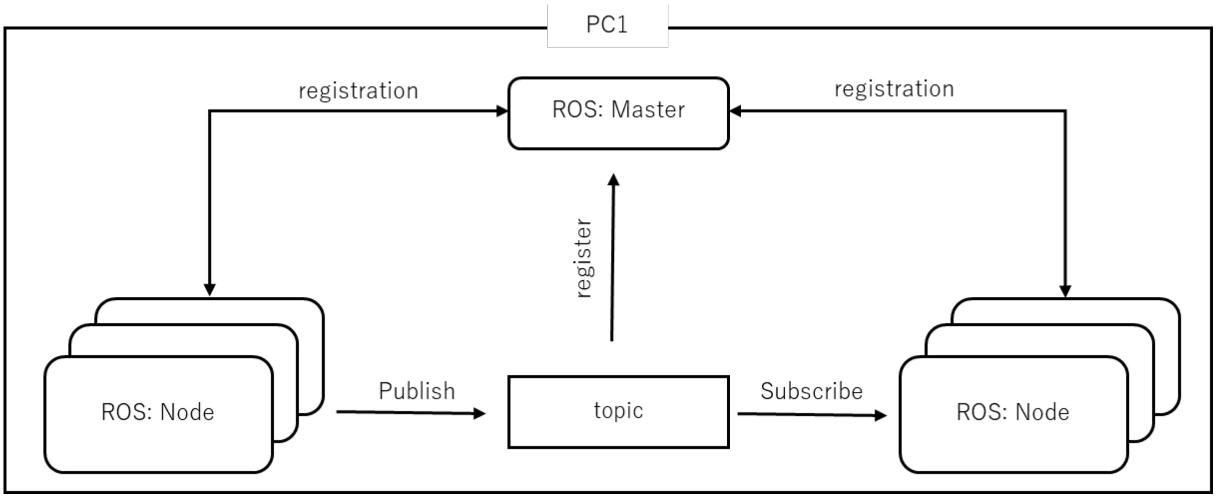

Figure 2. ROS communication outline

ROS also supports communication between heterogeneous devices. Communication between ROS nodes can be easily realized because it is possible to check the installation and operation of ROS regardless of the type of OS and programming language used. This indicates that it is possible to check a robot controlled by a PC with Ubuntu installed from a PC with a different OS, and to send commands to the robot.

Visualization in digital space is performed using RVIS. Therefore, the digital twin of myAGV, which is the actual machine used this time, is assumed to be created in URDF format. In addition, myAGV is equipped with LiDAR, and the numerical values measured by this device are also visualized.

VARIOUS SETTING METHODS

In this teaching material, node: publish on the raspberry Pi and node: subscribe on the PC must communicate via the Internet. This setting can be Ethernet or Wi-Fi. However, there is no problem if it is communication within the LAN, but communication over the Internet may be blocked because communication with many ports is required.

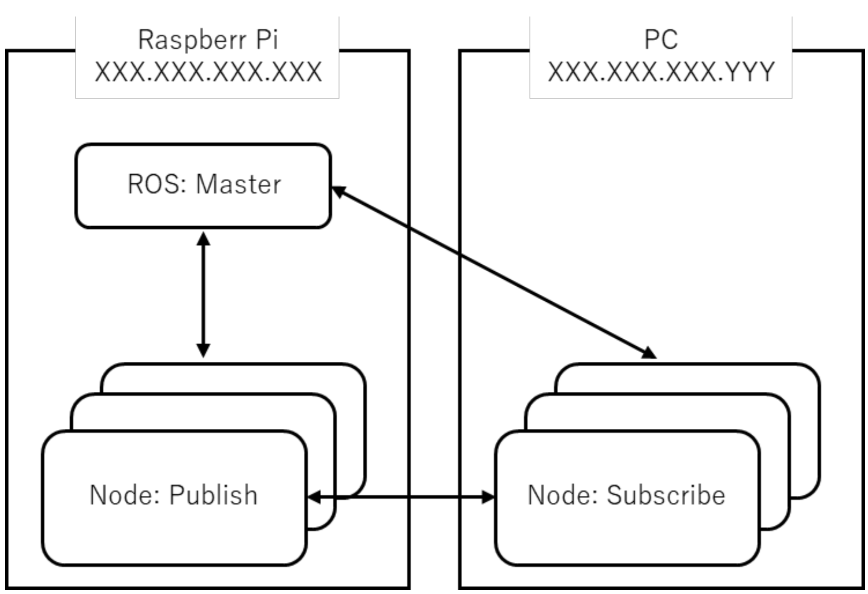

Figure 3. ROS communication outline in this material

Table 1 shows the topics that are communicated between the PC and the Raspberry Pi.

Table 1. Topics and its communication contents

topic	Communication content
/cmd_vel	Instruct robot movement
/gmapping/entropy	Estimate of the entropy of the distribution over the robot's pose
/initialpose	Initial positioning on Rviz
/joint_states	Joint State for each non-fixed joint in the robot
/map	Created map
/map_metadata	Receive the map metadata via this latched topic.
/map_updates	Local map updates for specific robot
/move_base_simple/goal	Robot target position
/odom	Odometry information
/point_cloud	Point Cloud data
/rosout	All node logs
/rosout_agg	Aggregated feed of messages published to /rosout
/scan	LIDAR scan data
/tf	Current transform tree.
/tf_static	static transform tree

CONCLUSION and FUTURE WORKS

It was possible to connect the actual machine and the digital twin built on the PC via Ethernet and operate the actual machine from the PC. It suggests that even if the equipment is not owned by the college to which you belong, if it is owned by another college, you can do experiments and training by connecting to the equipment via the Internet. This means that schools will be able to use equipment more effectively, and students will have more equipment to use. In the future, by setting Gazebo, which is a simulator, it will be possible to operate the actual machine and the digital twin model independently. In other words, it is possible to conduct sufficient experimental training with the digital twin even in an environment such as an online class where the actual device is not at hand. In addition, it is expected that the learning effect will be enhanced by operating the actual machine through the Internet as necessary. We would like to expand opportunities for students to handle more equipment, whether virtual or real.

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