Application Example of Integrated Data Acquisition System to Effect Evaluation of Labor-saving Agricultural Work by Introducing Assist Suit

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Abstract

In this paper, it is described the example of using the integrated data collection system developed by the authors in an evaluation demonstration experiment of the labor-saving effect of agricultural work by wearing an assist suit. The first author has been requested by Kumamoto Prefectural Agricultural Research Center Production Environment Research Institute to carry out the contracted research from December 2020 to March 2021. As part of the test research project "Evaluation of the effect of labor - saving agricultural work by introducing assist suits in Reiwa 2 (2020)", the degree of autonomic nerve activity and muscle activity are investigated using dedicated equipment, and to quantify the effect of labor - saving agricultural work by wearing an assist suit is the purpose. In order to evaluate the labor-saving effect, "stress evaluation by autonomic nerves", "reduction rate of muscle activity" and "motion analysis by a video" are required, and as measuring devices, heart rate sensor, EMG sensor, and video camera are used. However, since the various measuring instruments owned by the authors are separate systems, it is impossible to synchronously acquire the respective data. Therefore, it is very burdensome for the analyst to manually adjust the acquisition timing of each data after the experiment is completed, and it is difficult to perform perfect synchronization. Therefore, it is reported to be able to facilitate the acquisition of data for demonstration experiments by using the system the authors developed.

Keywords: Labor-saving agricultural work, Assist suit, Integrated data acquisition system.

1. Introduction

The mountainous area of Kumamoto Prefecture accounts for 37.5% of the cultivated land area and 45.0% of the agricultural land output and is an important area that supports agriculture in this prefecture. However, there are many agricultural lands with steep and narrow slopes, so agriculture The production conditions are unfavorable, and improvement of the farming environment is required.

From the above, it is necessary to popularize assist suits in order to reduce the burden on the body of farmers and improve work efficiency, and it is necessary to collect data on the functions of various suits in order to use them as selection materials for a suit introduction. This study uses 6 types of assist suits and asks about 5 subjects to perform movements during farm work, and measures the posture and movements, biological signal at that time. Since this is a simulated experiment, it does not impose any further physical or mental burden on the subject, and it is judged that its implementation is appropriate.

In order to evaluate the labor-saving effect, "stress evaluation by autonomic nerves", "reduction rate of muscle activity" and "motion analysis by a video" are required, and as measuring devices, heart rate sensor, EMG sensor, and video camera are used. However, since the various measuring instruments owned by the authors are separate systems, it is impossible to synchronously acquire the respective data. Therefore, it is very burdensome for the analyst to manually adjust the acquisition timing of each data after the experiment is completed, and it is difficult to perform perfect synchronization.

Previously, the authors developed a system with synchronization between sensors and sensor customizability according to the user's purpose⁽¹⁾. This system uses ROS1 (Robot Operating System 1) and one Raspberry Pi 4, and utilizes the feature of ROS1 that it is easy to introduce sensors related to robots. However, with respect to the

amount of data that increases with the use of multiple cameras and sensors, the performance shortage becomes noticeable with only one Raspberry Pi 4, and it is complicated while assuming data synchronization recording of multiple computers. We needed a system with a UI that could be used without any settings.

Therefore, the authors are developing a compact and highly expandable data synchronous collection system using multiple small computers using ROS2 and the GUI of that system. Unlike ROS1, ROS2 inherits the basic framework of ROS1 and is equipped with functions for industrial robots such as network design assuming multiple robots, communication quality control, and real-time control, in a real environment and it is a framework with improved reliability in operation⁽²⁾.

In this paper, it is reported to be able to facilitate the acquisition of data for demonstration experiments by using the system the authors developed. Chapter 2 outlines the integrated data collection system using ROS2 developed by the authors. Chapter 3 describes the outline of the test research project using the assist suit and the sensor used.

2. Used Data Acquisition System

2.1 Data Acquisition System Configuration

The overall configuration of the proposed system is shown in Fig.1.

This system consists of one or more Raspberry Pi 4, one M5 Stack Core2 to control Pi4, a camera and various sensors connected to Pi4 by USB, and a USB memory for data collection. Pi 4 and M5 Stack Core2 are connected to Wi-Fi. The Wi-Fi router needs to be connected to the Internet in order to acquire the time of the devices.

The Operating system of the proposed system is in the Micro SD card installed in the Raspberry Pi 4. The USB memory has a recording program, setting files for various sensors and Wi-Fi connections, and folders for saving acquired data and logs.

As the controller of the system, M5 Stack Core2 equipped with a small display and a microcomputer that can connect to Wi-Fi is used, and the user can operate Pi 4 and check the logs after starting data acquisition. There is the setting program in a Micro SD card.

2.2 Data Acquisition System Software Diagram

Next, the operation of the system will be explained using one Raspberry Pi 4 as an example. The green frame in

Fig. 1. Data acquisition system diagram.

Fig. 2. Software diagram.

Fig. 2 shows the operation order.

First, the operation of the controller will be explained. The controller starts by pressing the power switch on the left side and turns it off by pressing and holding for about 6 seconds. When it starts up, it first reads the information in the configuration file on the SD card and tries to connect to Wi-Fi. After connecting to Wi-Fi, gets the time from the

NTP server. Then, try to connect to Raspberry Pi 4 based on the IP address of Raspberry Pi 4 described in the configuration file. Once the connection is complete, recording can be started by performing a recording start/end operation. During operation, the scheduled start time is always sent and log data is received by the controller. Operation display of the controller is shown in Fig.3.

Fig. 3. Operation display of the controller.

Next, the operation of Raspberry Pi 4 will be explained. Raspberry Pi 4 starts automatically when a 5V power supply is applied. At present, the power is applied manually, but by creating a power supply system using relays, it can be started with a single switch. A shutdown of Raspberry Pi 4 is performed by pressing and holding the red switch of "Reboot / Shutdown button" in Fig. 2 for 5 seconds after starting the system. After Raspberry Pi 4 starts up, it reads the settings from the USB memory and sets Wi-Fi and each sensor. When all the settings are applied, launch the ROS2 recording program. This program receives the scheduled start time "/start_time" sent from the controller and the data sent from the sensor driver and sends the log "/log_at2" to the controller.

The recording start timing is determined by comparing the scheduled recording start time transmitted by the controller with the current time. When the user presses the start button of the controller, the update of the scheduled recording start time is stopped and recording is started. Also, the recording is ended by press the end button.

The save destination folders are divided for each sensor, and the video and CSV format save files are saved separately according to the recording start time. Fig. 4 shows the system connection.

3. Survey Commissioned Study

Since December 2020, we have been conducting

contract research from the Kumamoto Prefectural Agricultural Research Center to evaluate the labor-saving effect of assist suits.

The department to which the authors belong owns the multi-telemeter system WEB-9500 manufactured by Nihon Kohden and the optical motion analysis system FrameDIAS 6 manufactured by DKH, which can acquire EMG, heartbeats, and physical movement. However, these

Fig. 4. System connection example.

systems are separate systems, and the various acquired data must be synchronized manually.

Therefore, the data required for evaluation is acquired at the same time using the system described in Chapter 2.

3.1 Survey consignment content

A. Stress evaluation by autonomic nerves

(A-1) Measuring equipment:

Autonomic nerve balance analyzer:

(A-2) Objective:

Investigation of increase/decrease in the stress of workers due to wearing an assist suit.

B. Reduction rate of muscle activity

(B-1) Measuring equipment: Myoelectric electrometer

(B-2) Objective:

Investigation of muscle activity reduction rate and fatigue level by wearing an assist suit.

C. Motion analysis using camera

(C-1) Measurement equipment: Motion capture

(C-2) Objective:

Investigate differences in work efficiency, joint burden, and fatigue depending on whether or not an assist suit is worn.

3.2 Survey commissioned method

A. Test content (simulated work)

6 types of assist suits x Yes / No wearing (comparison) x 3 types of work x 10 minutes of work time or total weight

350 kg x 3 sets (5 minutes or more break between each work) x about 5 subjects

- **Work A:** Light work that involves movement in the middle waist (assuming management work)

- **Work B:** Heavy work involving movement (assuming harvest transportation)

- **Work C:** Loading luggage (350 kg) from the floor to the loading platform of a light truck (no movement)

* Load a 10 kg container 35 times. The rationale is that the maximum load capacity of a light truck is 350 kg. If all the participants in the experiment try to work on it and the continuous work is laborious, make appropriate adjustments such as reducing the load capacity.

B. Number of times: 2 to 3 days are required for each assist suit x 6 times.

Fig 5 shows the environment of survey commissioned study in this study.

(a) Work A:

(b) Work B:

(c) Work C:

Fig. 5. Survey commissioned study environment.

3.3 An example of experimental results using an integrated data collection system

Figure 6 shows the results of the two cameras when work A was performed.

From the result of Fig.6, it can be seen that synchronized images can be collected.

4. Conclusions

In this paper, we have described an example of using the integrated data collection system using ROS2 developed by the authors for an experiment to evaluate the effect of

(a) File name: output_video0_10hz_rpi0_1610614095.jpg

(b) File name: output_video0_10hz_rpi1_1610614095.jpg

Fig. 6. Operation display of the controller.

labor-saving agricultural work by introducing assist suits. By using the developed system, it has become possible to easily collect the synchronized data required for effect evaluation.

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In addition, it has been approved by the Ethics Review Committee for Research Involving Human Subjects at National Institute of Technology, Kumamoto College (approval number 2020-3).

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