Title:

Teaching Method using New Interfaces for Basic Control Education in Higher Education

Theme:

General Culture Course

Education of Control System

New Interface as a teaching material

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Abstract:

In “the control by the computer program” taught in university, the students are expected to master the control system which is consisted of actuators, sensors, interface and computer. But in real control system there are used many interfaces that students cannot recognize easily. In this study, a newfound, these factors easy to understand, physically separated and visualized interface has been developed by the authors. In addition, the authors have tested the interfaces above mentioned as a teaching material in the control education, and have confirmed the usefulness of the interfaces.

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1. Introduction

Control refers to an operation required for an object to be adapted for its certain purpose. In our control learning based on this definition, we'll provide instructions for Open-loop Control in introductory part by which control is performed through one-way flow from input signal to output signal without any effects on the input signal from output results as well as for Feedback Control in developing part where learning has been advanced, by which control is performed by restoring the signal, which has flown from input signal to output signal, to the original signal.

In the early stage of control learning performed in universities, learning materials are required, such as easy-to-understand programs, interface, actuator and sensor which operate on computers. LED is appropriate for actuator since it is capable of confirming operational state visually. It's because lighting-on and lighting-off of LED correspond to the program operation for turning LED ON/OFF without delay.

The authors considered that it is necessary to newly develop a simple-structured inexpensive interface and software to operate a control system that can make it easy for students to create programs (hereinafter referred to as "software for system operation") while considering the expandability of the control system.

This paper talks about the details of an interface and software for system operation as learning materials that enable teachers to conduct comprehensive instruction and the usefulness thereof.

2. Development of learning material for control systems

It must be clarified that hardware as ideal learning material has a computer, interface, actuator and sensor as its basic elements, functions that are essential to control systems. Therefore, this study decided to develop an interface that can simplify functions to make them physically independent, visualize and develop them from the implementation of open-loop control learning to feedback control learning [1] [2].

As the authors thought it desirable to develop software for system operation by which learners are able to easily create programs based on programming language with high general versatility, the authors have focused on Logo as a programming language to satisfy the condition.

Logo has such properties as; 1. it is not such a programming language as is confined to specific purpose, 2. therefore it has high description characteristic, 3. it is possible to create a procedure which is a handling process created by learners on their own as well as a new procedure by organizing primitives which have been mounted as reserved words, and 4. it is possible for learners to use procedures created by teachers if learners weren't able to achieve their goals. the authors believe Logo has adequate general versatility judging from linguistic properties mentioned above. In terms of easiness for program creation: 1. Logo is possible to utilize primitives and procedures as equivalent when creating a program; 2. it is possible to describe names of not only primitives but also procedures and variables in mother language; and 3. it may be said that it is adequately practical judging from such fact that procedure can be easily created.

From those described above, the authors have decided to develop software for system operation by using Logo-Writer in such a way that additional commands for control (hereinafter refers to as "additional commands") is created by a procedure allowing for learners to be able to understand in advance.

2.1 Development of interface

Since the interface should provide easy-to-understand functions and be versatile, it was developed in two parts; the Base configuration unit (Figures 1 and 2), which is an interface that only enables the information that each component of the control system has to be conveyed, as well as an applied interface, which can be expanded by increasing its functionality.

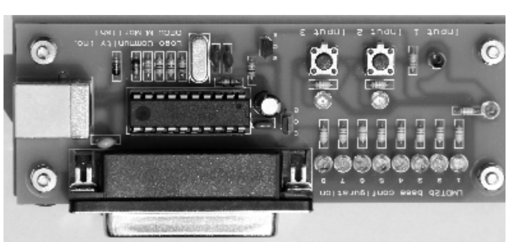


Figure.1. Base configuration unit

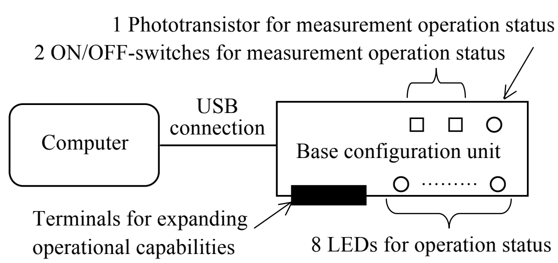


Figure.2. Base configuration unit connection diagram

The Base configuration unit was designed and developed considering the following 5 conditions:

1. Adopt a method of connecting the computer and the base configuration unit constantly by USB so that students will not have to work to transfer programs.
2. Create centering on ATtiny2313 by Atmel, which is a readily available and inexpensive one-chip microcomputer. ATtiny2313 has 11 controllable digital inputs/outputs and 8 of them are used to control the actuators and 3 of them are used for measurements from the sensors. The reason why the authors decided to use 8 digital inputs/outputs to control the actuators is to present an instructive opportunity which allows students to learn through experience that 8 bits have 256 kinds of decimal values.
3. Implement 8 LEDs for control and 2 on/off switches and 1 phototransistor for measurements so that validation can be conducted by the interface alone.
4. Supply the DC5V operating power source using USB bus power from the computer.
5. Ensure to implement terminals for function enhancement and supply signal transmission between the Motor control unit and the High voltage control unit and the DC5V operating power source. In addition, equip them with scalability so that various actuators and sensors can be connected.

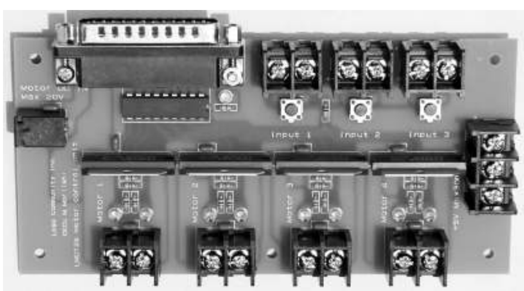


Figure.3.Motor control unit

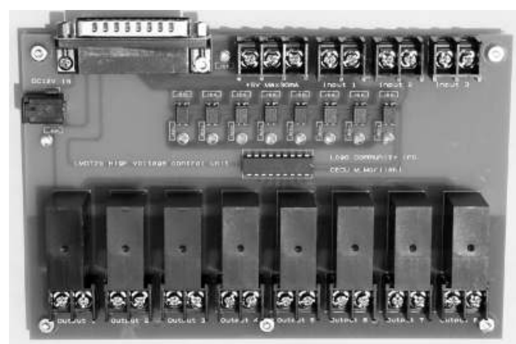
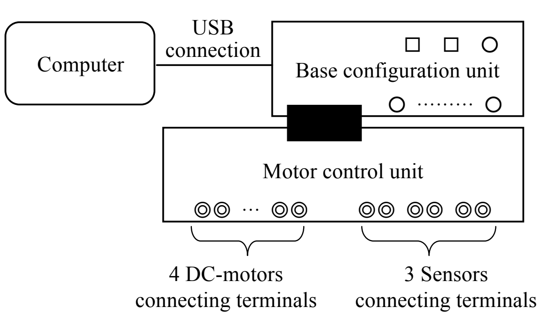


Figure.4.High voltage control unit

The applied interface is a Motor control unit (Figure 3) that can control the rotation in the normal and opposite directions and the stopping of 4 DC motors, and a High voltage control unit (Figure 4) that can control 8 actuators that require high voltage or large current using electromagnetic relays. In addition, connect the applied interface directly with the Base configuration unit using terminals for function enhancement (Figures 5 and 6).



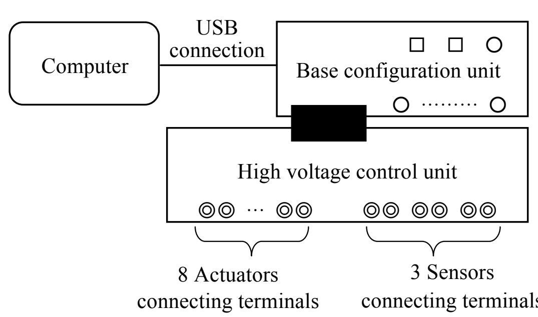


Figure.5. Motor control unit connection diagram **Figure.6.** High voltage control unit connection diagram

It is possible to control creations that have DC robot motors and line tracers, etc., as actuators by using this Motor control unit. In addition, it is possible to create simulators for street lamps that turn on when it is dark, etc., by using the High voltage control unit.

2.2 Development of software for system operation

Naming additional commands, which consist of software for system operation, in such a way that students are able to easily presume their functions as well as teachers to easily instruct students, we have decided to minimize the number of additional commands.

Primarily as additional commands for open-loop control learning, [lmdt_out], which controls the on/off state of electrical conduction to the actuators, and [lmdt_out_all_off], which turns off electrical conduction to all the actuators, were implemented (Figure 7). In addition, [lmdt_motion_time], which maintains the immediately preceding operating state on a secondary basis, was implemented. Furthermore, [lmdt_motor], which can rotate forward, backwards and stop the DC motors connected to the Motor control unit, was also implemented.

```
To LED_lighting_2sec_intervals
    lmdt_out 1 1 lmdt_motion_time 2
    lmdt_out 2 1 lmdt_motion_time 2
    lmdt_out 3 1 lmdt_motion_time 2
    lmdt_out 4 1 lmdt_motion_time 2
    lmdt_out 5 1 lmdt_motion_time 2
    lmdt_out 6 1 lmdt_motion_time 2
    lmdt_out 7 1 lmdt_motion_time 2
    lmdt_out 8 1 lmdt_motion_time 2
    lmdt_out_all_off
end
```

Figure.7. Example of Actuator controlling program

As additional commands for feedback control learning, [lmdt_sensor_switch], which determines the use of the sensors, and [lmdt_sensor?], which executes a procedure created beforehand when a sensor starts operating, were implemented as well.

The authors considered that while it is ultimately ideal to use the command mentioned later, [lmdt_measurement] for instruction on feedback control program creation, it is important to have students experience feedback control with simple programs without instructing them to create elaborate programs in the early stages of feedback control learning. This idea was realized in the following procedure (Figure 8): 1. Create in advance procedures such as [sensor_2_ON], which is executed when the sensor starts operating. 2. Have students create programs in the procedures for the actuators to function in accordance with the purpose. 3.

Have students create a recursion procedure and state [lmdt_sensor?] in it.

```
To SensorCar
        lmdt_sensor_switch 1
        lmdt_sensor?
        moving_forward
        SensorCar
end
to sensor_2_ON
        turn_right
end
to sensor_3_ON
        turn_left
end
to sensor_2&3_ON
        moving_backward
end
to moving_forward
        lmdt_motor 1 1 lmdt_motor 2 1
end
to moving_backward
        lmdt_motor 1 -1 lmdt_motor 2 -1
end
to turn_right
        lmdt_motor 1 -1 lmdt_motor 2 1
end
to turn_left
        lmdt_motor 1 1 lmdt_motor 2 -1
end
```

Figure.8. Example of Sensor-based program

As additional commands that conduct advanced control expansively, [lmdt_8bit], which controls the on/off state of electrical conduction to the actuators with 8-bit decimal notation and [lmdt_measurement], which merely assigns measurement results from the sensors to the variable [result], were implemented.

3. Evaluation of the learning material the authors developed

One of the authors (Moriishi) conducted training for students at this college using the interface and the software for system operation developed by the authors as learning material.

This training administered a pre-training questionnaire (15 items) and a post-training questionnaire (20 items) to First year class students (hereinafter referred to as “students”), and data on the usefulness of the learning material developed by the authors was obtained from the results. As the number of students had not reached the number of samples that would allow for statistical analysis because the number of all students was 15, however, the data was processed as categorical data.

Although the number of students who had an understanding of the functions of the interface before the training was 6, all the students answered that they understood the functions of the interface after the training (Table 1). As the introductory part of the training merely briefly explained the role of the interface, it can be inferred that the effects of the knowledge on the understanding of the functions of the interface gained in the training using the learning material developed by the authors is significant. It can further be concluded from this that it was observed that the functions of the interface developed by the authors are easy to understand. It can also be assumed that this result lead to the confidence of the students. All but one of the students answered before the training that they could not instruct another students to make them understand the functions of the interface, and after the training responded that they could (Table 2). It can be inferred from these results that the usefulness of the interface the authors developed was observed.

Table 1 Understanding functions of interface (number of students)

	Pre-questionnaire	Post-questionnaire
understandable	6	15
not understandable	5	0
Uncertain	4	0
Total	15	15

Table 2 Is it possible to make another students understand the interface functions? (number of students)

	Pre-questionnaire	Post-questionnaire
Yes	4	14
No	8	0
Uncertain	3	1
Total	15	15

Table 3 shows the answers obtained from the post-training questionnaire survey administered as to whether the students concluded that students could readily create programs to conduct control. It can be assumed that the students concluded that students could create programs readily when they instruct them, because they had an understanding from their experience in the training that open-loop control learning can merely be done by creating procedures and entering additional commands. However, it can be assumed that they concluded that the method of operating software for system operation for feedback control learning is somewhat more difficult than for open-loop control learning.

Table 3 Is it easy for another students to create programs? (number of students)

	Open-loop Control	Feedback Control
Yes	13	7
No	0	2
Uncertain	2	6
Total	15	15

It can be inferred from this result that the usefulness of the software for system operation developed by the authors was observed in open-loop control learning. The authors also think that feedback control learning still has room to be reconsidered.

4. Future challenges

As learning material to instruct on control education, the authors developed (i) an interface having easy-to-understand, physically independent functions with a strong focus on visualization and (ii) software for system operation in which additional commands for facilitating students' understanding were created in advance with procedures based on Logo-Writer. Furthermore, the usefulness of this learning material was able to obtain a certain reputation from students, albeit limited.

The authors are hoping to propose class designs that use this learning material and methods of grasping learning outcomes, etc., in the future.

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References

(1) Minekazu MORIISHI, Hirotaka UOI. (2008). *Teaching Material Development for the subject of Technical Arts and Home Economics for junior high school students to study "Control Management"*. Japanese Society for Information and Systems in Education. Proceedings of the 33th Annual Conference. pp.162-163

(2) Minekazu MORIISHI, Susumu KANEMUNE. (2009). *Teaching Material Development for the subject of Technical Arts and Home Economics for junior high school students to study "Control Management" Part2*. Japanese Society for Information and Systems in

Education. Proceedings of the 34th Annual Conference. pp.252-253