

Objective Evaluation of the Educational Effects on the Feedforward, Feedback and PID Control*

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Abstract

The aim of the present study is to improve the understanding of the control engineering for university students through the experience of the control experiment, and hence an experimental device is developed. The students are educated using the device, and the educational effect is evaluated. In the present study, the students take examinations for the control engineering before and after the experiment, and the effect is evaluated objectively.

Keywords: Control education, evaluation, feedforward, feedback, proportional, gain.

1. Introduction

In the engineering education, the control engineering is educated for the students who have taken mathematics, applied physics, mechanical engineering, electrical engineering and so on. The control engineering is not easy for students to understand intuitively only by the classroom lecture. Therefore, effective educational methods are demanded¹. To realize the class of the control engineering through an experience of the control experiment, experimental devices have been developed²⁻⁴. In the conventional studies^{3,4}, the educational effect is evaluated subjectively. On the other hand, in the present study, questionnaire is answered before and after the experiment, and the difference between the questionnaires. As a result, the educational effect is evaluated objectively.

2. Educational objective

The educational objective for developing an experimental device is that engineering students understand the following control actions:

- Manual control
- Automatic control
- Feedback control
- Feedforward control
- Proportional control

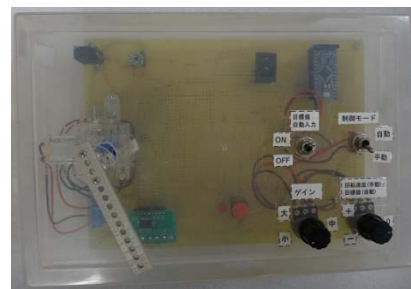


Fig. 1. Arm control device.

3. Experimental device

The developed experimental device is shown in Fig. 1. In the device, and its schematic diagram is illustrated as Fig. 2. In the device, the arm is rotated by a motor, and the control objective is to make the rotation angle of the arm be settled at the specified angle. In the manual control, the torque generated by the motor is changed by tuning a volume manually. In the automatic control, the rotation angle of the arm is measured, and the torque is decided by a computer using the measured angle.

Using the device, the students experience the control actions and can understand these meanings intuitively. The control actions implemented in the device are listed as follows:

- Manual control
 - Feedback control
 - Feedforward control
- Automatic feedback control
 - Small proportional gain
 - Middle proportional gain
 - Large proportional gain

4. Evaluation

To objectively evaluate whether the educational objective is achieved, the students answer the questionnaire shown in Table 1 before and after the experiment. The questionnaire consists of 19 questions, the correct answer rates are depicted in Fig. 3. In the figure, the blue bar shows the correct answer rate before the experiment, and the red bar shows after the

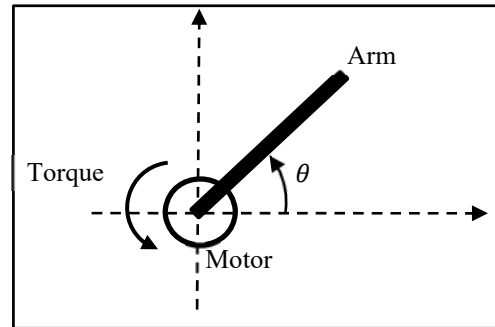


Fig. 2. Schematic diagram of the experimental device.

Table 1. Questionnaire before and after experiment

Term in control system	Question	Number in Figure 3
Manual control	Manipulated amount is decided by human	1
	Manipulated amount is decided by other than human	2
Automatic control	Manipulated amount is decided by human	3
	Manipulated amount is decided by other than human	4
Manual control vs automatic control	Manual control structure is simpler than automatic control	5
	automatic control structure is simpler than manual control	6
Feedback control	Stability can be improved	7
	Stability can be worsened	8
	Reference tracking performance can be improved	9
	Reference tracking performance can be worsened	10
Feedforward control	Stability can be improved	11
	Stability can be worsened	12
	Reference tracking performance can be improved	13
	Reference tracking performance can be worsened	14
Feedback control vs feedforward control	Feedforward control structure is simpler than feedback control	15
	Feedback control structure is simpler than feedforward control	16
Proportional control	Response speed can be improved	17
	Response speed can be worsened	18
	No steady-state error	19

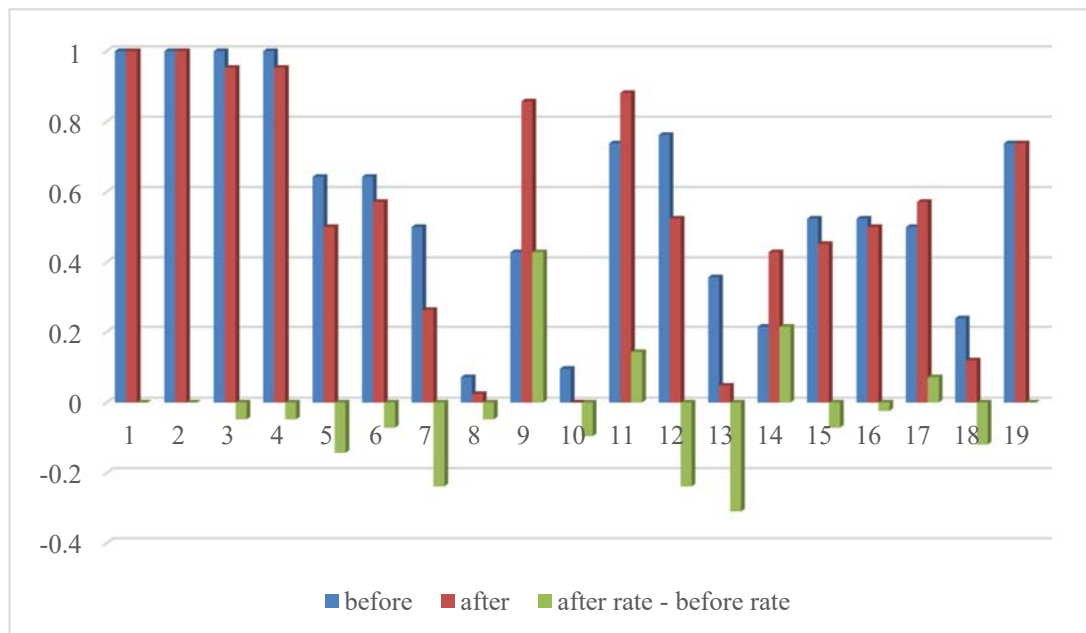


Figure 3. Correct answer rate before and after experiment

experiment. Further, the green bar shows the difference between the before and after experiments.

Fig. 3 shows that most of the students understand the mechanisms of the manual control and the automatic control and understand little about that the stability and the tracking performance can be worsened by the feedback control. Since the rates of Questions 9 and 14 of after experiment are increased compared with those before experiment, the number of the students who understand that the tracking performance can be improved and worsened by the feedback control and the feedforward control, respectively, is increased by experiencing the control experiment. On the other hand, from Questions 7, 12, and 13, the number of the students who misunderstand that the stability and tracking performance can be changed by the feedback control and the feedforward control.

5. Conclusion

In the present study, the educational effect using the experiment is evaluated objectively. A future work is to enhance the control engineering lesson to increase the correct answer rate after experiment.

Acknowledgment

This study was supported by JSPS KAKENHI Grant Number 16K06425.

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