

The Remote Laboratory Development for 21st Century Education: Case Study in Speed and Position Control DC Motor with PID

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Abstract. This research was aimed to design and create the remote laboratory development in speed and position control DC motor with PID and to design architectural use of Client-Server without PC-Experimental Device. This research was to create Server-Side Hardware consisting of two main parts including Control Unit/DAQ/Network and Experimental Devices by implementing Ni-MyRio as main controller. The study result was found that connection and controlling from client to server through Wi-Fi could be easily and convenient done. The test of remote speed and position control of DC motor with PID gave satisfactory result and learners were satisfied with such laboratory set at high to highest level.

I. INTRODUCTION

Technology directly influences necessity to develop new learning environment from the past till present as we could see from educational technology and instructional media development in the past. Since 1995, it has been the era of technological development such as television, projector leading to the research and development of educational technology, instructional media or laboratory involved with development of different animated pictures [1, 2]. Later in 1990s, it was the period of computer technology development; research and development would be related to educational technology in term of computer-assisted media. After that, when internet technology has been highly developed with advanced communication, educational technology would be about research and development through online channel. Currently, it's noticeable that education is developed as Massive Online Open Courses [3] and Big-data personalized learning [4] due to the advancement of technology and communication.

21st century education about engineering focuses on learners to have knowledge in main subjects and to be able to apply scientific, mathematical, engineering, designing, experimental and analytical knowledge in working with various duties in different contexts [5, 6]. Moreover, they should have ethical understanding and responsibility [7] with communication ability and should realize and understand impacts on the world and society as well as emphasize lifelong learning [8, 9] and pay attention to contemporary issues. In addition, they should be able to

use techniques, methods, skills, proficiency and modern instruments in engineering practices [5, 10].

Speaking of engineering education, learning and laboratory are extremely essential especially the creation of practical graduates and instructional process where learners have Hands-on Experience with instructional media and actual learning instruments which are one of the best learning processes. [11] In fact, price and sufficiency of instructional media and learning equipment are still limitations of most educational institutions.

With technological advancement and modern equipment necessary to learning in providing engineering education and interest in development of modern instructional media to solve the problem of instructional media inadequacy for in-class learning, the researcher conducted this research with objectives to design and create remote laboratory set of Client-Server without PC-Experimental Device architecture and test the developed remote laboratory set. This invention aimed to enable learners to access more experiments while the laboratory sets are limited and they can learn as same as using direct laboratory set as before because it is in the same learning environment as learners. This remote laboratory set would enhance opportunity to access more experiments through WI-FI systems and learners could study behaviors of real experiments as the original set.

II. LITERATURE REVIEW AND RELEVANT RESEARCH STUDIES

A. Remote laboratory

Remote Laboratory has been widely used for education purposes with many reasons such as unavailability of tools in physical laboratory when the physical space is not sufficient for laboratory set installation, limited access of students or even desire of the lecturer for learners to do remote experiment [12]. This also increases possibility of accessing scientific experiment and educational environment [13]. After doing literature review, the researcher could summarize that the laboratory

could be considered in three aspects including 1) physical aspect which were real situation and simulation.

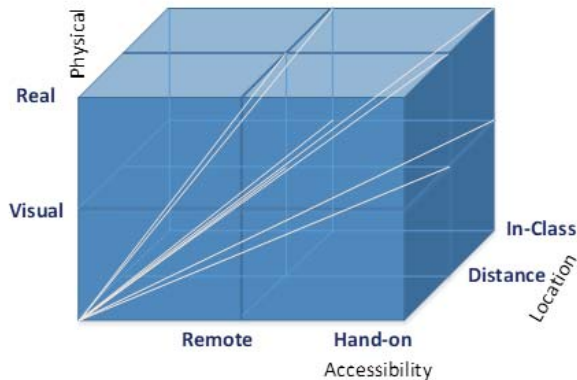


Figure 1: Laboratory characteristic

2) Consideration by accessibility which could be divided as direct access and remote access and 3) Consideration by location of the laboratory which could be categorized as remote location and location inside the laboratory. The researcher has summarized previously mentioned data in figure 1. Length of aspect line of each laboratory set indicated impacts on learning of learners by types of the laboratory such as real laboratory where learners could directly access and equipment was installed in class as the laboratory that affected learning most. Therefore, the aspect line was longest as shown in figure 1.

B. Architecture of Remote Laboratory

Martin et al [13] examined and divided architecture of remote laboratory as 5 following formats

1) Architecture of Client-Server with Control Software-Experimental Device: the structure of this architecture consisted of parts of client and server with control software directly connected with experimental devices.

2) Architecture of Client-Server with Control Software-Data Acquisition (DAQ) Device-Experimental Device: this format comprised parts of client and server with control software connected with experimental devices though data acquisition (DAQ)

3) Architecture of Client-Proxy Server-Control PC-Experimental Device: this format contained parts of client and proxy server with control software connected with computer or control equipment directly connected with sub-laboratory set. This architecture would be multi-experimental system and the proxy server controlled access of each experimental set. [14]

4) Architecture of Client-Server with SCADA System Control Unit-Experimental Device: the structure of this

format consist of parts of client and server in SCADA type connected with unit control like PLC and experimental devices.

5) Architecture of Client-Server PC/ Microcomputer Programmable Electronic Board-Experimental Device: the structure of this format would be Low-cost model comprising parts of client and server that could be PC or Single board computer connected with experimental devices through micro-controller board or FPGA.

III. METHODOLOGY

A. Architecture of Remote laboratory Design

Architecture of Remote laboratory proposed by the researcher in this article was different from aforementioned five formats. The structure of this architecture contained parts of client and server directly connected with experimental devices and server-controlling computer is not necessarily required. It can be referred as to Client - Server without PC- Experimental Device as shown in figure 2.

B. Remote laboratory Development

Remote laboratory proposed by the researcher is a laboratory set for learning of control engineering about speed and position control of DC motor. This architecture was shown in figure 3- the parts designed and created by the researcher were Server-Side Hardware consisting of two main parts including Control Unit/DAQ/Network and Experimental Devices.

1) Control Unit/DAQ/Network was main controller of Remote Laboratory. The researcher selected Ni-MyRio as a controller which had 3 functions such as 1) transmitting signal as network to communicate with Client through WI-FI; in this part, it would be set up once through Ni Max Program to determine parameters and password to access the system 2) receiving and sent data (DAQ) to contact with Experimental Device which could be applied with both analog and digital system and 3) controlling experiment by programming through LabVIEW and Downloading it to such controller through WI-FI System as shown in figure 2.

2) Experimental devices were designed according to the objectives of this research that needed to create instructional media about speed and position control of DC motor with PID. This experimental device was designed by the researcher as 3 panels consisting of power supply panel, motor speed control panel and motor position control panel as shown in figure 2.

C. Remote Laboratory Test

To assess remote laboratory, Dominik May et al[15] stated that it could be done in 3 ways 1) assessing learning process of learners in laboratory environment 2) assessing technical characteristics of the laboratory set and 3) assessing curriculum context that incorporated such laboratory set with the courses. As the research and development was in initial stage, the second guideline, assessing technical characteristics of the laboratory set, was selected. To test the laboratory set, the researcher designed two main parts of the test as follows.

1) Testing the connection and remote control could be done by preparing the laboratory set in server part containing Ni-MyRio panel, Motor Encoder panel and Power Supply panel circuited with the experimental devices and opening Wi-Fi connection of Ni-MyRio panel as shown in figure 3 A). After that, in client part, any computer in the laboratory was used to connect Wi-Fi with Ni-MyRio. After the connection was complete, the contact could be checked as shown in figure 3 B)

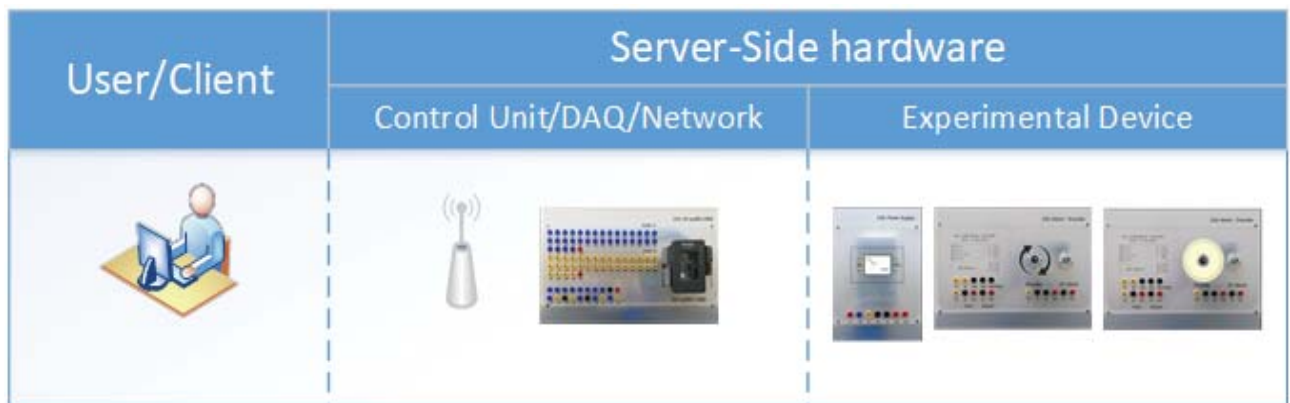


Figure 2: Architecture of Remote laboratory Client - Server without PC- Experimental Device

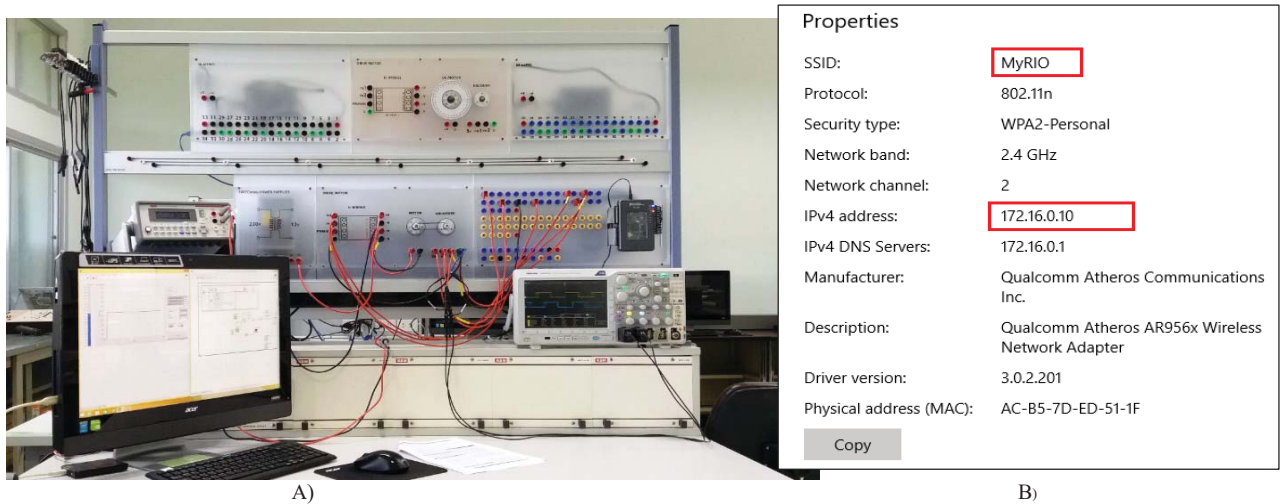


Figure 3 A) Function test of Remote Laboratory B) Connection with Remote Lab

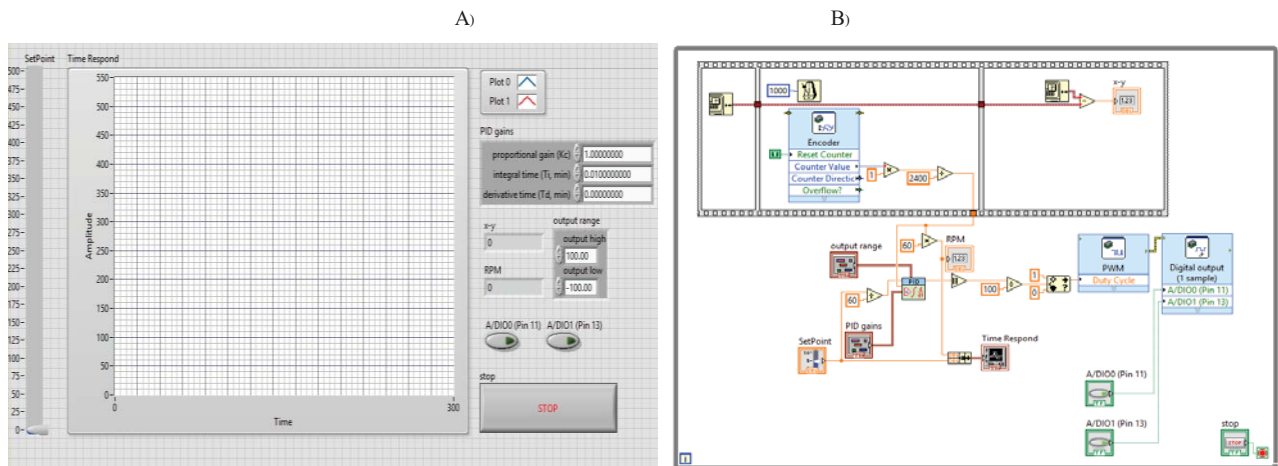


Figure 4: Result of control testing with PID A) Front Panel B) Block Diagram

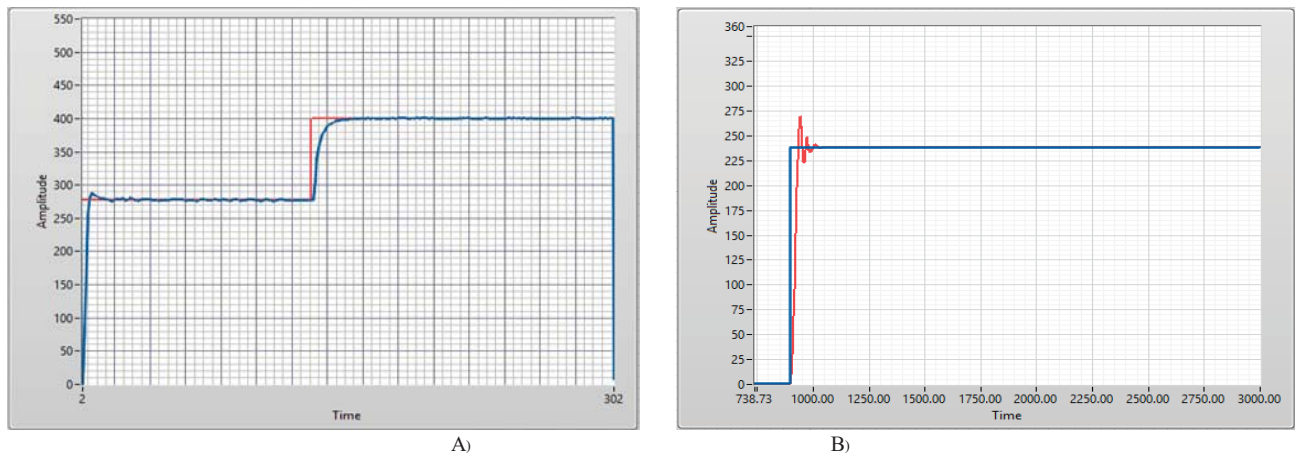


Figure 5: The result of testing control with PID A) Speed control B) Position Control

2) Testing remote speed and position control with PID, the researcher conducted it by programming speed and position control program with PID by employing LabVIEW as the component of Front Panel and Block Diagram as shown in figure 4.

IV. RESULT

A. Remote Laboratory Testing Result

The result of testing remote connection and control was found that the client part in same leaning environment as the server part could be easily connected through Wi-Fi System. In addition, it indicated that when the connection was completed, the control program could be set and downloaded in control unit conveniently as same as connection through USB and there was no disconnection event during use.

The test of remote speed and position control of DC motor with PID was aimed to test if controlling could be normally functioned. The researcher programmed it to control speed and position of DC motor with Trial and

Error by testing controlling. The result of controlling speed of DC motor showed that when Gain, K_p , K_i , K_d were properly set, the system could give satisfactory response as shown in figure 5 A) with overshoot not over 5% and steady state error less than 1% which was acceptable. According to figure 5 B), it showed the position control of DC motor with less than 1% steady state and slight overshoot depending on gain estimation.

B. Learner's satisfaction

The first try out a remote laboratory was conducted to 15 learners to test its operation and efficiency. The result was found that the learners were satisfied with such laboratory set at high to highest level as shown in table 1.

V. CONCLUSION

This research was to design and create remote laboratory with objectives to enhance opportunity of learners to access more experiments through Wi-Fi system. It also examined behaviors of real experiment as same as original one because the laboratory was in the same

learning environment as learners. For the creation, the researcher applied architecture of Client Server without PC- Experimental Device making the Laboratory small and cheap. The test result was found that remote connection and control could be easily and conveniently done. The test result of speed and position control of DC motor was satisfactory and learners were pleased with such laboratory at high to highest level.

TABLE I
Learner's satisfaction

| Question | Mean |
|--|------|
| Remote Laboratory helps develop problem-solving skill | 4.20 |
| Remote Laboratory enables learners to access more experiments | 4.53 |
| Remote Laboratory helps promote understanding in lessons | 4.40 |
| Using Remote Laboratory is easy and convenient | 4.13 |
| Remote Laboratory helps learners to understand usage in real condition | 4.67 |
| It promotes learning exchange among learners | 4.47 |
| It promotes 21st century skill development | 4.40 |
| It enables learners to understand and use modern equipment | 4.53 |
| It gives clear experimental result and promotes understanding in lessons | 4.13 |

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