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COMPUTER BASED NON TRADITIONAL CONTROL SYSTEM COURSE TEACHING IN INDONESIA ELECTRONICS ENGINEERING POLYTECHNICS EDUCATION

Ekojono
Department of Information Technology, Politeknik Negeri Malang, Malang, Indonesia
ekojono@polinema.ac.id

Andriani Parastiwi
Department of Electronics Engineering, Politeknik Negeri Malang, Malang, Indonesia
parastiwi@polinema.ac.id

Cahya Rahmad
Department of Information Technology, Politeknik Negeri Malang, Malang, Indonesia
cahyarahmad@polinema.ac.id

Anugrah Nur Rahmanto
Department of Information Technology, Politeknik Negeri Malang, Malang, Indonesia
anugrahnur@polinema.ac.id

Abstract

Visual simulation is expected to provide simulation results with a view that allows the students to see and feel like doing the practice of creating a control system. Software control system simulation applications are expected not only easy to use but also interactive to the needs of the computer specifications used are not too sophisticated. In this study the computer based control system course teaching was designed using the combination of an electronics control plant and control system simulation which is called nontraditional control system course teaching. The modelling simulation software application is a solution to see the performance of the controlled system which was developed to implement a control system which is light and easy-to-operate.

Spreadsheets can be used to simulate the electronics controlled plant in the development of linear control system which is easy to operate with minimum computer specification that can be used by students. The result of proposed simulation confirms the well-known PID controller effects, and verified by the response of the real DC motor speed electronics control plant developed and can be used as a visual simulation for students of electronics engineering polytechnics students. Modeling simulations to visualize the performance of electronics control circuits are used to overcome the limitations of resources in the laboratory on the administration of polytechnic education in Indonesia. In its implementation in the laboratory, lecturers are encouraged to improve the spreadsheet programming capabilities. The development of this study is that non-traditional electronic control teaching can be implemented through internet of things and cloud computing.

Keywords

Control System, Electronics Engineering, Polytechnics Education, Simulation, Spreadsheet

1. Introduction

Indonesia's population in July 2017 amounted to more than 263 million people living in 17,500 islands where 17% of them are aged between 15-24 years old which is the age of entering the labor market. Based on Indonesia Central Statistics Agency that from 7.56 million of open unemployment, 21% are vocational school graduates. In terms of age, the number of unemployed people at the age of 15-19 reached 23% in 2010 raise to 31% in 2015. These statistics show that the vocational education system in Indonesia needs to be carefully reoriented. Reorientation of the Indonesia vocational education can be done in the term of institution development, teachers and staff development, as well as in learning process. The regulation of Indonesia vocational education system has been arranged in Education Act No. 20/2003 where the providers of higher vocational education are academies and polytechnics. Polytechnic has over Diploma 1 to Diploma4, Specialist Program1, and Specialist Program2. The number of Indonesia state polytechnic is 39 and the number of private polytechnic is 1034.

Polytechnic is a vocational' higher education institutions that provide professional skills and diploma degrees and the Indonesia Government turns to polytechnics to boost skilled workers (Omposunggu, 2017). The quality control of higher education institutions is run through an external and internal accreditation system in Indonesia. This is one of the thing to be considered in building a good ideal curriculum. In the Polytechnics Education curriculum in

Indonesia, all courses are presented in a package system where students must take all courses presented in a semester. This makes the student has a heavy burden, because failing in one course will make it not pass in that semester. This makes heavy loads both for students and for lecturers. Lecturers must be able to choose the appropriate method of learning delivery for the course with the existing resources of laboratory equipment. However, the limitation of the resources and large number of courses in laboratories make the commencement of engineering polytechnics education costly.

Courses composition of 55% practical courses in laboratories and in workshop and the remaining 45% theoretical courses for Indonesia Polytechnics Curriculum implementation has several argumentations. There is an increasing awareness among the polytechnics educators that polytechnics students need more practice in laboratories than theory in classes. One of the argumentation is that theory important and good, but real practice provides motivation and contributes greatly to the success of learning. Real practice is widely applied in the field of engineering science but this method requires a large cost, because the error of designing the system will be fatal and the process must be repeated until the resulting product with the appropriate specifications. Similarly, for the process of creating control systems in a plant, simulation software applications are a solution to see the performance of control systems designed before the plant is developed.

Software control system simulation applications available on the market such as FluidSIM, Automation Studio, MathLab, and many others can be obtained with expensive prices and high specifications of computer hardware. To be able to use the software required a long training for a particular plant. This makes it difficult for researchers in the system control field and also students who need to learn the implementation of a control system that wants a light and easy-to-operate simulation software application. Visual simulation is expected to provide simulation results with a view that allows the students to see and feel like doing the practice of creating a control system.

Software control system simulation applications are expected not only easy to use but also interactive to the needs of the computer specifications used are not too sophisticated. In this study the computer based control system course teaching was designed using the combination of electronics controlled plant and control system modelling simulation which is called nontraditional control system course teaching.

2. Objectives of the Study

The objectives of this study are: designing electronics controlled plant to be used in teaching non-traditional control system computer based course; and designing a modelling simulation program application to visualize electronics circuit control to be used in teaching non-traditional control system computer based course.

The main practical aspects of control system course which is one of the electronics vocational courses in electronics engineering polytechnics education using Arduino Uno and spreadsheet are presented through one motor control example. We propose a new computer based teaching using non-traditional control system simulation that better fits the need of students in electronics engineering polytechnics vocational course without adding an expensive hardware and software.

3. Literature Review

The three most important factors affecting the quality of engineering education are finance, faculty, and lack of standardization (Mishra, 2017). In order to increase the quality of engineering education, the strengthening program in engineering education by student exchange program, internship in local business and industries, optimize the study time of the students were introduced (Tinajero & Pérez-Fragoso, 2015). However, curriculum planners were urged to recognize global needs as well as to develop curricula for today's learners (Felicia & Innocent, 2017). On the other side, most companies now prefer to hire graduates who have both hard skills and soft skills while the students realize that soft skills are important for education and the future of their work (Ramlan & Ngah, 2015). Educational engineering institution and students both realize that emotional intelligence is very important in a professional life where the acknowledgement of emotions and expressions improves the physical skills, thoroughness, wisdom, and politeness that can create a good working attitude that will improve the workplace environment (Susan Tee Suan & Yusoff, 2017). Other considerations, such as the complexity of the newest technology and diversity in technology applications in society call for a new approach to undergraduate engineering education adding the problem of the quality of engineering education (Katenberg, Hauser-Kastenberg, & Norris, 2006).

In engineering education, there is usually lectures in the classrooms, whereas some courses are done in laboratories. For courses in the laboratories, a lecturer should be able to choose the appropriate teaching method in accordance with the availability of existing equipment. However, limited resources in the laboratory make the provision of polytechnic education to be expensive. Therefore, the use of a simulation program is one of the cheaper solution. However, the success of a simulation program is measured by effectiveness, complexity, cost, and the main one is its ability to describe the problem (El-Hajj, Kabalan, & Khoury, 2000).

In addition, the control system simulation application program should follow the current trend in which real time control systems over the internet with real-time are widely implemented in the industry (Blaho, Bielko, Farkas, & Fodrek, 2014). Also included is the tendency to utilize distributed control systems by using DCS (distributed control system) in process control and monitoring in industry (Winn, Tun, & Mon, 2012). Distributed control systems are widely applied using multiple sensors and actuators which use both on-wire and wireless communications networks (Schwartz, Mulder, Trent, & Atkins, 2010). The purpose of providing a control system in a plant is to improve the performance of the system with the addition of sensors, processors and actuators. The sensor measures various signals on the system and the operator gives commands to the processor to process the measured signal and move the actuator that changes the condition of the system as seen in Figure 1. The disturbances signal will affect the system to be controlled, hence change the value of the sensor signals. These sensed signals combined with command signals as operator inputs will be processed by control processor to provide controlled actuator signals which is can also be displayed as warning indicators. This Figure 1 shows control system architecture which can be applied in various plans such as a plane, a power plant, a distribution system, and so on.

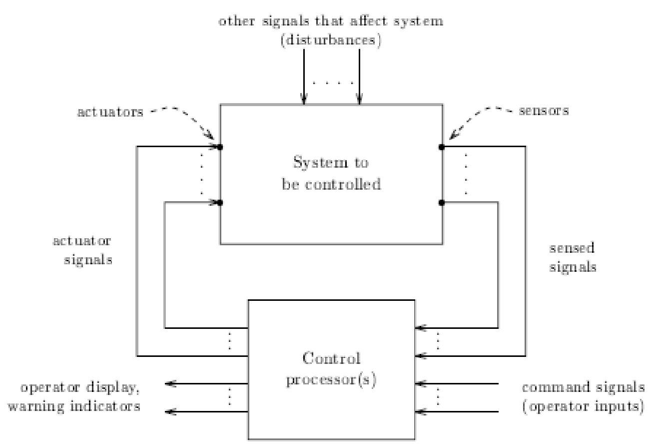

Figure 1: *General Control System Architecture (Sommerville, 2008)*

Control signals can be transmitted analogue or digital using electrical, mechanical, pneumatic, or hydraulic signals. Processors can also be mechanical, pneumatic, hydraulic, analog, and so forth. Since the sensor signal can affect the controlled system, in Figure 1 the system is called a feedback or closed loop control system that shows the signal loop indicated clockwise. Conversely, a non-sensory control system is usually called an open-loop system, just like a system that does not have an actuator called a monitoring system (Sommerville, 2008).

The linear control system uses negative feedback to produce control signals based on variables, with little maintenance of the control process in the desired range of operations. The output from the linear control system becomes a control process in the form of a direct variable signal, such as a valve that opens 0% to 100%. Sometimes this is not feasible so after the calculation, the linear control system will repeatedly turn on the actuator, such as a pump, motor, or heater to be full and off on full, by arranging pulse width modulator (PWM). Minimum system such as Arduino Uno can be used as a PWM in addition to use it as a controller. The Arduino Uno is used to store the control strategy, PID algorithms, and to communicate with the PC (through COM port). The computer should have a program which can read the data from COM port and processed the data into the desired forms. The program used in this study is spreadsheet.

A modern electronic spreadsheet provides good formulation functions in which cells interact, allowing automated computations, and thus making the spreadsheet an excellent modeling and simulation tool for other fields (Ang, Chong, & Li, 2005). System simulation is a helpful tool to manage the complexity of representing systems and the performance. Spreadsheet is a basic software package available in almost all institutions. They are easy to learn, allow step by step study of the behavior of a system and the influence of changing one or more parameters related to this behavior, are equipped with graphical display tools, and do not require much programming effort (El-Hajj et al., 2000). In these circumstances, computer simulations can provide insight into the fundamental concepts and offer a valuable instrument to facilitate learning (Aliane, 2008).

4. Materials & Methods

The development of spreadsheet simulation modelling is to provide learning tool that enables students focus on control system concept rather than on programming. The simulation is intended to be interactive so that it allow users to vary parameter values and see the effects and behavior of the proposed system. In this study, electronics controlled plant is modelled by finding the transfer function, and then a PID tuning of DC motor speed control is simulated in spreadsheet.

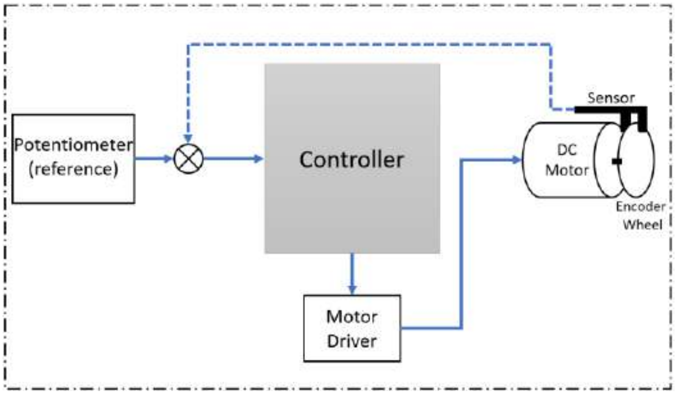

Figure 2: *Electronics Controlled Plant Block Diagram*

The modelling simulation to visualize electronics circuit control in this study is demonstrated by motor speed control using PID controller. Speed control means a deliberate change of drive speed of the value required to perform a specific work process. Speed control is a different concept of speed regulation where there is a natural change in speed due to changes in load on the shaft. The speed control is done manually by the operator or with some automatic controls. One important feature of DC motor is its speed can be controlled with relative ease. DC motor speed can be varied by changing terminal voltage of the armature V, external resistance in armature circuit Ra, and flux per pole φ. In this study, the parameter that is used to control the DC motor speed is terminal voltage.

The block diagram of electronics controlled plant developed in this study is included in Figure 2. The controller used is Arduino Uno, and the motor controlled is DC motor type DCS-30AE05FA. Table 1 listed the components used in electronics controlled plant design.

Table 1: *List of Components in Electronics Controlled Plant Design*

No	*Item*	*Unit*	*Type*
1.	Arduino	1	Uno
2.	DC Motor	1	DCS-30AE05FA
3.	Motor Driver	1	L298
4.	Encoder Wheel	1	20 holes
5.	Speed Sensor	1	LM 393
6.	Potensio	1	10K
7.	Power Supply	1	12 V

5. Discussion

The computer based non-traditional control system course teaching is a teaching method using electronics controlled plant combined with a modelling simulation in a PC. The electronics controlled plant is a plant as real world practice control system to be observed, which will provide motivation and contributes the success of learning. In this study, electronics controlled plant has been developed to use in control system course in Electronics Engineering Politeknik Negeri Malang Indonesia. The developed electronics controlled plant has been simulated in spreadsheet. Figure 3 shows the breadboard schematic of the electronics controlled plant proposed. The DC motor used is DCS-30AE05FA, with max rpm is 6500 rpm. To measure the speed of the motor, an encoder wheel with 20 holes was used. The speed sensor used is LM393 as a motor speed sensor the major goal is to check the rate of a motor. The minimum system use is Arduino Uno can be used with this speed sensor for motor speed detection by counting the events for a given period of time and then simply dividing the number of events by the time to get the rate. The rate is how many rotations the motor per minutes (RPM). The calculation of the rate can be seen in Figure 3.

```
void timerIsr()
{
  Timer1.detachInterrupt();  //stop the timer
  Serial.print("Motor Speed: ");
  int rotation = (counter / 20);  // divide by number of holes in Disc
  Serial.print(rotation,DEC);
  Serial.println(" Rotation per seconds");
  counter=0;  //  reset counter to zero
  Timer1.attachInterrupt( timerIsr );  //enable the timer
}
```

Figure 3: *Program to Calculate the Rpm of the Motor*

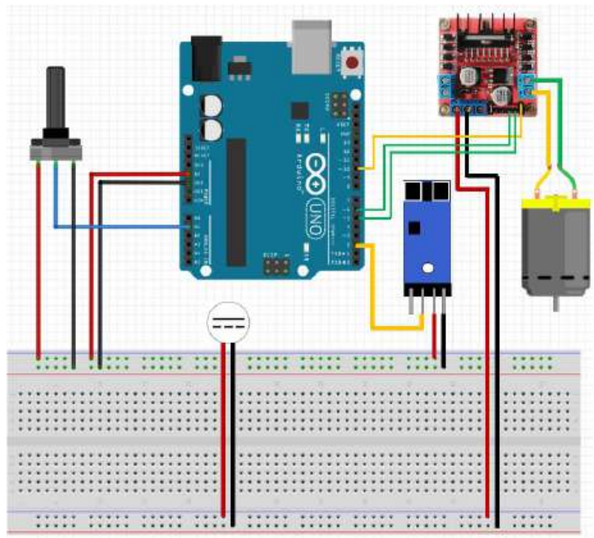

Figure 4: *Breadboard Schematic of Electronics Controlled Plant*

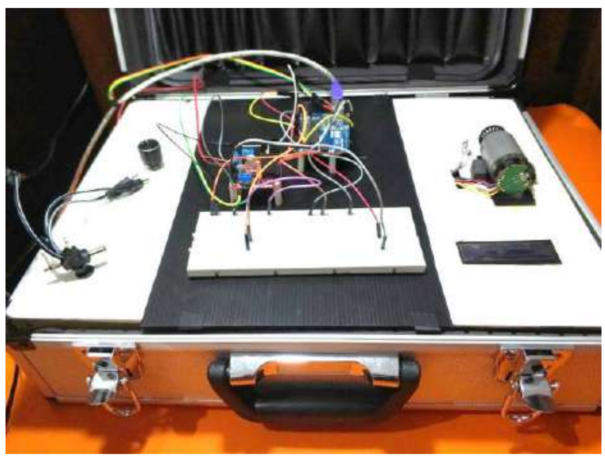

Figure 5: *DC Motor Speed Electronics controlled Plant*

The motor speed and setpoint can be monitored via PC (Personal Computer), while changing the PID constants tuning in PC to get the response to a set point change. The wheel passes through a photo interrupter to create a digital signal that was read by Arduino Uno as seen in breadboard schematic in Figure 4 and the DC motor speed controller plant in Figure 5. Figure 4 shows that the Arduino then obtain the speed of DC motor and compare it with setpoint given by potentiometer. This resulted in Arduino giving command to motor driver to adjust motor input voltage according to PID settings. The performance of a PID control of a DC motor are output response, minimum settling time, and minimum overshoot for speed demand application of DC motor (Meshram & Kanojiya, 2012).

Figures 6 show the example result of speed response using PID controller. First, only Kp is introduced, without Ki and Kd. The response in figure 6 shows that the steady state error is significant there.

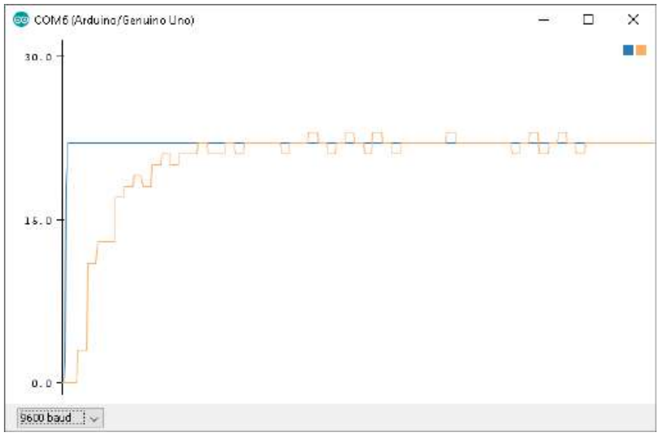

Figure 6: *Response of Speed Control with Kp=1, Ki=1, Kd=0*

Figure 6 shows the response of reducing Kp, increasing Ki, and reducing Kd to zero. This resulted in a well tuned system, with no overshoot and no steady state error. Spreadsheet simulation has been created to model the plant proposed in this study. Students can change the parameters in spreadsheet simulation to figure out the effects and behavior of the control system.

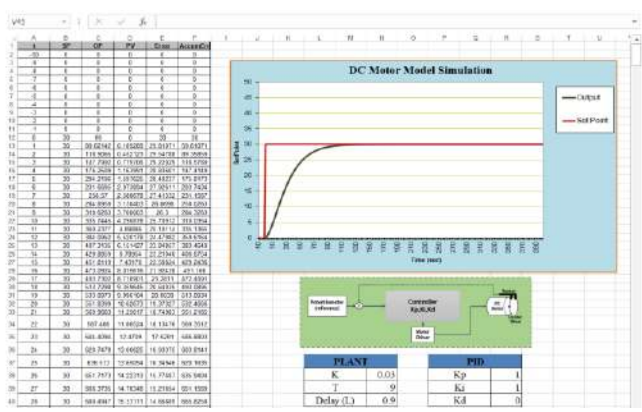

Figure 7: *Spreadsheet Model Simulation with Kp=1, Ki=1, Kd=0*

Figure 7 shows the simulation of the plant where Kp, Ki, Kd was set to respective values. This resulted in steady state error eliminated, but overshoot is introduced. The results of proposed spreadsheet simulation resembled and verified by the real plant response. Results of the simulation also confirm the PID controller theory shown in Table 2. With only Kp introduced, the steady state error is still high. When the system is well tuned, the steady state error and overshoot is eliminated. Figure 7 shows the unstable system for such PID tuning. Such outcome makes the proposed simulation can be utilized to get the better understanding about the basic of PID controller.

Table 2: *Effect of PID Controller*

Parameter	Rise Time	Overshoot	Settling Time	Steady State Error	Stability
Kp	Decrease	Increase	Small Change	Decrease	Degrade
Ki	Decrease	Increase	Increase	Eliminate	Degrade
Kd	Minor Change	Decrease	Decrease	No effect	Improve for small Kd

So far, the proposed spreadsheet simulation has been demonstrated to the students in control system course in Electronics Department Politeknik Negeri Malang. The students can use the simulation using regular laptop specification with an Office software in it and the software simulation using spreadsheet has been installed, learned, and can be modified easily.

6. Conclusion

The computer based non-traditional control system course teaching is a teaching method using electronics controlled plant combined with a modelling simulation in a PC. The electronics controlled plant is a plant as real world practice control system to be observed, the real world practice provides motivation and contributes the success of learning. The modelling simulation software application is a solution to see the performance of the controlled system which was developed to implement a control system which is light and easy-to-operate. Spreadsheets can be used to simulate the electronics controlled plant in the development of linear control system which is easy to operate with minimum computer specification that can be used by students of electronics, electrical, and control system engineering as well as in polytechnics education. The result of proposed simulation confirms the well-known PID controller effects, and verified by the response of the real DC motor speed electronics control plant developed and can be used as a visual simulation for students of electronics engineering polytechnics students.

7. Recommendations

The modelling simulation to visualize electronics circuit control plant performance in this study can be used to overcome the limitation of the resources in laboratories in the commencement of the polytechnics engineering education in Indonesia. Considering the implementation in the laboratories courses, lecturers are recommended to increase the ability on spreadsheet programming.

8. Scope of Future Research

Botta has been studied the emerging the internet of thing and cloud computing in both commercial and open sources platform (Botta, De Donato, Persico, & Pescapé, 2014). Based on the Botta study, the possible further research of this study is that the replication over various electronics controlled plants could be undertaken especially in the usage of controlling over internet of thing and cloud computing.

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