The Development of Android-based Control System for Reinforcing the Electronic Control Subject

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Abstract. The advancement of technology has brought the control system technology recently to be more precise, stable, and reliable. It is also possible to utilize the sophisticated hardware embedded in the smartphone for controlling or monitoring system through the external modules. This study aimed to develop an Android-based control system that can be used to reinforce the students’ competence, particularly in the Electronic Control subject. The method used in this study was a linear sequential model that comprises analysis, design, coding, and testing. A total number of nine items of functional testing has been conducted, and the results revealed that the prototype control system could successfully react as designed. Nevertheless, the one that should be considered in the future study is the compatibility issue between the external controlled hardware and the smartphone.

Keywords: Android-based control, electronic control.

1. Introduction

Along with the rapid development of technology, the control system is also improving very speedily. The control system technology is not only exploiting hardware but also engaging software. Even today, the software plays a very important role to make the control system more precise, stable, and reliable. Apart from the existence of a computer or even microcontroller which has a processor inside, now the smartphone has also a processor implanted as a brain to control and process its system. Today’s smartphone has been widely supported with a high-speed processor and also some embedded hardware to support the usefulness of the phone. Some of the hardware includes a variety of sensors (compass, accelerometer, GPS (Global Positioning System), etc.) and communication devices (infrared, Wi-Fi, Bluetooth, etc.). It cannot be denied that with the existence of the processor and the embedded hardware inside the smartphone, it may possible to use them for the control and monitoring system purposes.

The most widely used operating system in the smartphone is Android. Android is a Linux-based operating system for mobile phones such as smartphones and tablets. Android provides an open platform for developers to easily create their own applications to use in a variety of mobile devices.
Android has also the capability to access and control the hardware of the smartphone. Thus, it is possible to develop the Android-based application to utilize Android hardware resources.

The Electronic Control subject is one of the practical courses with 2 credits that must be taken by students of the Electrical Engineering Education Department, Yogyakarta State University [1]. This course generally comprises 2 major topics, namely: 1) the electronic-based control, and 2) the control of servo motor. Since technology has raised fast particularly in mobile phone technology, it is necessary to add the control system which is based on the Android and smartphone devices as an updating topic in the electronic control subject. This advanced topic may upgrade the student's competency in more sophisticated control technology. Therefore, the objective of this study is to develop the Android-based control system in order to reinforce the student's competence in the electronic control subject.

2. Research Method

The development of the system in this study is adopting a linear sequential model. According to [2], the linear sequential model is sometimes referred to as the classic life cycle or the waterfall model. This model suggests a systematic and sequential approach in building software that normally begins at the system level and continuing to the sequential stages of analysis, design, coding, and testing. This model is included in the generic model in software engineering and one of the most widely used up to now. It is called a linear sequential model because it goes step by step. It also means that the next stage should wait for the completion of the previous stage. Figure 1 illustrates the stages in the linear sequential model.

![Figure 1. The linear sequential model [2]](image)

The analysis stage is the initial stage of the linear sequential model. It is a very important step to collect all the information needed to understand how the system should be worked as expected. This stage is also used to identify the requirements from both the software and hardware required. The information gathered in this stage will be used to the next stage, the design stage. The design stage deals with the most effective and efficient way to sketch the system based on the information obtained in the analysis stage. This stage will produce a blueprint for implementing the system. After that, the design must be translated into both the hardware and software forms. The translation, particularly in software, is normally conducted by a process of coding using a specific programming language. Once both the hardware and software have been built, the program testing begins. The testing is conducted to ensure that there is no bug found and the system may run as designed.
3. Research Result and Discussion

At the analysis stage, the system requirements analysis is carried out. The results of the initial identification reveal that 1) the system should be able to control the lamp using the Android-based operating system, 2) the system should be able to control the speed of a DC motor using the Android-based operating system, and 3) the system should be able to monitor the temperature using the Android-based operating system.

![Figure 2. Block diagram of an Android-based control and monitoring system](image)

From the results of the requirement analysis, it can be drawn the general design of the block diagram system as seen in Figure 2. Two program codes should be prepared. The one that will be installed in the smartphone is created by using the Android Software Development Kit (Android SDK). And the other one that will be installed in the microcontroller Arduino is created by using Arduino Mega ADK [3]. Figure 2 shows that there is a connection established between the smartphone and the microcontroller. Just after the microcontroller getting the command from the smartphone, the microcontroller will translate the command. Then the microcontroller will convey the command to the external modules attached. The command may either to control or to monitor. The control command means that the microcontroller will send the data to the output modules attached. Meanwhile, the monitor command means that the microcontroller will receive the data from the input module. The output modules in this study are the lamp module and the DC motor module as illustrated in Figures 3 and 4, respectively. In the meantime, Figure 5 shows the monitoring system of the temperature module.

![Figure 3. A prototype of a light control system based on Android smartphone](image)
Figure 4. A prototype of a motor control system based on Android smartphone

Figure 5. A prototype of a temperature monitoring system based on Android smartphone

Coding is an activity to translate a logic to the programming language. The activities in coding include the process of writing, debugging, repairing, and maintaining the program code. Once the code has been written, the process of debugging begins. Debugging is the process to find as well as to resolve the bugs found within the program code. Jogiyanto divides three coding errors related to the debugging process, namely: 1) language error or syntax error, 2) run-time error, and 3) logical error [4]. In this study, the process of debugging has been conducted by the programmer while they wrote the program code. The process of debugging and repairing the errors lasted until the program code is free from errors.

Just after the errors have not been found, software testing could be conducted. This testing aims to know whether the software developed could run as designed. Generally, there are two models of software testing, namely 1) Black Box Testing, and 2) White Box Testing. The Black Box Testing only focuses on the functionality of the application without testing into detail the internal structure of the program code [5]. This test is widely known as Functional Testing [6]. Contrary to the Black Box Testing, the White Box Testing will take into account the internal structure of the program code [7]. Luo called this test as Structural Testing [6]. Since many researchers have been used merely functional testing to test the system [8] - [10], thus this study employs the same testing model too. Table 1 shows the testing procedures as well as the results of the functional testing from this study.
Table 1. The functionality test result

| Testing Procedure                                                                 | Yes/No | Remark                                  |
|-----------------------------------------------------------------------------------|--------|-----------------------------------------|
| 1. The power is connected and the indicator lamp could turn on                     | Yes    | The system responds as designed         |
| 2. The connection between the Android smartphone and the Arduino microcontroller could establish perfectly | Yes    | The system responds as designed         |
| 3. The control system App in the Android could run smoothly                        | Yes    | The system responds as designed         |
| 4. The control system App could order the lamp to turn on successfully             | Yes    | The system responds as designed         |
| 5. The control system App could order the lamp to turn off successfully            | Yes    | The system responds as designed         |
| 6. The control system App could order the motor to rotate at the minimum speed     | Yes    | The system responds as designed         |
| 7. The control system App could order the motor to rotate at the maximum speed     | Yes    | The system responds as designed         |
| 8. The control system App could order the motor to rotate at various speed         | Yes    | The system responds as designed         |
| 9. The control system App could monitor the temperature continuously               | Yes    | The system responds as designed         |

From Table 1, it can be seen that there are nine testing items. Items 1 until 3 deal with the system preparation stage in general. It shows that the Android-based application could run and establish a connection with the Arduino as designed. Testing items 4 and 5 focus on whether the control system App could order the lamp to turn on and off respectively. The results show that the lamp module could successfully react as commanded. The next testing is related to motor speed control. It can be seen from testing items 6 until 8 that the motor could rotate its shaft as ordered by the Android-based control system application. The last testing item concerns on monitoring the temperature data sent by the temperature sensor. The result also shows that the Android application could read the temperature data regularly. All in all, it can be concluded that the system built both the hardware and software could perform and react successfully as designed.

4. Recommendation and Conclusion

The development of electronic control recently has significantly increased. Undoubtedly, the smartphone has many features including some useful embedded hardware that is already installed. High-speed processors, sensors, and various modes of communication may bring the smartphone to becoming a powerful device. With all the advantages that have had by the smartphone, it is possible to use the smartphone as the main control system or a monitoring system for certain additional modules. This study deals with the development of Android-based control and monitoring system. The development process has been successfully conducted by following the linear sequential model. Furthermore, the nine testing schemes have also been successfully executed. The results of the nine-scheme functional testing showed that the system developed has acted as designed. As the old-version of the electronic control subject merely discusses the conventional electronic control system, thus this proposed Android-based control and monitoring system may be used to reinforce the electronic control subject. The students may have a new paradigm in an advanced control system. Although there are many advantages offered by this new-model control system in this study, nevertheless there is still a shortcoming revealed. The compatibility between the controlled hardware and smartphone becomes the main issue that needs to resolve for the future study.
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