Advanced Science and Technology Letters
Vol.29 (CA 2013), pp.214-217
http://dx.doi.org/10.14257/astl.2013.29.44

Development of PCR Control Software for Smartphone Using Bluetooth and USB Communications

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Abstract. The polymerase chain reaction (PCR) is a detection method used in almost all the experimental processes that involve manipulation of the current genetic materials to amplify the specific target genetic material to be preferably detected. The recent PCR thermal cycler has adopted a general-purpose computing platform in which specific operation systems run in a computing device to support the GUI. In this paper, Smartphone PCR control software, including the GUI, which can be run on Bluetooth, USB Communications, is proposed. The GUI is implemented in Android platform, and the connection to the PCR device uses a standard interface USB and Bluetooth to minimize the dependence on the platform. The proposed system has been verified to run in the commercial system using Smartphone.

Keywords: PCR thermal cycler, USB Communication, Bluetooth Communication.

1 Introduction

The polymerase chain reaction (PCR) is a general technology used for amplifying DNA in molecular biology [1]. A PCR thermal cycler is used for controlling the temperature required for the PCR by controlling the temperature in a chamber. It should not only have a biochemical process drive function but also a system management function such as data processing and user interface [2].

Other than these, the essential functions of the PCR control software include PCR protocol creation, editing, storing, and transmission to the PCR device. Further, it should include a function for updating the firmware of the PCR device via the web. Therefore, even if the PCR thermal cycler is standalone type, internally, for the user interface, the use of a general-purpose computing platform has many benefits.

In this study, we developed PCR control software, which significantly reduces the expenses related to software development and maintenance and supports Smartphone applications; further, we verified its operation. We has developed a PCR control software using the USB communication following we developed a Bluetooth PCR control software existing. The Smartphone connected to the PCR device by the USB and Bluetooth; this minimized the dependence on the platform.

ISSN: 2287-1233 ASTL

The proposed PCR control software was applied to the PCR device [3], which was developed and commercialized by our research team. The PCR control software was designed to run on all Smartphones by supporting the Bluetooth and USB communication.

2 PCR protocol and communication protocol

The PCR device uses a heater and a fan for heating and cooling; further, other than basic functions such as temperature measurement, it should have a protocol processing function by which the PCR protocol, consisting of a permutation of a temperature and time pair, is interpreted, thereby maintaining the required temperature for a given period of time.

Fig. 1 shows the GUI in the Android Smartphone environment. The protocol is explained by the table given in the figure. The No. 1 item in the table implies that a temperature of 95°C was maintained for 30 seconds for warming up the chamber. No. 2, 3, and 4 pertain to the processes of PCR degeneration, restoration, and extension, respectively, and convey that the amplification process occurred once up to this point. The GOTO label is for the flow control, indicating the cycle to return to the No. 2 for 34 times. The example consists of 35 cycles in total. In general, the PCR is completed by inserting the last extension process such as No. 5.

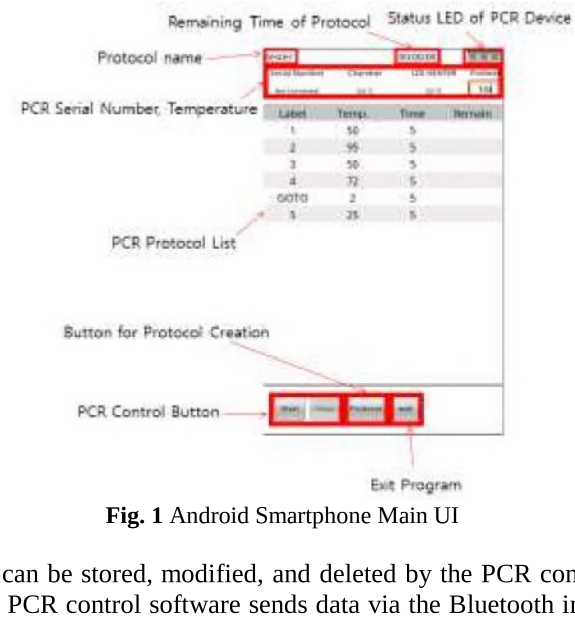

Fig. 1 Android Smartphone Main UI

This protocol can be stored, modified, and deleted by the PCR control software to be run later. The PCR control software sends data via the Bluetooth interface or USB interface to control the devices or transmit the PCR protocol to the PCR devices. To transmit data, messages in Table 2 are used.

Table 2 Message type

Message	Function
STATUS	Obtain the status of PCR
TASK_WRITE	Write protocol information on PCR
TASK_END	Notify PCR writing completion
GO	Run the PCR
STOP	Stop the PCR

3 Implementation

The PCR device used for the experiment was MyPCR from Labasis. A Smartphone controlled the operation through the Bluetooth or USB. Once a RUN command was given from the controller to PCR, the PCR device was run normally even if the connection was disconnected because it can operate as an independent device. Using this device, the proposed software which could be run in Smartphone environment was implemented.

The following four parts were implemented in Smartphone software: the Bluetooth communication system, the USB communication system, the GUI configuration, and the web interface. The Android platform includes support for the Bluetooth network stack, which allows a device to wirelessly exchange data with other Bluetooth devices. The application framework provides access to the Bluetooth functionality through the Android Bluetooth APIs, These APIs let applications wirelessly connect to other Bluetooth devices, enabling point-to-point communication

The USB communication also support in Android platform. This function is acts as the USB host, powers the bus, and enumerates connected USB devices. After installing the software, connecting the PCR device, software is automatically executed. When the software is executed, attempts to communicate the USB device, if the connection is successful, getting the serial number of the current device and it is possible to run the PCR device by transmitting the PCR protocol by “Start” button

From the GUI, the serial number of the current device or chamber temperature and the LID temperature were checked through the received data, as well as the remaining time of the protocol currently running, and the label location of the running protocol. The GUI in the Android Smartphone environment shown in Fig. 1.

Once a connection was made with the PCR device, the version of the firmware, which was installed from the device, was checked first. Then, the up-to-date firmware version was checked via the web server, and if the version was not up-to-date, the most recent version was downloaded from the web server and stored. If the PCR control software showed the serial number correctly, the update was completed.

Fig. 2 shows the flow chart of the PCR control program. Once a connection was done with the PCR device, a timer was run to transmit the STATUS message in every 0.1 seconds, thereby receiving the status of the device.

When the PCR device was running, if the control program was started, the protocol list and the device information running in the current device were fetched and displayed.

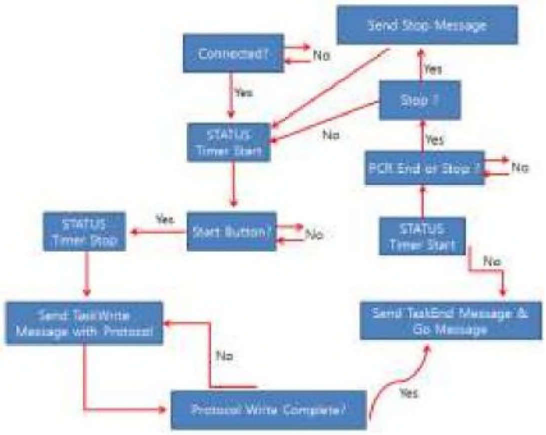

Fig. 2 Flow chart of the PCR control program

4 Conclusion

This paper, by using the Bluetooth and USB communication with Smartphone to develop a PCR control software, because to reduce the installation costs by reducing the need for host PC. By increasing the stability of the communication support USB communication as compared to PCR control software that was only support Bluetooth communication, it is possible to be able to support the PCR control software on all the type of Smartphones. Through these developments, not only was the cost of the PCR device reduced, but the inconvenience of PCR use in a small laboratory environment was also minimized. If the developed PCR control software that supported multi-communications use has a function that monitors multiple PCR devices at the same time, one Smartphone can run multiple PCRs with minimal effort at the same time, and hence, the costs related to the PCR purchase and installation can be reduced significantly.

Acknowledgments. The research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education, Science and Technology (2013R1A1A2013490).

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