Development of PCR Controller for Smart-Phones based on Bluetooth Communication

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Abstract. Polymerase Chain Reaction is an amplification method of genetic materials. Conventional PCR machines control the process with a computer that is connected with a wire, limiting the mobility and requiring an expensive, high technological installation skill. This paper utilizes the wireless Bluetooth technology to resolve such problems, enabling the user to control the PCR process with a smartphone. By controlling the PCR machine with a smartphone many advantages can be achieved from enabling PCR machines to be installed in an environment that does not provide wired networking, reduce the cost and improvement in convenience of control and mobility.

Keywords: PCR thermal cycler, Bluetooth, smart phone

1 Introduction

Polymerase Chain Reaction (PCR) is a common method to amplify DNA in molecular biology [1]. PCR thermocycler should not only have the biochemical control function that controls the temperature of the chamber which in turn controls the temperature of the sample prepared for PCR [2], but also should have other system management functions such as data analysis and user interface [3-5]. Recently, even the simplest electronic devices require graphical user interface (GUI) and data accessibility through the internet, there is a high advantage when managing the system using a computer [6].

In most cases, the PCR thermocycler is controlled by machine with GUI. Recently, the PCR thermocycler is controlled by a host PC that is connected with a wire. However, this gives rise to an additional cost for the PC installation, and also decreases the efficiency since the PCR thermocycler and host PC is connected with a wire. In this research, a PCR thermocycler controller based on the Bluetooth function of smartphones is developed and its performance was evaluated to resolve such problems. In detail, an attempt to control the Stand alone form PCR machine by SPP (Serial Port Profile) using Bluetooth function of an android smartphone was made.

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The smartphone was made to have a function where it can detect Bluetooth devices and a GUI that displays the results. The desired PCR thermocycler can be selected and connected to the smartphone. The user can input and save the protocol that will be used to control the PCR thermocycler in the smartphone, and can send the protocol to the PCR machine that will initiate the PCR process once connected. A method to prevent any problems that might occur when the smartphone is far out of the range to be connected via bluetooth with the PCR machine is also dealt with, stabilizing the overall system. As a result, the installation of a host PC was eliminated, increasing the efficiency space-wise. This paper introduces the research on PCR and Bluetooth in chapter 2, explains the program developed in chapter 3, and the conclusion is made in chapter 4.

2 Bluetooth Module

To use the bluetooth function in PCR control, the FB155BS model of Firmtech was used. This bluetoothe module is installed in the PCR thermocycler with an antenna connected to the module.

Most android smartphones already have Bluetooth functions as a default. Galaxy Tap 10.1 from Samsung electronics was chosen in this paper. For the smartphone to detect the SPP Bluetooth module inside the PCR machine, the UUID(Universally unique identifier) of the smartphone Bluetooth has to be set into SPP, then it can be connected with the PCR machine via Bluetooth. After connected, the following messages shown in table 1 will be displayed in the GUI of the smartphone, enabling the users to control the PCR thermocycler.

Table 1. Function of each message.

Message	Function
STATUS	Get status of PCR
TASK_WRITE	Write TASK to PCR machine
TASK_END	Notify user that TASK is successfully written
GO	Start PCR protocol
STOP	Stop PCR protocol

Table 1 shows the message shown in the GUI of the smartphone and its functions. ‘STATUS’ receives the status of the PCR thermocycler every 0.1 seconds after it is connected to the smartphone. The reply of this message includes the current temperature and TASK of the PCR machine, and the remaining time. If there is a malfunction in the PCR thermocycler, or if the TASK value that increases the temperature is too high, the PCR protocol stops and the error value is transmitted to the smartphone. ‘TASK_WRITE’ and ‘TASK_END’ determine the duration and temperature for each steps of the PCR protocol. ‘GO’ orders the PCR thermocycler to start with the given TASK values. ‘STOP’ can end the PCR protocol manually.

3 Realization

The PCR machine used in the experiment is the MyPCR from Labasis Co., which is controlled by a PC that is connected with a USB. Since this PCR machine is developed in a standalone form, once the RUN order is transmitted to MyPCR form the host, it becomes an independent machine, and therefore can continue the PCR protocol without any trouble even is the connection is interfered. A PCR thermocycler that can be controlled via Bluetooth was made by installing the FB155BS Bluetooth module from Frimtech co. in MyPCR. A controller to control MyPCR was developed on a android platform by using a Bluetooth API supported by android. The controller should consist of three parts: a part connecting with the PCR machine, a part to set the TASK manually, and a part that shows the current status of the PCR.

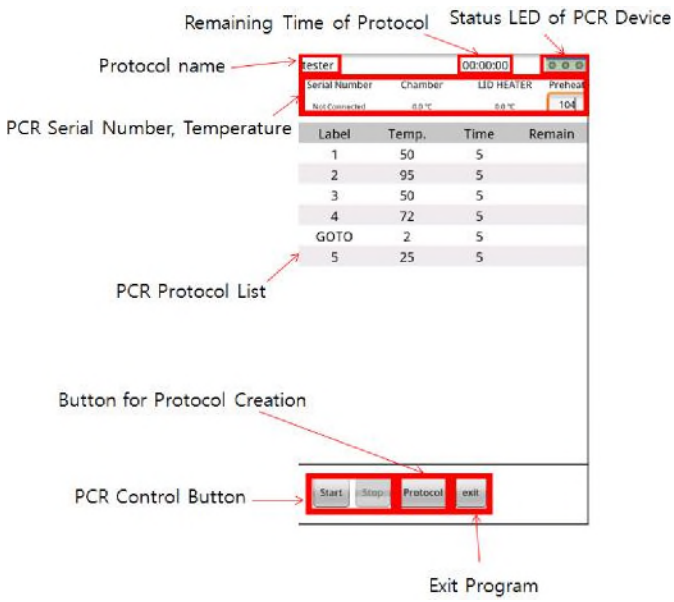

Fig. 1. Android smartphone Main UI

Figure 1 illustrates the smartphone user interface of the PCR control application. The user can create their own TASK and save them in a list by pressing the 'Protocol' button, and also choose which TASK to send from the list. When a protocol(TASK) is selected, the 'Start' button activates. The Bluetooth devices are detected by pressing the 'Start' button, and the protocol is only transmitted when MyPCR is selected from the list of devices. The value of TASK is transmitted to the PCR thermocycler every 0.1 seconds, and is set so that no other device can be connected during the transmission. After the PCR starts, any other messages except for 'STATUS' and 'STOP' will be read as 'STATUS' when input, and will send the status of the PCR machine to the smartphone. Since Bluetooth function has range limitation being a wireless network, the PCR machine will disconnect form the smartphone. However, the PCR thermocycler runs according to the independently saved protocol, the PCR will stay in a regular or irregular stop status. When reconnected, the result of the last execution will be sent to the smartphone to notify the user of its status.

4 Conclusion

This paper developed a bluetooth based smartphone PCR controller with the goal to decrease the installation cost by elimination the need of a host PC, and to increase the convenience of installation by using wireless network. This will also help manage the PCR protocol easily, and enable the installation of PCR machines in laboratories with insufficient space. Control of multiple PCR thermocyclers can also be achieved with less effort, if integrating a function that can read the protocols from the PCR machine to the smartphone and a function that can monitor multiple PCR machines simultaneously in the smartphone application. If this can be realized, the space and cost problems that might arise when purchasing and installing PCR thermocyclers can be resolved.

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