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Development of tranceiver using Flashlight and camera in VLWC

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Abstract. Receiver in existing visible light communication uses LED (Light Emitting Diode) or PD (Photodiode). In this thesis, Android mobile devices without any additional devices transmits data via its transmitter which uses only flashlight to send OOK(On-Off Keying) signals and its receiver uses a camera module which receives binary signals by using light sensitivity. in this thesis, basically regarding Android application development technology and we have identified that VLWC(visible light wireless communication) can be performed regardless of place or time, which expect to be applied to technology development for WPAN(Wireless Personal Area Network) among low power mobile devices in personal activity area.

Keywords: data communication, VLWC, embedded system, LIFI

1 Introduction

In these days, there are growing number of researches on technology for wireless communication without restrains of time and space. In particular, studies on visible light communication using LED light are actively being conducted as convergence of wireless communication and green IT. Since luminous efficiency of LED is increasing while the cost is sliding thank to the related technical advance, LED lamp has been replacing fluorescent and incandescent lamp [1]. Technical advance of semi-conduct allows implementation of diverse range of wavelength for LED and it has outstanding benefits including miniaturization, weight lightening, low power consumption, and semi-permanent life span, thereby being greatly anticipated as the next generation, eco-friendly light source [2]. LED can significantly save energy due to its high energy conversion efficiency and apply to visible light communication which enables high speed digital signal transfer, allowing wireless communication in any places with LED light. Using electromagnetic wave free uses visible light as a medium, visible light communication is harmless to human body and can be used in places in which electromagnetic wave may cause malfunction or serious problem of

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equipment such as airplane, hospital, etc. Applications of the convergence system will be increasing by simultaneously implementing lighting and communication system based on those strengths [3]. Standardization of visible light communication has been established in accordance with international standard of IEEE 802.15.7 which has completed in 2011. Reviewing existing studies, the results shows visible light communication using LED light has several meters of short transmission distance and under 100 Mb/s of speed [4,5]. The organization which is the most actively involved in standardization of visible light communication is IEEE 802 standardization group and 802.15 WPAN group has established IG (Interesting Group) on November 2007, and SG(Study Group) on May 2008 for standardization of visible-light wireless communication and formed TG(Task Group) on January 2009 (IEEE 802.15.7 TG-VLC), recently completing specifications for visible-light wireless communication PHY and MAC standard[6]. Among the number of wireless communication technologies, IEEE 802.15.3 HR-WPAN(High Rate Wireless Personal Area Network) is standard for wireless personal area network for transmitting large volume of multi-media data such as video, high resolution image, high quality voice, etc. For high transmission rate and QoS(Quality of Service), IEEE 802.15.3 HR-WPAN uses TDMA based MAC protocol, allowing operation at data rates up to 55 Mbps and [7]. The intensity of the LEDs is varied by changing the current passed through them at very high speeds. However, the human eye cannot perceive this change and the LEDs appear to have a constant intensity. This ON-OFF activity of LED lights enables data transmission using binary codes i.e., when the LED is ON, logical '1' is transmitted and when the LED is OFF, logical '0' is transmitted[8]. several research result concerning dimming methods for the VLC were presented. Especially, inverse source coding using non-return-to-zero on-off key(NRZ-OOK) was proposed in[9]. Communication equipment is being designed in smaller size and its price is getting lower today and WPAN (Wireless Personal Area Network) technology is being actively developed for communication among low power mobile devices in personal activity area.

The purpose of this thesis is to develop Android application development for smart phone and other devices in order to verify visible light communication among mobile devices. Android smart phone and Android system Trailing kit were used for visible light communication among the mobile devices. Verification test has been conducted to prove that data transmission through visual light uses OOK(On-Off Keying) which can be made by on/off of flashlight of smart phone and camera on Android system board can receive data. This thesis is comprised of following chapters. Chapter 1: introduction, Chapter 2: design directions regarding system embodiment, Chapter 3: the system's embodiments and results of experiments, and is finalized with conclusion in chapter 4.

2 System Design

Android platform device was used for this study. As shown in Figure 1, the transmitter for visible light communication sends binary signal by turning on/off data

using flash, and the receiver gets binary signal by detecting on/off of light by using image sensor of camera.

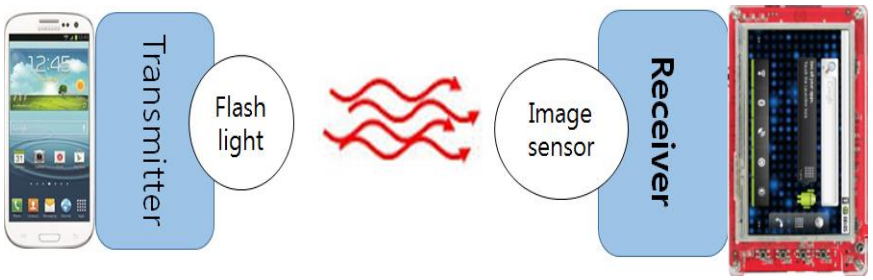

Fig. 1. System architecture

.We have developed flash-light Android application for transmitter which is designed to be on and off when binary is '1' and '0' respectively and Android-NDK for converting on/off signals to binary code '1' and '0' according to strength of light and application for displaying them on Android Platform were developed for the test .

2.1. Transmitter application design

The transmitter for visual communication uses flashlight of Android smart phone. Since light tends to travel in a straight line, the shading changes depending on the angles, resulting in lower reliability. This thesis is used Beamforming that beams the light down only on receiver. Application was packed into Android –based apk. The operation processes as shown in Figure 2, are; run application, enter binary and save the binary data in array by bit. The transmission as shown in Figure 3, uses OOK(On-Off Keying) of level detection method. According to the order stored in array, it turns 'on' flashlight if the code is ‘1’and 'off' for ‘0'.

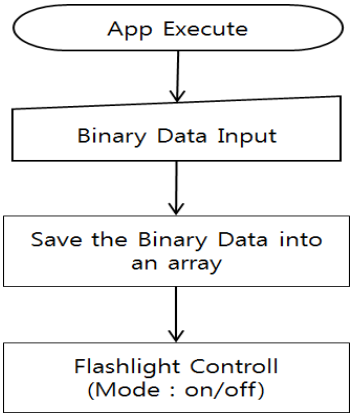

Fig. 2. Transmitter application Flowchart

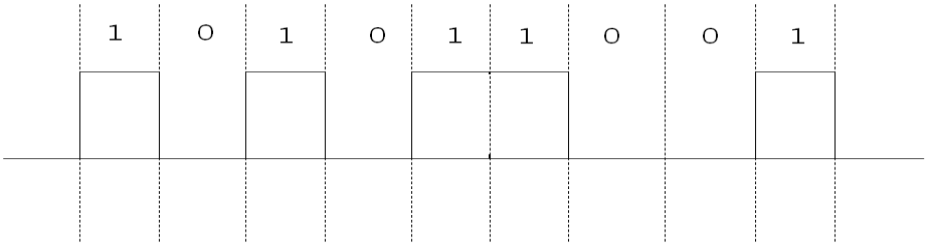

Fig. 3. Creation of the OOK signal

2.2. Receiver application design

The receiver for visual communication uses Trailing kit with Samsung S5PV210 Processor which is designed in ARM architecture. Trailing kit is running on Android OS. As shown in Figure 4, Android-NDK was developed and camera captured and detected color changes of the data signal sent from transmission. If the detected value is bigger than a certain value, it is set to '1', if not, set it as '0'. The binary data for the recognized '1' and '0' value is displayed in TextView on the Android application.

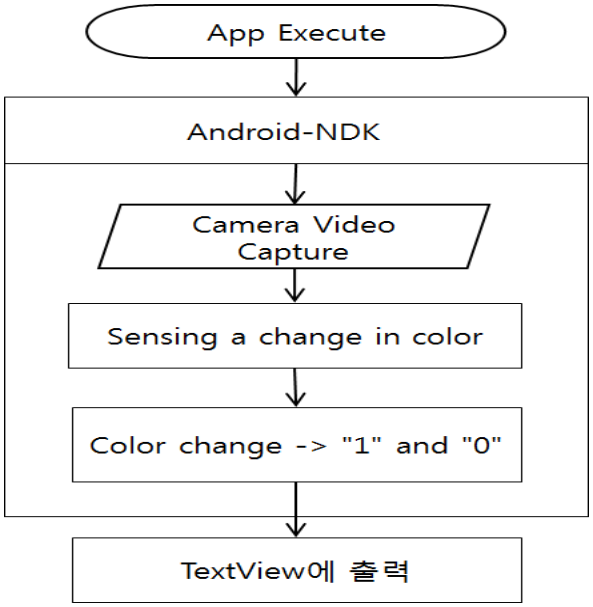

Fig. 4. Receiver application Flowchart

3 System implementation and experiments

With Android platform mobile devices, we developed an application that allows flashlight to turn ON/OFF '1' and '0' in sending side. For receiving side, we developed Android-NDK that detects '1' and '0' using camera and an Android application in which the detected '1' and '0' codes are actually displayed. Software Development Environment is described in Table 1.

Table 1. Software Development Environment

Division	Descriptions
OS	Ubuntu14.04, Window7
Language	JAVA, C Language, XML
JDK version	JDK 1.6.0
tool	Eclipse, Android-SDk, Android-NDK

3.1. Transmitter applications implementation and testing

Data reception in this paper used flashlight of smart phone. Figure 5 shows a part of source codes of the Android application. It receives the binary entered in EditText, recognizes the length, and saves binary data for the length in array. With setFlashMode method, it runs 'torch' if the value of saved array is ‘1’ and 'off' for the value of ‘0’ , turning on/off flashlight by OOK(On-Off Keying) of Level detection method.

```
BinData = (EditText) findViewById(R.id.InputText);
  final String data_arg = BinData.getText().toString();
  int length = data_arg.length();
  char[] bin_arg =new char[length];
for(int i=0; i<length; i++)
  {   bin_arg[i] = data_arg.charAt(i); }
  for(int i=0; i<length; i++)
  {
        if (bin_arg[i]=='1'){
              mCameraParameter.setFlashMode("torch");
              mCamera.setParameters(mCameraParameter); }
        else if (bin_arg[i]=='0'){
              mCameraParameter.setFlashMode("off");
              mCamera.setParameters(mCameraParameter);
```

```
                                        }
                    }
```

Fig. 5. Sending side Android source Code

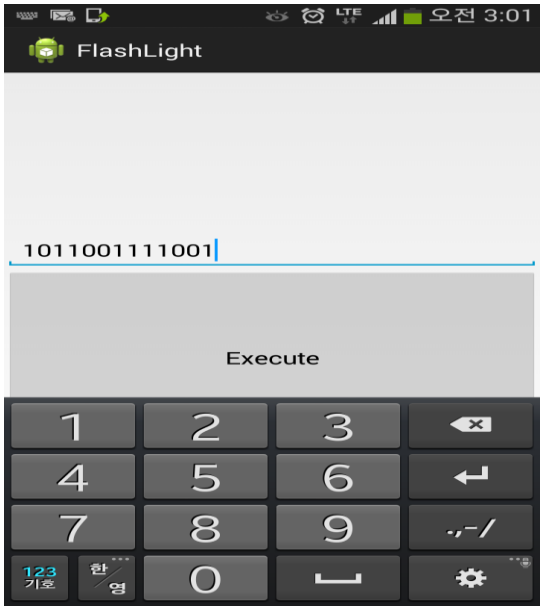

Fig. 6. Flashlight Android Application Execute

Figure 6 shows how the application operates flashlight by the binary data entered into EditText.

3.2. Receiver applications implementation and testing

This thesis is used Android system Trailing kit with S5PV210 processor for data reception in order to verify that any device equipped with camera is able to receive data. Resolution of the camera was 640 X 480. Figure 7, shows a part of Android-NDK source codes. Height for light detection range was set between 200 and 300 pixels and width was between 300 and 400 pixels. Red and blue color was used for detecting change of light. It converted the change of light to binary code by detecting the strength of light, setting it to '1' if exceeding the strength of default color, and to '0' if there is no change. The converted binary was sent to Java code in Android Application.


```
JNIEXPORT  void
JNICALL Java_glory_image_bindata_ImageBinData_ReturnDATA(JNIEnv * env,
j object obj, jintArray rgb, jbyteArray yuv420sp, jint width, jint height)
    {
                              :
                              :
   if((j > 200 && j < 300) && (i > 30 0 && i < 400)){
                                  sum[0]= (sum[0]+(Cr+128))/2;
                                  sum[1]= (sum[1]+(Cb+128))/2;
                                 }
                               :
                               :
   if (sum[2] >= XX) dataRGB[0]=0;
                     else if (sum[2] < XX) dataRGB[0]=1;
  (*env)->SetIntArrayRegion(env, rgb, 0, sz, (const jint * ) dataRGB);
                                  :
}
```

Fig. 7. Android-NDK Source Code

Figure 8, shows a part of JAVA source codes in Android application. It sends image captured by camera to Android-NDK, and display binary received from Android-NDK in TextView.

```
   public native int  ReturnDATA(int[] image,byte[] yuv, int width, int height);
   static {
        System.loadLibrary("cameraRGBdata");
     }
                                        :
   closeButton.setOnClickListener(new View.OnClickListener()  {
          @Override
```

```
        public void onClick(View v) {
                mCamera.setPreviewCallback(new PreviewCallback()
                {
                        :
                public void onPreviewFrame(final byte[] data, Camera
c)
                {
                        String binDATA;
                        ReturnDATA(rgba,data,width,height);
                        binDATA=Integer.toString(rgba[0]);
                        strDATA=strDATA+binDATA;
                                :
                            :
                         bitMap.setText(strDATA);

                        }
                        :
```

Fig. 8. Android Application Source Code

As shown in Figure 9, we indentified that Android application transmitted for change of light, received displayed the transmitted binary in TextView and received the '1'and '0' binary by camera.

Fig. 9. Android Application Source Code

4 Conclusions

This thesis is used Android platform mobile devices. The sending side used smart phone and the receiving side used Android system Trailing kit equipped with S5PV210 Processor. The study identified that the application can turn on/off flashlight by 'torch''and ‘off’’in setFlashMode method based on OOK(On-Off Keying) signal of Level detection method, capture the image with camera, and convert the image to binary data. Therefore, the study clearly identified that visible light communication among Android platform mobile devices with flashlight and camera can be made by using Android application without having to use any additional devices. This study also suggests further development of software that complied with IEEE 802.15.3 HR-WPAN for Wireless Personal Area Network to transmit large volume of multi-media data such as video, high resolution image, high quality voice, etc.

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