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Wireless Virtual Joystick

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ABBREVIATIONS

API	Application Programming Interface
dll	dynamic link library
GUI	Graphical User Interface
IDE	Integrated Development Environment
IP	Internet Protocol
JNI	Java Native Interface
JVM	Java Virtual Machine
WAN	Wide Area Network
WIFI	Wireless Fidelity
WLAN	Wireless Local Area Network
WVJoy	Wireless Virtual Joystick
QA	Quality Assurance
QFD	Quality Function Deployment
SDK	Software Development Kit
UI	User Interface
XML – RPC	extensible markup language – remote procedure call

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ABSTRACT

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Wireless Virtual Joystick is an Android application which enables users to use their Android mobile device act like a real joystick /1/. It provides a solution to establish a wireless connection between Android mobile device and server computer. Whenever the server receives correct message, the server will simulate a virtual joystick input signal. Wireless Virtual Joystick does not worry about the small space, wires jam or USB port limitation.

The objective of this thesis project is to develop a smart phone joystick which enables people to use a smart phone application to do the joystick job. Different with real joystick, it is wireless. This is an advantage in some special cases.

This thesis introduces the scope of this project at first. There are details of the project background, used technology, the scope of this application, and the design of this project. Then there is coding and testing procedure description. In the last there are a summary and conclusion of this project.

The application has been developed successfully. All functions expected are carried out and the performance is excellent. It can send messages from mobile devices to target server and simulate joystick input correctly without any delay. All of the objectives are achieved.

Keywords Joystick, Android, Programming, Software development, mobile device, XML-RPC, JAVA, C++.

Contents

1. INTRODUCTION

This project idea is to develop an Android application that can manipulate as a joystick. It communicates with server computer through web service technology so that there will be no distance limit.

1.1 Background of topic

The background of this topic can be divided into 3 parts:

- Software aspect
- Hardware aspect
- Telecommunication aspect

1.1.1 Software aspect

First part is the software aspect. There are 2 most popular smart phone operating systems nowadays. They are iOS and Android /2/. iOS is only support for iPhone, iPad, and iTouch 3 kinds of Apple company products. Android is open source, and compatible with many different companies' products. Almost all smart phone producers are based on the Android operating system, except Apple and Nokia.

BlackBerry and Symbian were popular a few years ago. But their market share is going down every day at this moment. Their technology is out of age already. Based on their design of the operating system, they cannot make a revolution and follow up the steps of iOS and Android.

Windows Phone is not as popular as iOS or Android /1/, since it is a new system. Only Nokia Company is focused on the Windows Phone operating system, the other companies are focusing on Android development, meanwhile, produces few Windows phone products for different customer needs, too.

There are some other mobile device platforms, but their technology is not mature and they are not popular in the market.

IDC (International Data Corporation) is a famous data analysis company /4/. From their analysis, it is obviously that Android is the most popular smart phone operating system at this moment.

***Table 1**. Top 6 Smartphone Operating Systems, Shipments, and Market Share, Q3 2012 from IDC (Preliminary) (Units in Millions) /5/*

Operating System	3Q12 Shipment Volumes	3Q12 Market Share	3Q11 Shipment Volumes	3Q11 Market Share	Year-Over-Year Change
Android	136	75.00%	71	57.50%	91.50%
iOS	26.9	14.90%	17.1	13.80%	57.30%
BlackBerry	7.7	4.30%	11.8	9.50%	-34.70%
Symbian	4.1	2.30%	18.1	14.60%	-77.30%
Windows Phone 7/ Windows Mobile	3.6	2.00%	1.5	1.20%	140.00%
Linux	2.8	1.50%	4.1	3.30%	-31.70%
Others	0	0.00%	0.1	0.10%	-100.00%
Totals	181.1	100.00%	123.7	100.00%	46.40%

From the user experience to see, Android can meet their needs and easy to use. This proves the Android system is mature enough already. That is the reason this thesis project is developed with the Android platform.

1.1.2 Hardware aspect

Second part is the hardware aspect. The Android operating system is compatible with almost all smart phones nowadays. So there are plenty of choices for Android mobile devices. No matter which brand of it, most of them have at least 800MHz CPU and 640*320 touch screens.

Based on this situation, this application is designed for mobile devices which have at least 640*320 touch screen resolution. There is no requirement for the processor, but the recommend processor configuration is no less than 800MHz.

1.1.3 Telecommunication aspect

The last part is the telecommunication aspect. To establish a wireless controller with a mobile device, Bluetooth is possible. But due to its range limit is too small, and it will require a Bluetooth in target computer, that is not convenient. At last, Bluetooth technique is abandoned in this project.

When 3G network came out a few years ago, smart phone users experienced a lot of benefit from it. At the same time, smart phone manufacturers realized the need of the Internet for their customers, all of them had successfully carried out a WIFI module for every new smart phone. All mobile devices produced currently can access to wireless routers. WVJoy is based on web service to transmit data from smart phone to target server computer. 5 years earlier, without the 2G / 2.5G network, it can hardly perform well, the Internet connection is very unreliable. But now, the telecommunication technology is mature enough to stand for the data communication. People can use WIFI connect their mobile device and use the Internet. Besides, the 3G network can have 100 KB/s download speed, but WVJoy only need less than 1% of it. Without WIFI, WVJoy can still perform well.

1.2 Motivations

The original idea of this thesis project was developing a mobile joystick for the VAMK robot team. But the usage is too limited if there is only an interface to give the robot server receives commands. It should be able to manipulate as a real joystick for all kinds of programs, not only for the VAMK robot, but also available for some other PC programs such as PC games. In the end, Android application was aimed.

There is no such application can be found in either Android Google Play Store or iOS App Store at this moment. WVJoy is the first one. This is also an important motivation.

1.3 Objectives

The objective of this project is to develop an Android application that can remote controls a target computer, let the computer receives messages from a mobile device and generates corresponding joystick input without any distance or cable limit. This is practical in some special cases.

Besides, practice self – study ability is also a significant objective. In the process of doing this project, learning new technology and manage its usage is always necessary.

1.4 Short description

This project can be divided into 3 parts: mobile device GUI client, communication between mobile phone and server computer, and invoke virtual joystick and simulate real joystick signal input.

First part is to make a GUI for the mobile device, which contains 4 arrow buttons, 4 normal buttons, select button and confirm button.

They are simply named with, JoyButtonUp, JoyButtonRight, JoyButtonDown, JoyButtonLeft, JoyButton1, JoyButton2, JoyButton3, JoyButton4, JoyButton5, and JoyButton6. Different standard joystick may have different number of buttons. Consider about the size of touch screen is normally about 3.5 inch at this moment, 6 buttons will be the best design.

The second part contains 2 small parts. Build an Android development environment with Eclipse /6/, use Java to program an Android web service and transmit messages to the server /7/. After that, the server returns the corresponding message to client mobile device.

The third part generates keyboard input at server computer. Java does not good at kernel program, so there is a dll file integrated in the server to simulate a virtual keyboard input so that PPJoy can detect it /8/.

The last part is to start PPJoy and load appropriate configuration. PPJoy is a famous virtual joystick simulator. It can create a virtual joystick device, detect keyboard input and generate corresponding configured joystick input.

1.5 Advantages and disadvantages

The most important advantages are:

- Convenient to use. A real joystick is not necessary in daily life, but smart phone is. WVJoy can provide a solution to use a smart phone to do the joystick job. It can be used at almost everywhere on the earth.
- No distance or cable limitation. Most joysticks are connecting with cable. Few of them are wireless. But there is a distance limit still. WVJoy do not have these restrictions.

The most important disadvantages are:

- The smart phone device has a lot of restrictions. Battery restriction, sensitive restriction, and performance restriction.
- Network connection is necessary. If the device network is unstable, the performance will be low.

2. RELEVANT TECHNOLOGIES

In this project, programming technique involves Java, Android SDK, web service XML – RPC, JNI, and C++.

2.1 Android SDK

The first part of this project is developing a GUI for Android application with Java using the Android SDK. Android SDK can be downloaded from the Android official website for free.

The IDE for Android development have many choices. The most popular one is Eclipse.

Before the first time to develop an Android application, download the Android SDK is necessary. This powerful SDK provides a lot of functions corresponding to different Android version. In this project, the minimum SDK version equal to 8, which is corresponds to the Android 2.2.x and higher version. There are a lot of big changes between these 2.1.x and 2.2.x versions. Android has become very popular since the Android 2.2.x version. According to the data collected from the Android developers' website of in year 2012, more than 96% of Android device support the 2.2.x or higher version. That is the reason the minimum SDK version is 8 in this project.

After downloading the Android SDK, Eclipse needs a few steps of setting. The detailed step can be found in the appendices.

Since this project is going to use the Android application sends message to the XML – RPC server. A web service XML – RPC API is needed. But different with normal Java web service, Android needs a special API in order to use XML – RPC web service. This API is available at Google Code website /9/. Download it and import it into the project. The preparation of Android development is ready.

2.2 XML – RPC server

The second part of this project is the XML – RPC server. It is a normal Java XML – RPC server. The web service communication will continuously send and receive messages between Android mobile device and XML – RPC server. The API is available at Apache official website /10/.

2.3 Generate keyboard input

The last part of this project is using visual studio to write a C++ file that can perform virtual keyboard input and generate it as dll form. Meanwhile, use JNI, to integrate the dll file function into the web service XML – RPC server. The server will generate keyboard input corresponding to message received from client application. PPJoy will detect keyboard input event and simulate joystick input on the server computer.

3. APPLICATION DESCRIPTION

Analysis with project objectives, constraint factor, requirement, design QFD table, and use case diagram are significant before start coding.

3.1 Objective, constraints

The objective of this project is to make an Android application which is able to communicate with XML – RPC server and use the server to generate a keyboard input event in order to let PPJoy detects corresponding keyboard input and simulates correct joystick input.

There are a lot of factor constraints this project.

Android mobile device is the most important factor. The screen resolution, the Android system version, the touch screen function, the 3G module, and network connection will determine the performance of this project.

The constraint for server computer is not much, any computer installed Win XP or higher version is able to start the server. But the computer must be able to join the same network range with the Android mobile device. If the server computer has a WAN IP, then Android mobile device needs an Internet connection. If the server computer does not have Internet Access, it has to join a wireless router so that the mobile device can join the WLAN too and communicates with the server.

Advanced IT professionals who can do the IP / port mapping, can map the server IP address and port to upper layer connection point. It might help with connecting Android mobile device to the server sometimes.

3.2 Requirement analysis

The requirement analysis is start by making a QFD table for this project. After the priority of objective functions has been determined, a use case diagram can demonstrate different user group’s authority difference.

3.2.1 QFD of WVJoy

In this table, it is obvious that the top 5 rows are maximum priority. If any requirement is not reached, this application will be impossible to run.

The 6th and 7th rows are showing that Wifi and 3G network is not max priority. But if combine both of them, 3 + 2 = 5 is the maximum priority. It means, the smart phone or tablet should have at least one of them. Otherwise, the mobile device cannot use web service to transmit data to the server.

The last 2 rows are telling that server computer does not have to have good performance. Any normal computer is enough. But the smart phone or tablet needs better performance. Otherwise the application cannot run very well. Meanwhile, it is not necessary to have very good performance.

The following table shows the priority of hardware and platform required.

***Table 2**. QFD table of WVJoy*

QFD of WVJoy (1min - 5max)	
Requirements	**Importance level**
Windows XP / Windows 7	5
Android 2.2.x	5
Min screen resolution 640*320	5
Touch screen smartphone	5
network connection for server computer	5
Wifi for smart phone	3
3G for smart phone	1
Server computer hardware performance	1
smart phone hardware performance	4

3.2.2 Use-case diagram

The administrator is the one who has the right to control the server computer. If he / she have a mobile device that meets all those requirements mentioned above, then he / she can do everything. Otherwise, he / she cannot start or stop the WVJoy Android application.

The user is anybody who has the WVJoy Android application. When user gets server information provided by the administrator, the WVJoy will be able to connect to the server.

The following chart is a capture of use case diagram.

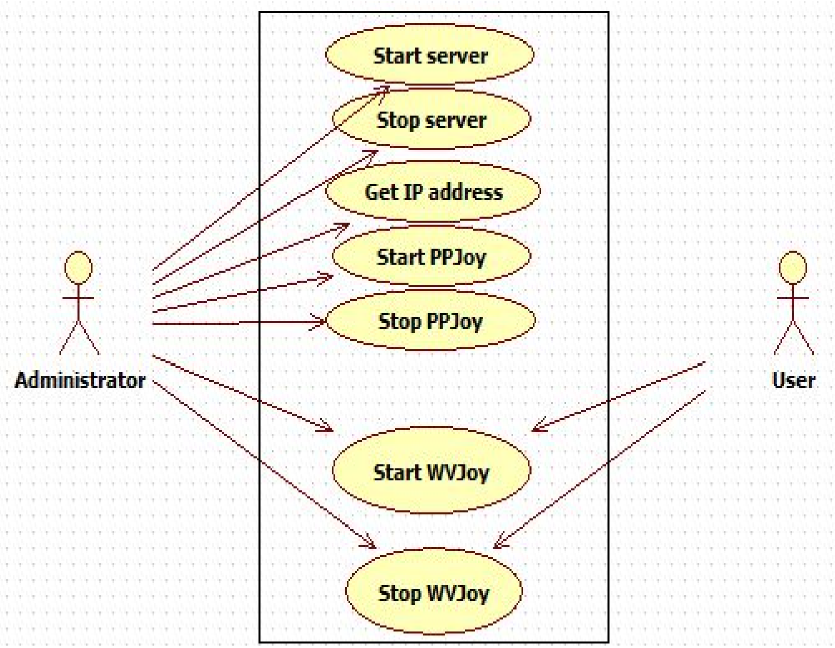


***Figure 1**. Use case diagram of WVJoy*

3.2.3 Flow chart

There are 3 initiate points in this figure. Normally it starts with the Start web server. If this step has any problem (only possible when web container crashes), the server computer owner has to fix it first. Otherwise the whole project will not work.

The following chart is a capture of the flow chart.

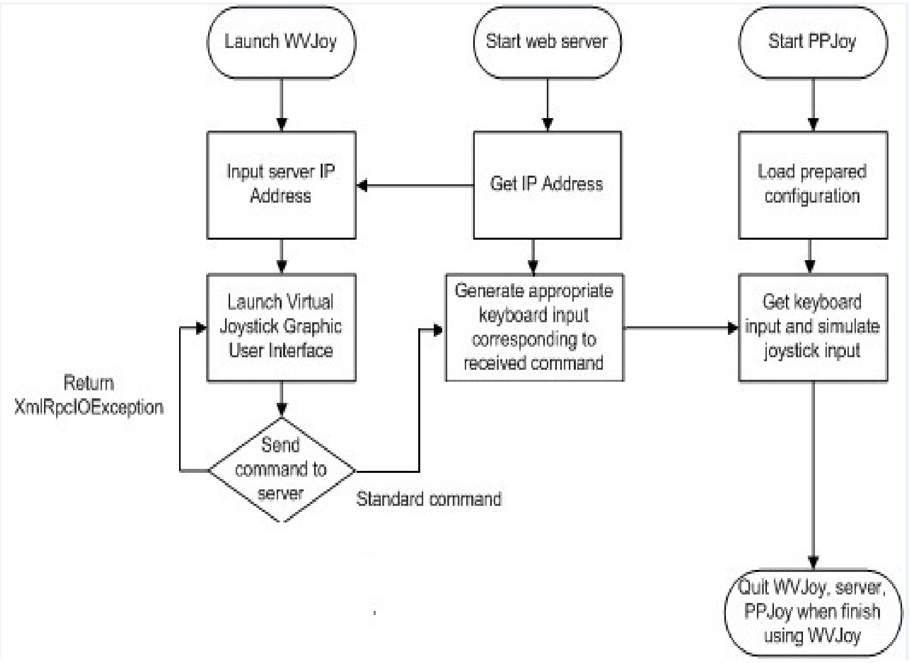

Launch WVJoy
Start web server
Start PPJoy
Input server IP Address
Get IP Address
Load prepared configuration
Launch Virtual Joystick Graphic User Interface
Generate appropriate keyboard input corresponding to received command
Get keyboard input and simulate joystick input
Return XmlRpcIOException
Send command to server
Standard command
Quit WVJoy, server, PPJoy when finish using WVJoy

Figure 2. *Flow chart of WVJoy*

4. GUI DESIGN

There are 2 GUI designed for WVJoy application. When user launch WVJoy application, the screen will display 2 text fields with hint information and a submit button. After user filled the web service information, WVJoy will direct to a joystick GUI.

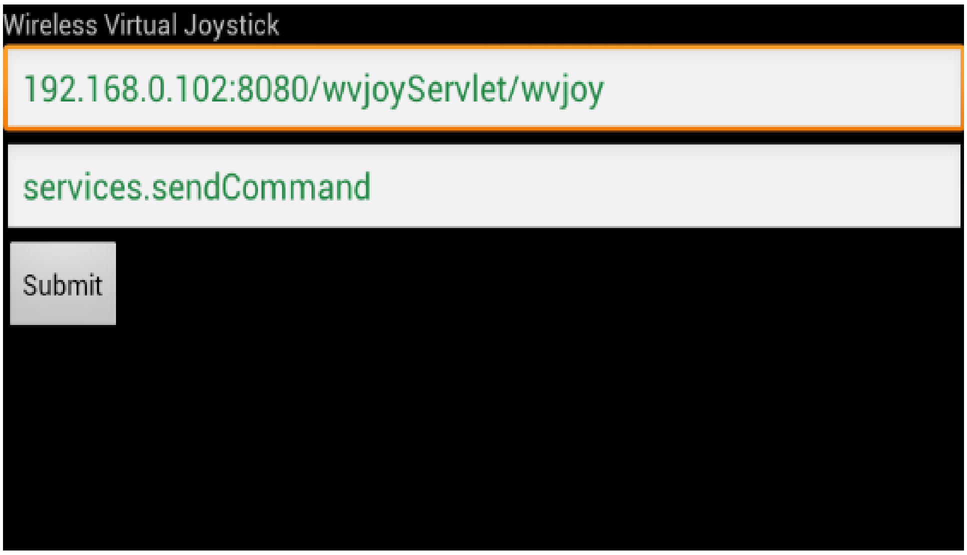
There is a constraint with the mobile device that the touch screen resolution has to be at least 640 * 320. This is caused by the design of the joystick GUI. If the screen resolution is exactly 640 * 320, the UI components will take every corner of the screen, there is no space left at the border. I suggest using 800 * 480 similar resolution mobile devices. The UI components will be displayed at perfect position. If the screen resolution is more than 1200 * 800, those UI components will look a little bit smaller, and not easy to press at right position.

4.1 Web service connection information submit activity

The first text field is the XML – RPC server url address. The second text field is the function to be called in the server.

This GUI could be much simpler than this. It could only acquire the IP address and port number. But in this case, if the server is upgraded later, for example, develop another XML – RPC server with different functions, WVJoy is not able to access to the new server. That is the reason there are 2 text fields acquire boring information.

The following graph is a screen capture of WVJoy connection information submits GUI.



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192.168.0.102:8080/wvjoyServlet/wvjoy

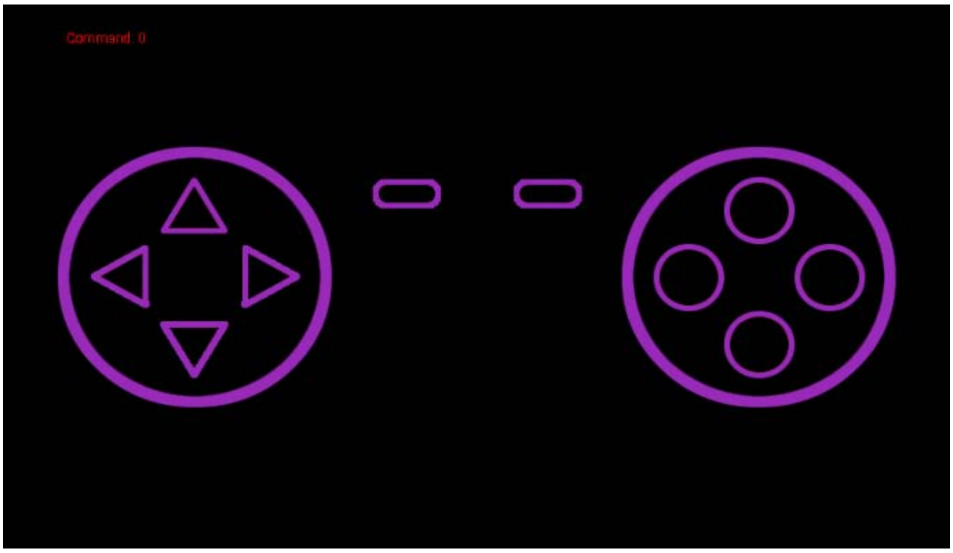
services.sendCommand

Figure 3. *WVJoy Launch Activity GUI*

4.2 Joystick activity

There are 10 buttons in this GUI. No “hidden button” exists. 4 direction buttons, 4 normal buttons, 1 select button and 1 confirm button (actually they are just 2 more normal button, we just get used to call them select button and confirm button). There are 2 big bold purple circles, they are just background to let this GUI looks similar to real joystick.

The following graph is a screen capture of the WVJoy joystick GUI.



Command: 0

Figure 4. *WVJoy Joystick Activity GUI*

Here is a table display all those UI component's size properties.

***Table 3**. UI components size*

UI components size property	
UI	**Size (pixel)**
JoyButtonLeft	**60 * 60**
JoyButtonDown	**60 * 60**
JoyButtonRight	**60 * 60**
JoyButtonUp	**60 * 60**
JoyButton1	**60 * 60**
JoyButton2	**60 * 60**
JoyButton3	**60 * 60**
JoyButton4	**60 * 60**
JoyButtonSelect	**60 * 30**
JoyButtonConfirm	**60 * 30**
JoyBigCircleLeft	**240 * 240**
JoyBigCircleRight	**240 * 240**

There is a row of text displayed at the top of the screen. It is the message received from the server. When everything is fine, the received message should be a 16 bit hex number. If there is some problem with connecting the server, then the text will be the error information about the web service connection. This row of text is always displayed on the left top of the screen with a certain distance to the corner. No matter what is the screen resolution of the device, the distance remains same value all the time.

Assume the mobile device is a 640 * 320 screen resolution smart phone. JoyBigCircleLeftWidth + JoyButtonSelectWidth + JoyButtonConfirmWidth + JoyBigCircleRightWidth = 240 + 60 +60 +240 = 600. There will be only 20 pixel space left on each side of the GUI.

In this GUI, WVJoy will always acquire device information of screen width and height at the beginning in order to calculate the center point coordinate. After it, WVJoy will calculate the JoyButtonSelect, JoyButtonConfirm, JoyBigCircleLeft, and JoyBigCircleRight coordinates compare with the center point coordinate. At last, WVJoy calculates the coordinates of direction buttons and normal buttons compare with JoyBigCircleLeft and JoyBigCircleRight. All these coordinates of UI is the left top coordinate of it.

If the mobile device is 480*240 screen resolution, both JoyBigCircleLeft and JoyBigCircleRight will miss some part.

This Application supports multi points touch control. The limitation of the number of point is mostly determined by the mobile device hardware. Some devices can only support 2 point multi point control, but some devices can support 10 point multi point control. The application limitation is 5 points. If the device supports 10 points multi point control, WVJoy will only send messages to the server and tells the information about the first 5 pressed buttons.

5. IMPLEMENTATION

Here is the detail of this project development procedure. First part is the general description of it. The second part will go through with each important code snippet.

5.1 General description of implementation

In the beginning, 1 month was spent to design the prototype for this project. The consideration was about smart phone platform selection, mobile device constraint factors, target server computer operating system requirement, similar usage application completion, application available period, technology used for transmitting data between smart phone and target computer, validity and reliability of this project specifying method, implementation period of this project, and obstacles there might be

After all these complex factors had been figured out one by one, coding was started from the smart phone application, to data communication, and to the input signal simulation. The smart phone application part is the most complex and challenging part.

5.2 Implementation of different parts

The coding can be separated into 4 parts as follows:

- Android application GUI
- Web service data communication
- Input signal simulation
- Message between mobile device and server

5.2.1 Android application GUI

For the first part, the Android application, about a month was spent on learning how to develop an application for Android. During this time, building development environments for Android, compile and test with downloaded sample projects and write test application programs was figured out. After that, design a joystick GUI used 1 week. Android components are able to establish the GUI, but the performance is really low. It could only generate signal input once every second. That is not acceptable. In the end, mySurfaceView was the solution to develop the GUI Activity. Most of Android games are using this method to plot their UI components, this method is has excellent performance.

After testing with different Android smart phones and Tablets, finally, the design of Joystick GUI Activity was determined with 640*320 screen resolution size standard. If the screen resolution is smaller than it, the GUI will be not able to show all the UI components. If the screen size is exactly 640*320 standard, the GUI will take full size of the screen. If the screen size is larger than 640*320, there will be some space left out at each border, it will look better, and all UI components will still locate at the center of the screen. If the screen resolution is too larger than 640* 320, the UI components will be looking a little bit small and hard to control.

Before plotting these UI components, first of all, acquire the screen size from the smart phone.

Secondly, calculate its center point coordinate with (screenWidth / 2, screenHeight / 2).

Thirdly, give each WVJoy UI component a coordinate comparing with the center point of the device. Plot them on the canvas.

The following code demonstrates how to acquire screen size and how to draw them on the canvas.

```
float centerX=MySurfaceView.screenW/2;
float centerY=MySurfaceView.screenH/2;
...
//draw JoyBigCircleLeft
canvas.drawBitmap(joystick_roundImg, pJoyLeftUp1.x, pJoyLeftUp1.y, paint);
...
//draw button LEFT
matrix.setTranslate(pLeft.x, pLeft.y);
canvas.drawBitmap(joystick_leftImg[isFocused[JOYSTICK_LEFT]], matrix, paint);
```

Snippet 1*. Acquire screen size and draw UI on the canvas*

After all those UI components have displayed correctly. WVJoy need to detect touch event from a mobile device. Whenever the system detects a touch event, no matter it is a move event or press / release event, call a “position check” function to figure out if there is a button pressed or released and which button it is.

The following code demonstrates how to detect touch events and how to check which position is being pressed / released.

```
//check touch point area
public void touch(MotionEvent event){
    int pointerCount = event.getPointerCount();

//if touch point more than MAX_TOUCHPOINTS, set pointerCount=MAX_TOUCHPOINTS
    if (pointerCount > MAX_TOUCHPOINTS) {
        pointerCount = MAX_TOUCHPOINTS;
    }
...
for (int i = 0; i < pointerCount; i++) {
            float x = event.getX(i);
            float y = event.getY(i);
            PointF p = new PointF(x, y);
            switch (event.getAction()) {

            case 0:         // ACTION_DOWN
            case 5:         // ACTION_POINTER_1_DOWN
            case 261:   // ACTION_POINTER_2_DOWN
            case 517:   // ACTION_POINTER_3_DOWN
*/          case 2:         // ACTION_MOVE
                if (PositionCheck.inRectangle(p, pLeft, pDown)) {
        //Do anything you want at JoyButtonLeft
                        ...
                }
...
}



//check touch point position
public static boolean inRectangle(PointF pos, PointF posA, PointF posB) {
        //check whether touch point in rectangle area or not
   if (pos.x>posA.x && pos.x<posB.x && pos.y>posA.y && pos.y<posB.y) {
           return true;
       }else{
       return false;
       }
    }
```

Snippet 2. *Specify touch point position*

After touch events have been detected, I will set up a button statement parameter and modify the message which is going to be sent to the server. When button statement changes, the image resource change too so that the button will change a color and user will understand the button is being pressed down.

The following code shows how to implement these changes.

```
...
else if (PositionCheck.inRectangle(p, pDown, pDownRightBottom)) {           //Button down
            msg |= 0x4000;
            }
...
public void updateJoystickStatus(){

      if((msg & 0x8000) == 0x8000){
                  isFocused[JOYSTICK_LEFT]=1;
      }else{
            isFocused[JOYSTICK_LEFT]=0;
}
...
}
```

***Snippet 3**. update message when button pressed and change button press state*

5.2.2 Web service data communication

Android has its own web service API. Different with normal Java web service API, it is not a packaged jar file. It is a package of source code. I downloaded it from Google Code and directly imported it into my Android project, and then it works.

The following code demonstrates how to use this API to call the XML - RPC function and send message to the server. It is integrated in the draw function so that every time the canvas refreshes, WVJoy will send a message to the server.

```
//xml rpc connection
try{
      XMLRPCClient client = new XMLRPCClient(url);
      showMsg = (String)client.call(xmlRpcService, msg);
      } catch (XMLRPCException e) {
                  showMsg = e.toString();
      }
```

***Snippet 4**. Use Android XML - RPC API to build connection with the server*

The server side is written with normal Java XML - RPC servlet standard. It receives messages from client continuously and return messages simultaneous. The API is from Apache.

The following code demonstrates how to receive messages from client devices and what message is going to return.

```
public String sendCommand(int command){

    int cmd=0;

    if(command!=0){
        try{

            if((command&0x8000)!=0){
                //Do anything you want at here
                ...
            }
        }catch(AWTException e){
            return e.toString();
        }
    }
    return "Command: "+ Integer.toBinaryString(command);

}
```

Snippet 5*. XML – RPC servlet*

It was weird when the XML - RPC web service has been done. The application does not work properly and there is no error or warning. After a few days effort, finally it was confirmed that Android application needs the Internet access permit. It has to be configured in the AndroidManifest.xml file as follows.

```
<uses-permission android:name="android.permission.INTERNET"></uses-permission>
```

Snippet 6*. Internet access permit configuration*

With this Internet access permit, WVJoy can send and receive messages correctly.

5.2.3 Input signal simulation

PPJoy is famous virtual joystick simulation software. It can receive keyboard or mouse input and generate joystick input. After install this software, PPJoy will create a virtual joystick driver in Windows system. If there is any keyboard input on the target server computer, PPJoy will detect the input and generates joystick input corresponding to the PPJoyKey configuration.

Java has a function named Robot. It has been available since JDK 1.3 version. Using this method, it is easy to generate keyboard input at the target server computer. But there is a problem: it could generate correct text to application files such as txt file, and docx. But PPJoy could not detect any input signal from it. Explore the reason is not simple. After a few days, the reason was founded. Java is based on the JVM and the input is based on the JVM, too. The JVM can detect the input, but Windows cannot. In the end, a dll file was written in C++ using Visual Studio in order to replace the Robot function. Put it under C:/Windows/System32/ folder, and use JNI technique to integrate it into the XML – RPC server. It works well.

The following code demonstrates how does the dll file works and how to call it from the XML – RPC server.

```
JNIEXPORT void JNICALL Java_handlers_CommandHandler_kbdEvent(JNIEnv *, jobject, jint i)
  {
        keybd_event(i,0,0,0);
        keybd_event(i,0,KEYEVENTF_KEYUP,0);

        return;
  }
```

Snippet 7*. dll file main content*

```
public native void kbdEvent(int command);

      static{
          System.loadLibrary("kbdEvent");
      }

...
if((command&0x8000)!=0){
//in windows.h, VK_LEFT=0x25, it will generate a direction left keyboard press and release event
      cmd=0x25;
      kbdEvent(cmd);
}
...
```

Snippet 8*. XML – RPC servlet use JNI to load dll file and call its function*

5.2.4 Message between mobile device and server

Even though there is no need to write a virtual joystick driver for Windows system, Understands how does a virtual joystick work is significant. In this project, the message format definition was borrowed from the joystick driver signal input message format. The message between mobile device and server is a 16 bits binary variable (unsigned int) and it changes in String format when transmitting to the server. The first 4 bits are corresponding to buttonLeft, buttonDown, buttonRight, and buttonUp. The next 4 bits are button0, button1, button2, button3. The following 2 bits are button4, and button5. Normally it is known as switch button and confirm button. There are 6 bits left still. They are not in use at this moment. They are designed for extended keys. If there is a need to improve this GUI, put more buttons there, this “protocol” does not need any modification. Directly add some buttons, and use the rest bits to transfer commands is enough.

When no key is pressed, the message is always 0000 0000 0000 0000.

When button left and button0 are pressed, the message is 1000 1000 0000 0000.

After the server receives messages correctly from a client, it will return a same message. If there is any connection error or warning, the server will return the error or waning detail to the mobile device client and the joystick GUI will display it at the top of the screen.

This command message transferring is triggered every time the Android canvas refreshes. It means it will cause 16 * canvasRefreshFrequency * 3600 bits data uploading amount per hour. Assume the canvasRefreshFrequncy is 100, 720Kb data will be transferred in 1 hour. Nowadays, the 3G network is good enough, 720Kb per hour (0.2KB/second) is almost ignored by users.

Android supports multi point of touch, but different mobile devices have different limitations. Anyway, all of them can support at least 2 point multi-point touch control. That is enough for the basic control of this simple WVJoy. Nowadays, most new mobile device products can support at least 5 point multi-point touch control. This means WVJoy can have excellent performace in most mobile devices currently. Due to 5 buttons control is enough already at this version, this project set a maximum touch point limit to 5. The value has been used in the Snippet 2.

6. TESTING

Test code frequently, carefully, and systematically is necessary for programming work. Every time an isolated part of the code has been completed, programmer should test it. When some prototype or important part has been done, there are a lot of different tests. For example, α test, β test, and QA test. In this project, since it is not a heavy weight application, the test had been separated into 5 cases.

6.1 Test cases

There are 5 different cases need to be tested. The first one is GUI test. If the GUI is not stable, the joystick performance cannot be stable too. A good GUI should be reliable and user – friendly.

The second test is the web service communication test. If messages cannot be updated simultaneously and continuously, the joystick cannot have good performance.

The third one is a server input simulation test. It must be confirmed that the server can generate correct keyboard input to let PPJoy detects. This procedure should not have many problems. Once the server works fine, it will always perform pretty well.

The 4th one is the compatibility test. After the previous 3 test, WVJoy should have been confirmed that it can work well already. But there are too many different Android devices. There might be a lot of special cases unexpected. That is the reason compatibility test is always important to software developers.

The last test is the last confirmation of its validity. Combine the previous 4 tests together, and try to find any factor could influence its performance or reliability. After the previous 4 tests, there must be some unexpected factors founded and possible to improve. When this test has been done, the whole project is ready to prepare to publish. This validity test can be regarded as the QA test.

6.2 Detailed description of the procedure in each test case

The following content records this project testing procedure with each case in detail. Due to this project involves with Android device, XML – RPC servlet, and PPJoy software, the test is not a simple job.

6.2.1 GUI Test

Before starting to program this project, it was already prepared for upgrade server when necessary. With this consideration, there are 2 text fields at the web service connection information submit Activity (GUI). Testing this application and fill in the connection information again and again is a very boring job. But meanwhile, it provides a convenient way to change server when testing with different servers. In the end, this design has been kept.

At the beginning of this project, trying with Android components to develop the Joystick GUI seems to be pretty easy. Replace the Android Button pattern and use it to trigger the message sending procedure. After a little test, this method is discarded since Android Button can only trigger once per second in average. That is far away from the expectation. After abandoning that method, another way "mySurfaceView" was figured out and successfully deployed a new joystick GUI. This new GUI looks very good, and the performance has been proved well enough after a lot of tests.

6.2.2 Web service communication test

This test includes 2 parts. The first part is to test its communication efficiency with a WLAN connection. The method used to determine the efficiency is: open any text edit tool and press some key at WVJoy, The more keyboard input appears, the better efficiency it is. The final result shows that the communication efficiency within WLAN is excellent and the process is very stable all the time.

The other part of this test is to give the server computer a WAN IP address, let the mobile device use 3G network to connect to the server. Test the efficiency with the method mention above, and observe the result. The final result shows the 3G network is not reliable enough. In conclusion, WLAN connection has better quality than 3G connection.

6.2.3 Server input simulation test

Differences with data communication testing, server input simulation test is focusing on the test with performance of PPJoy. Whether PPJoy can generate joystick input with the same frequency of the server keyboard input is needed to be confirmed. In DirectX API /11/, there is a DirectInput joystick C++ sample code. The released executable application can continuously update the first joystick statement and information that system detected. The refresh rate is very frequently. This test result can be seen clearly that the joystick signal input is generating quick enough.

6.2.4 Compatibility test

After the previous 3 steps of testing, the project is generally acceptable already. But different devices always have different problems, test the application with different device is always necessary. There were 2 smart phones (SUMSUNG GALAXY S1 / S3) and 1 tablet (Nexus) used in this test. The good thing is there was no problem in this process. There is a little difference with the UI component positions. But it does not influence its performance at all. If the device hardware is better, the performance is better. In this test, the tablet is best performed with quality.

6.2.5 Validity test

In the end, test this project with any case it might happen. In conclusion of the test result, when WVJoy launched, do not fill in wrong server connection information. It will make the device stuck for a while. Besides, do not use the “return” button of Android in the joystick GUI, sometimes it will cause the application stop working. These two bugs are the most annoy cases. Unfortunately, there is no good solution to fix them yet.

In fact, some Java Swing executable application XML – RPC server was used for the test a lot of times. In this way, there is no need for a web container, and very convenient to use. But it was abandoned in the end since there are some serious compatibility problems between JDK1.7 / JRE7 and JDK1.6 / JRE6. Sometimes when testing with different computers, due to that reason, the server cannot run. Even if uninstall the JRE7 and reinstall the JRE6 cannot help. This project is expected to be very reliable, the Java Swing XML – RPC server was abandoned at the end.

6.3 Possible improvements after test

There are a lot of factors can be improved in the future. The most important 3 are: make a reliable Java Swing XML – RPC server after the compatibility problems solved; add a stop web service connection function in the joystick GUI in order to avoid the device stuck or stop working when return button is clicked; add some extra button when needed.

7. SUMMARY

WVJoy is an application for Android users who need a joystick. It provides a convenient solution for users to get a “joystick” with an Android mobile device. The original purpose was only for the VAMK robot team, but in the end, this application can work like a normal joystick for almost all computers already. It is much more practical and powerful than the original purpose. All the functions expected at the beginning have been fulfilled. All goals and objectives are achieved.

7.1 Project implementation procedure

The process of implementing this project can be summarized as following:

- Consider with project usage purpose, function and area.
- Analyze project objectives and obstacles.
- Design the project in detail.
- Manage technique involved in this project and start programming.
- Test this project.
- Revise and make specification for this project.

7.2 Most challenging part of this project

There were 2 most challenging part in the development process. The first one is the Android UI performance.

At the beginning, use Android components such as button, to trigger the message send to the server was expected to perform well. When it has been done, the frequency of sending a message is too low in the test result. It was far away from the expectation. Holding a real keyboard key for 1 second, the system normally can detect more than 10 times of input. After 1 month of patient self-study, the use of mySurfaceView was managed and the joystick GUI was developed with it very soon. It was patience overcame this obstacle.

The second challenge is the simulation of keyboard input. Java Robot function is very easy to use. So this function was used to simulate keyboard input at the beginning. Any text edit tool is OK to get the keyboard input. But unfortunately, PPJoy cannot detect any keyboard input so that there is no possibility to generate corresponding joystick input. After a few days trying, the reason was founded. At last, use JNI to integrate a piece of C++ code into the server was the final solution. The keyboard input signal simulation had been completed successfully.

8. CONCLUSIONS

WVJoy was designed to be implemented with either iOS or Android platform. Now the Android operating system can run WVJoy very well already. Although the server side is a little bit complex, I used a web container such as tomcat 6 /12/, to hold the XML – RPC server (servlet) in order to provide a reliable web service, all the functions expected have been successfully carried out by a lot of effort. The project has been implemented very well.

The main purpose of doing this project is not only to make a good application, but also practice the self–study ability. After a few months of programming day and night, the self-study ability is improved significantly. The most important goal of developing this project is achieved.

8.1 Future work, ideas for improving the application

After the project is tested and ready, there are a few ways to improve the application in the future founded.

First of all, the XML – RPC server could be improved. It could provide some different set of keyboard input. Or even custom define keyboard input set. In this way, the application can avoid some keyboard input confliction with some other application.

Secondly, the PPJoy also possible to detect mouse input and generate corresponding joystick input. Develop another XML – RPC server to simulate mouse input is possible. The advantage of this is also avoiding keyboard input confliction.

Thirdly, a terminate web service button is needed in the joystick GUI, when user click on this button. It can stop the web service communication. The user can either return to connection GUI or quit WVJoy quickly without any bug or stuck.

At last, if there is more button needed, it is possible to place some buttons else on the GUI. Since most of Android devices have something like gravity sensor, speed sensor, location sensor, and direction sensor. It is possible to create some “hidden button” with these sensors.

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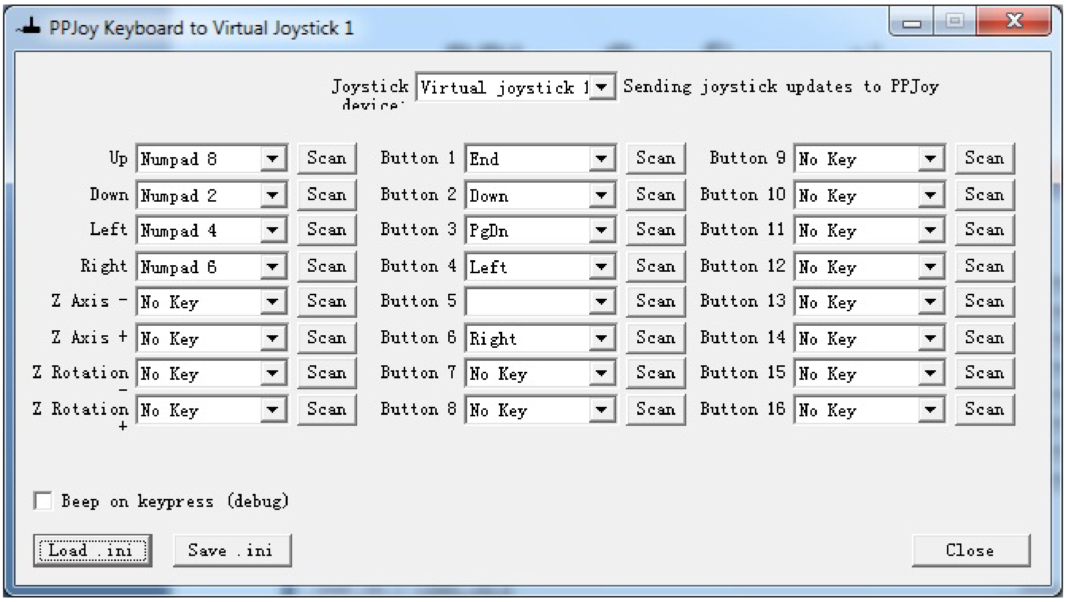
APPENDIX 1

Capture of PPJoy configuration



PPJoy Keyboard to Virtual Joystick 1

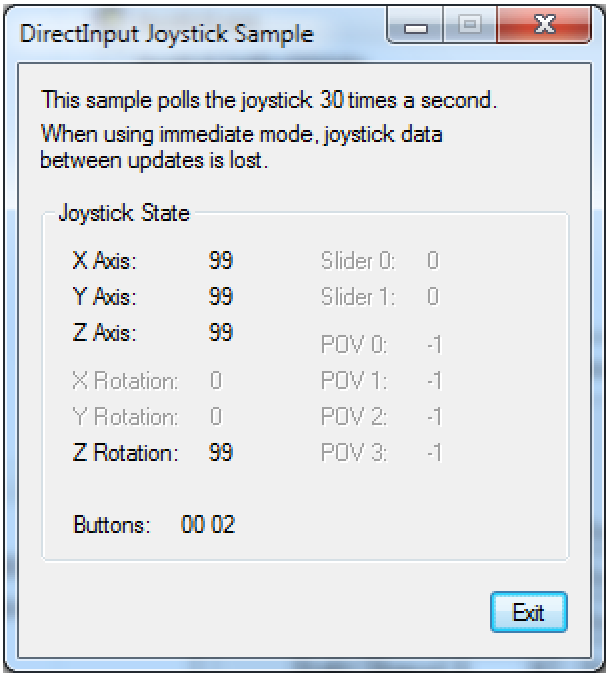
Joystick device: Virtual joystick 1 Sending joystick updates to PPJoy

Up	Numpad 8	Scan	Button 1	End	Scan	Button 9	No Key	Scan
Down	Numpad 2	Scan	Button 2	Down	Scan	Button 10	No Key	Scan
Left	Numpad 4	Scan	Button 3	PgDn	Scan	Button 11	No Key	Scan
Right	Numpad 6	Scan	Button 4	Left	Scan	Button 12	No Key	Scan
Z Axis –	No Key	Scan	Button 5		Scan	Button 13	No Key	Scan
Z Axis +	No Key	Scan	Button 6	Right	Scan	Button 14	No Key	Scan
Z Rotation –	No Key	Scan	Button 7	No Key	Scan	Button 15	No Key	Scan
Z Rotation +	No Key	Scan	Button 8	No Key	Scan	Button 16	No Key	Scan

□ Beep on keypress (debug)

APPENDIX 2

Capture of testing PPJoy input



DirectInput Joystick Sample

This sample polls the joystick 30 times a second.
When using immediate mode, joystick data between updates is lost.

Joystick State

```
X Axis:       99       Slider 0:   0
Y Axis:       99       Slider 1:   0
Z Axis:       99
                       POV 0:     -1
X Rotation:   0        POV 1:     -1
Y Rotation:   0        POV 2:     -1
Z Rotation:   99       POV 3:     -1

Buttons:    00 02
```

APPENDIX 3

WVJoy User Manual

1. Requirements:

a) Win XP / Win 7 as server.

b) Android 2.2.x or higher version mobile phone.

2. Installation:

Step 1: Install JRE (Java runtime environment) 1.6 or higher version.

You can download JRE from official website:

http://www.oracle.com/technetwork/java/javase/downloads/index.html

Step 2: Install Tomcat 6.0 or higher version.

You can download Tomcat from official website:

http://tomcat.apache.org/download-60.cgi

Step 3: Install PPJOY

You can download PPJOY 64bit version from PPJOY author’s official website:

http://ppjoy.blogspot.com/2009/11/finally-new-version.html

You can find the 32 bit version in the installer package.

PPJOY user manual can be found in the $(PPJoySetup/Doc/PPJoyMain.html).

Step 4: Install WVJoy.apk to your android phone

Before installing WVJoy.apk to your mobile phone, select Unknown sources under folder: Applications/Settings/Applications/

Step 5: Copy “kbdEvent.dll” to folder $(Windows/system32/).

3. Test

a) Server side:

(1) Start Tomcat, copy “wvjoyServlet.war” to folder: $(tomcat/webapps/).

(2) Run “cmd”, type “ipconfig” to acquire your ip address.

(3) Run “PPJoyKey”.

b) Client side:

(1) Start WVJoy application, type corresponding server address and service method.

(2) Configure PPJoyKey input, and use WVJoy as normal joystick.

APPENDIX 4

Configuration for Android development environment

(Source: http://developer.android.com/sdk/installing/index.html)

You should have already downloaded the Android SDK Tools. (If you downloaded the ADT Bundle, you should instead read Setting Up the ADT Bundle.)

The SDK Tools package is not the complete SDK environment. It includes only the core SDK tools, which you can use to download the rest of the SDK packages (such as the latest system image).

Your download package is an executable file that starts an installer. The installer checks your machine for required tools, such as the proper Java SE Development Kit (JDK) and installs it if necessary. The installer then saves the Android SDK Tools into a default location (or you can specify the location).

- Double-click the executable (.exe file) to start the install.

- Make a note of the name and location in which it saves the SDK on your system—you will need to refer to the SDK directory later, when setting up the ADT plugin and when using the SDK tools from the command line.

- Once the installation completes, the installer offers to start the Android SDK Manager. If you'll be using Eclipse, do not start the Android SDK Manager, and instead move on to installing the Eclipse plugin.

- If you're using a different IDE, start the SDK Manager and read Adding Platforms and Packages.

Installing Eclipse Plugin

Download the ADT Plugin

- Start Eclipse, then select *Help* > *Install New Software*.
- Click *Add*, in the top-right corner.
- In the Add Repository dialog that appears, enter "ADT Plugin" for the *Name* and the following URL for the *Location*:

  ```
  https://dl-ssl.google.com/android/eclipse/
  ```

- Click *OK*.
- If you have trouble acquiring the plugin, try using "http" in the Location URL, instead of "https" (https is preferred for security reasons).
- In the Available Software dialog, select the checkbox next to Developer Tools and click *Next*.
- In the next window, you'll see a list of the tools to be downloaded. Click *Next*.
- Read and accept the license agreements, then click *Finish*.
- If you get a security warning saying that the authenticity or validity of the software can't be established, click *OK*.
- When the installation completes, restart Eclipse.

Configure the ADT Plugin

Once Eclipse restarts, you must specify the location of your Android SDK directory:

- In the "Welcome to Android Development" window that appears, select Use existing SDKs.
- Browse and select the location of the Android SDK directory you recently downloaded and unpacked.
- Click “Next”.
- Your Eclipse IDE is now set up to develop Android apps, but you need to add the latest SDK platform tools and an Android platform to your environment. To get these packages for your SDK, continue to Adding Platforms and Packages.