Android Sensor Framework

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Outline

- Introduction of Android System
  - Four primary application components
  - AndroidManifest.xml
- Introduction of Android Sensor Framework
  - Package
  - Interface
  - Classes
- Examples of Using Accelerometer
  - Using background Service
  - Using foreground Activity

Introduction

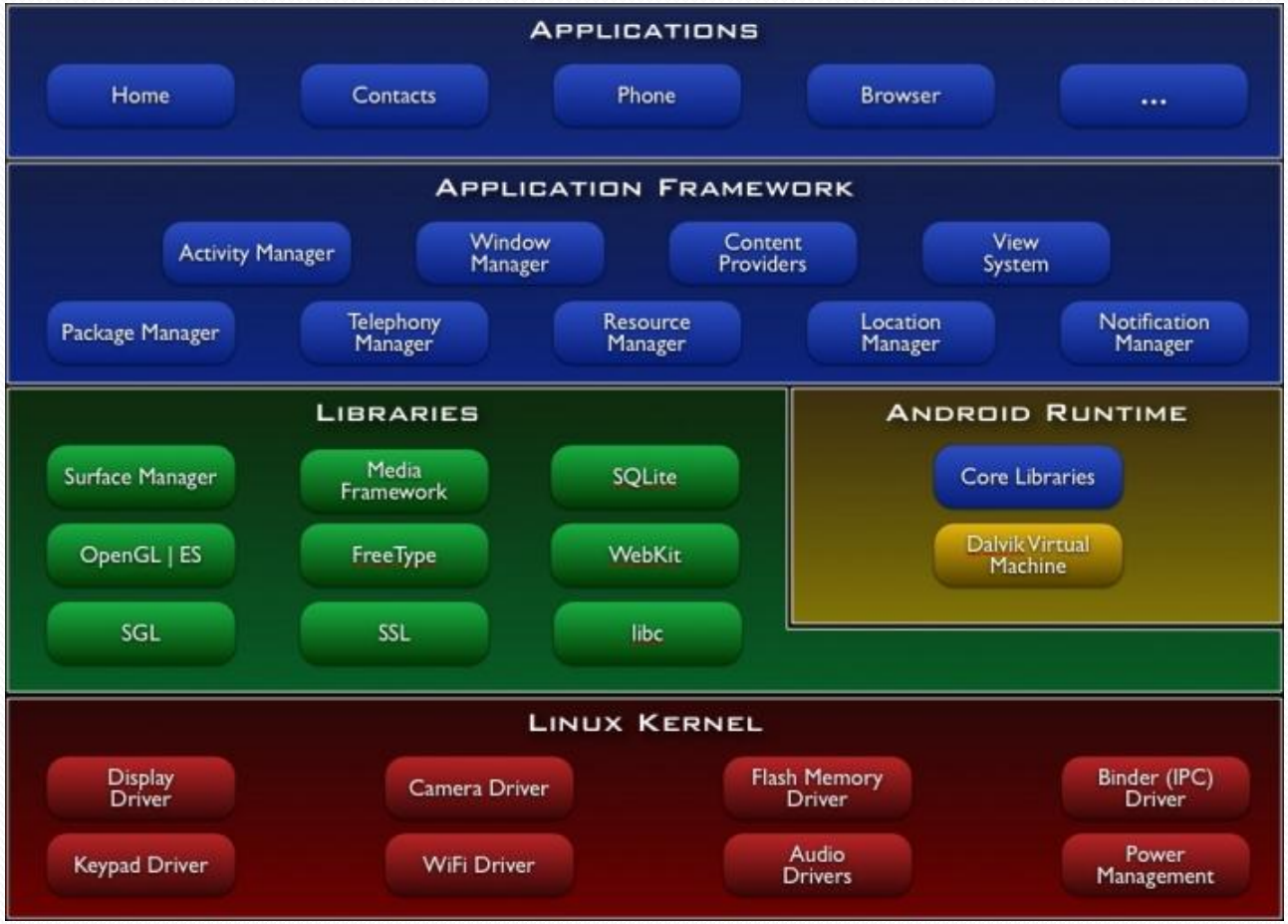
- Android Inc. is acquired by Google in 2005.
- Open Handset Alliance was established and Android was announced in 2007.
- The first Android handset and source code was released in 2008.
  - Open and comprehensive platform for mobile devices.
  - Platform is powered by Linux.

Android Version History

Version	Release Date	Linux Kernel	Selected Key Updates
1.x	Sep 2008 – Sep 2009	2.6.23/ 27/29	Camera, WiFi, and Bluetooth supported.
2.x	Oct 2009 – Dec 2010	2.6.29/ 32/35	Bluetooth 2.1, API changes, system speed, memory, and performance optimizations, media support, video chat.
3.x (Honeycomb)	Feb 2011 – Jul 2011	2.6.36	The first SDK release for tablet computers. Motorola Xoom tablet is the first device featuring this version.
4.x (Ice Cream Sandwich)	Oct 2011	3.0.1	Face Unlock, Wi-Fi Direct. Galaxy Nexus is the first device featuring this version. added facial recognition, social networking, information sharing, and other features.

Android Architecture

- This diagram shows the major components of Android operating system.



http://developer.android.com/guide/basics/what-is-android.html

Android Architecture

- Android software layers consists of:
  - Linux
    - Provides process and memory management, security, networking, and device drivers.
  - Libraries
  - Runtime
    - Dalvik VM
  - Application Framework
    - provides services to applications, such as notification and activity managers. These are all implemented as Java classes.
  - Applications
    - Component-oriented and integration-oriented

Android Application

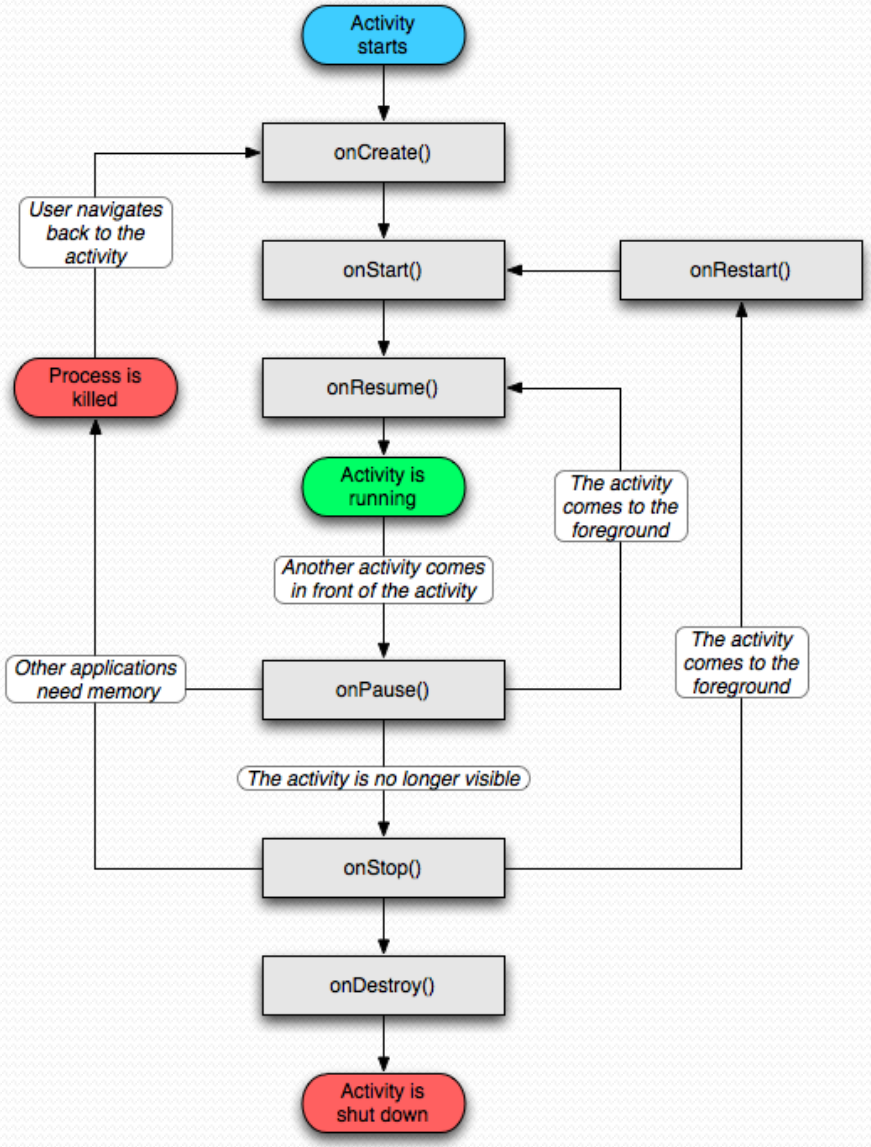
- Written in Java programming language.
- Packaged into a .apk file.
- Runs isolated in its own VM.
- Composes of one or more application components.
- Starts the components when needed.
- Ends the components when no longer needed.

Application Components

- Android process has four primary components:
  - Activities
    - a component that provides a user interface, e.g. send an email.
  - Services
    - a component that can perform long-running background operations without user interface.
  - Content providers
    - a component that manages application data
  - Broadcast receivers
    - a component that responds to system-wide broadcast announcements.

Activities

- Android is sensitive to the lifecycle of an application and its components.
- Android provides callbacks to process state changes.
- Lifecycle callbacks for an activity
  - onCreate()
    - OnStart()
    - OnRestart()
      - OnResume()
      - OnPause()
    - OnStop()
  - onDestory()



http://developer.android.com/guide/topics/fundamentals/activities.html

Services

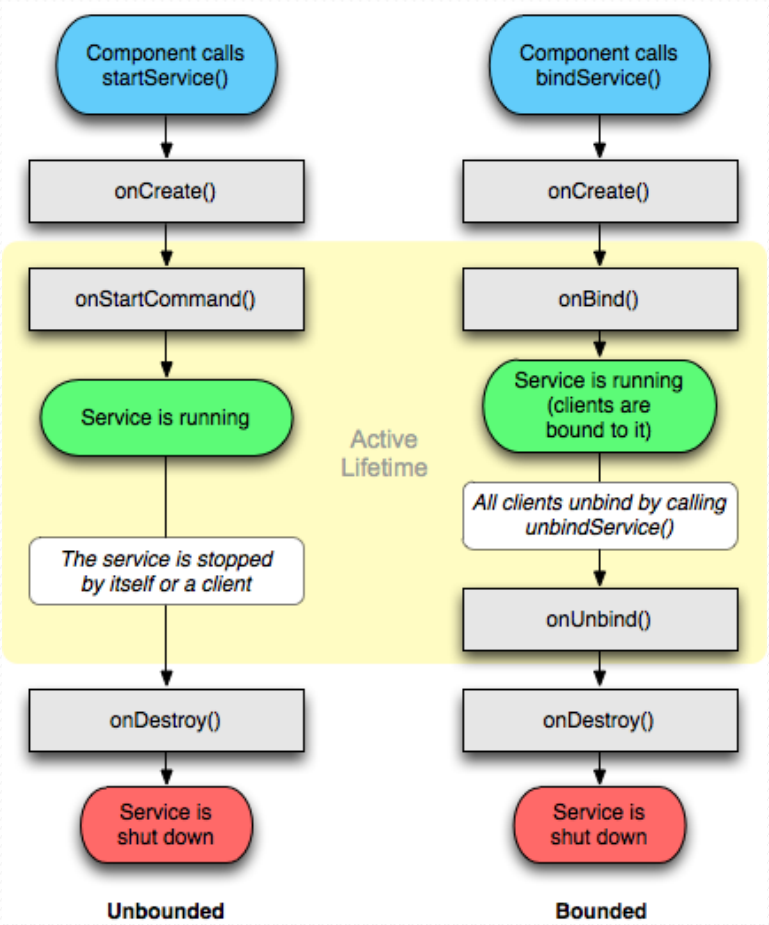
- A service runs in the background.
- A service needs to be declared in the mainifest

```
<manifest ... >
  ...
  <application ... >
     <service android:name=".ExampleService" />
     ...
  </application>
</manifest>
```

- Services can be started with Context.startService() and Context.bindService().
- Service will only stop when Context.stopService() or stopSelf() is called.
- Context.bindService() can be used to obtain a persistent connection to a service.

Service Lifecycle

- Service lifecycle callback methods are used to monitor changes in a service's state.
  - onCreate()
  - onStartCommand()
    - Or onBind() and onUnbind()
  - onDestory()



http://developer.android.com/guide/topics/fundamentals/services.html

Content Providers

- Content providers store and retrieve data.
- android.provider package
- The information needed to query a content provider,
  - URI to identify the provider
    - A Uniform Resource Identifier that identifies an abstract or physical resource
  - The name of the data fields
  - The data types of the fields
    - Audio, video, images…

Broadcast Receivers

- BroadcastReceiver object is only valid during the call to onReceive().
- Once onReceive() returns, BroadcastReceiver is no longer active, and system will consider its process to be empty and kill the process.
- Therefore, for long-running operations, Service and BroadcastReceiver should be used together to keep the process active.

The Manifest File

- Every application must have an AndroidManifest.xml file (with precisely that name) in its root directory.
- AndroidManifest.xml defines all the components, contents and behavior of the application, e.g. activities and services.

```
<application>
    <activity/>
    <service/>
    <receiver/>
    <provider/>
</application>
```

- xml class will parse the contents

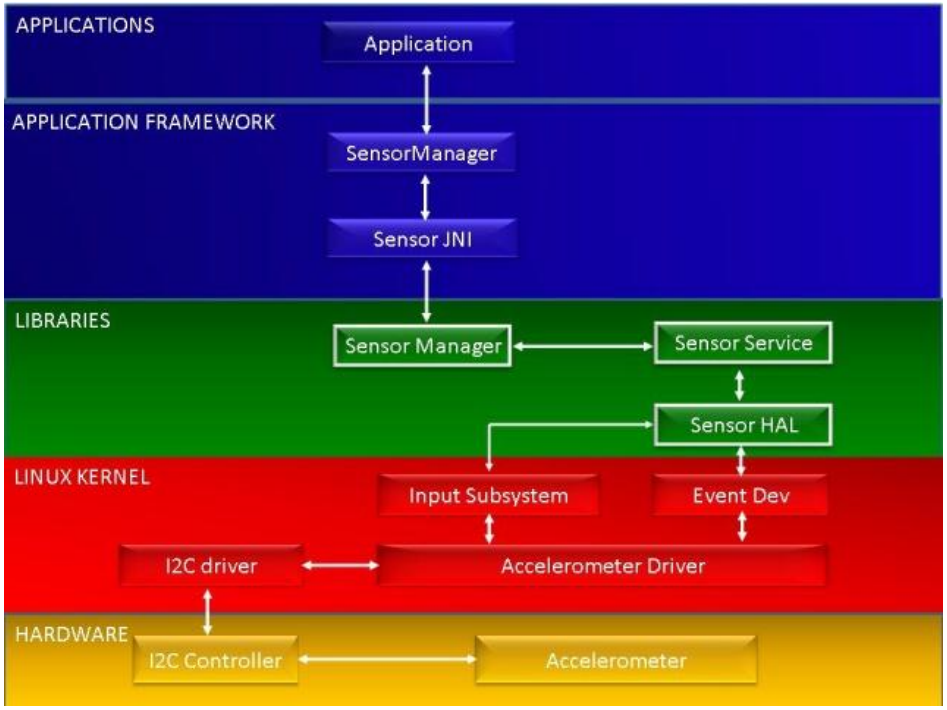
Introduction of Android Sensor Framework

Sensor Types

- Android supports multiple types of sensors
  - Light sensor
  - Proximity sensor
  - Temperature sensor
  - Pressure sensor
  - Gyroscope sensor
  - Accelerometer
  - Magnetic field sensor
  - Orientation sensor
  - Gravity sensor
  - Linear acceleration sensor
  - Rotation vector sensor
  - Near Field Communication (NFC) sensor
  - GPS (GPS is similar to a sensor, but not a sensor)

Android Sensor Framework

- Layers from bottom to top
  - Sensor driver
  - Sensor Hardware Module
  - Sensor JNI
  - Java Sensor Class
  - Java Application



http://processors.wiki.ti.com/index.php/Android_Sensor_PortingGuide

Sensor Package and Classes

- Package: android.hardware
- Interface
  - SensorEventListener
- Classes:
  - Sensor
  - SensorEvent
  - SensorManager

Interface: SensorEventListener (I)

- Used for receiving notifications from the SensorManager when sensor values have changed.
- Public methods:
  - abstract void onSensorChanged(SensorEvent event)
  - abstract void onAccuracyChanged(Sensor sensor, int accuracy)

Interface: SensorEventListener (II)

- abstract void onSensorChanged(SensorEvent event)
  - This function is called by system when sensor values have changed.
  - This is an abstract function, need to be implemented by user.
  - The parameter of this function is an instance of Class SensorEvent (will introduce this class later), which holds information such as sensor type and sensor values.

Interface: SensorEventListener (III)

- abstract void onAccuracyChanged(Sensor sensor, int accuracy)
  - This function is called when the accuracy of a sensor has changed.
  - This is an abstract function, need to be implemented by user.
  - The parameters of this function are an instance of Class Sensor (will introduce this class later) and the new accuracy level (High(=3), Medium(=2), and Low(=1)).

Class: Sensor (I)

- Represents a sensor
- Use *getSensorList(int)* to get the list of available Sensors in Class SensorManager.

Class: Sensor (II)

- Class *Sensor* contains several constants to represent Android sensor type

Constant	Sensor
TYPE_ACCELEROMETER	an accelerometer sensor type
TYPE_ALL	all sensor types
TYPE_AMBIENT_TEMPERATURE	an ambient temperature sensor type
TYPE_GRAVITY	a gravity sensor type
TYPE_GYROSCOPE	a gyroscope sensor type
TYPE_LIGHT	an light sensor type
TYPE_LINEAR_ACCELERATION	a linear acceleration sensor type
TYPE_MAGNETIC_FIELD	a magnetic field sensor type
TYPE_PRESSURE	a pressure sensor type
TYPE_PROXIMITY	an proximity sensor type
TYPE_RELATIVE_HUMIDITY	a relative humidity sensor type
TYPE_ROTATION_VECTOR	a rotation vector sensor type

Class: Sensor (III)

- This class also includes a set of functions to get the properties of a sensor, such as
  - maximum range of the sensor in the sensor's unit.
  - name string of the sensor.
  - the power in mA used by this sensor while in use
  - resolution of the sensor in the sensor's unit.
  - generic type of this sensor.
  - vendor string of this sensor.
  - version of the sensor's module.

Class: SensorEvent (I)

- Represents a sensor event and holds information.
- Sensor event information includes:
  - The accuracy of the sensor data
  - The sensor that generated this event.
  - The time in nanosecond at which the event happened
  - Sensor data array. The length and contents of the values array depends on which sensor type is being monitored.

Class: SensorEvent (II)

- Sensor data Examples
  - Sensor type is Sensor.TYPE_ACCELEROMETER
    - Accelerometer has three directions: vertically, laterally, or longitudinally (X, Y, Z)
    - All values are in SI units (m/s^2)
    - values[0]: Acceleration minus Gx on the x-axis
    - values[1]: Acceleration minus Gy on the y-axis
    - values[2]: Acceleration minus Gz on the z-axis
  - Sensor type is Sensor.TYPE_GYROSCOPE
    - All values are in radians/second and measure the rate of rotation around the device's local X, Y and Z axis.
    - values[0]: Angular speed around the x-axis
    - values[1]: Angular speed around the y-axis
    - values[2]: Angular speed around the z-axis

Class: SensorManager (I)

- SensorManager provides sensor management services to other applications on the device.
  - provides a sensor selector package
  - provides a standard way to all supported sensors
  - Provides an interface to list and invoke the sensors
- Get an instance of this class by calling *Context.getSystemService()* with the argument *SENSOR_SERVICE*.

Class: SensorManager (II)

- An important Function
  - *registerListener (SensorEventListener listener, Sensor sensor, int rate)*
    - Registers a SensorEventListener for the given sensor.
      - You can make a single SensorManager, but for each sensor you want to track, you need to make a unique SensorEventListener, and Sensor.
      - To avoid the unnecessary usage of battery, you should register the listener in the onResume method and unregister in the onPause method when overriding Activity methods
    - Listener- A SensorEventListener object.
    - Sensor - The Sensor to register to.
    - Rate - The rate sensor events are delivered at.

Class: SensorManager (III)

- Delivering rate for sensor events must be one of :

Constants	
SENSOR_DELAY_FASTEST	get sensor data as fast as possible
SENSOR_DELAY_GAME	rate suitable for games
SENSOR_DELAY_NORMAL	rate (default) suitable for screen orientation changes
SENSOR_DELAY_UI	rate suitable for the user interface

Examples of Reading Accelerometer

Read Accelerometer

- It can be read in background service or foreground activity.
- We will look at both examples:
  - Service – write accelerometer data into log file
  - Activity – display accelerometer data on screen

Write Accelerometer into Log

- Steps:
  - Create an accelerometer **Service** and implement a SensorEventListener
  - Implement onAccuracyChanged and onSensorChanged method
  - Create variables for SensorManager and Sensor
  - Get Object of SensorManager using system service
  - Get Object of Acc Sensor from SensorManager
  - Register a SensorEventListener for the accelerometer sensor

Step1

- Create an accelerometer **Service** and implement a ***SensorEventListener*** interface to process sensor data and sensor accuracy change

```
Class AccServcie extend Service  implements SensorEventListener {

        public void onSensorChanged(SensorEvent event) {
        // deal with sensor data
            mNewValue = (int) event.values[0]*10;
            Log.d(TAG, Integer.toString(mNewValue));
        }

        public void onAccuracyChanged(Sensor sensor, int accuracy) {
        // deal with sensor accuracy change
        }
}
```

Step2

- Create and get instants of SensorManager and Sensor

```
Class AccService extends Service implements SensorEventListener {

        @Override
        public void onCreate() {

                SensorManager  sensorManager =
                (SensorManager) getSystemService(SENSOR_SERVICE);

                Sensor accSensor = sensorManager.getDefaultSensor(
                Sensor.TYPE_ACCELEROMETER);
        }
}
```

Step3

- Register a SensorEventListener for the accelerometer sensor.

```
Class AccService extends Service implements SensorEventListener {

        @Override
        public void onCreate() {
                SensorManager  sensorManager =
                (SensorManager) getSystemService(SENSOR_SERVICE);
                Sensor accSensor = sensorManager.getDefaultSensor(
                Sensor.TYPE_ACCELEROMETER);

                sensorManager.registerListener(
                this,
                accSensor,
                SensorManager.SENSOR_DELAY_NORMAL);
        }
}
```

Read Accelerometer in Foreground

- Steps:
  - Add a main.xml in /res/layout folder
    - main.xml describe the layout of the screen display
  - Similar to that of Service,
    - Create an accelerometer **Activity** and implement a SensorEventListener interface to process sensor data and sensor accuracy change
    - Create and get instants of SensorManager and Sensor, and register a SensorEventListener
  - Implement activity life cycle management for sensor reading

Step1

- main.xml

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android=http://schemas.android.com/apk/res/android
   android:orientation="vertical“
   android:layout_width="fill_parent“
   android:layout_height="fill_parent">
   <TextView android:id="@+id/textView“
      android:layout_width="match_parent“
      android:layout_height="match_parent“
      android:text="Shake to get a toast and to switch color"
   />
</LinearLayout>
```

Step2

- Create an accelerometer **Activity** and implement a **SensorEventListener** interface to process sensor data and sensor accuracy change

```
Class AccActivity extends Activity implements SensorEventListener {

        public void onSensorChanged(SensorEvent event) {
                // deal with sensor data
                TextView tvX= (TextView)findViewById(R.id.x_axis);
                mNewValue = (int) event.values[0]*10;
                …
                tvX.setText(Float.toString(mNewValue ));
                …
        }

        public void onAccuracyChanged(Sensor sensor, int accuracy) {
                // deal with sensor accuracy change
        }
}
```

Step3

- Create and get instants of SensorManager and Sensor, and register a SensorEventListener for the accelerometer sensor

```
Class AccActivity extends Activity implements SensorEventListener {
        @Override
        public void onCreate(Bundle savedInstanceState) {
                super.onCreate(savedInstanceState);
                setContentView(R.layout.main);

                SensorManager  sensorManager = (SensorManager)
                getSystemService(Context.SENSOR_SERVICE);

                Sensor accSensor =
                sensorManager.getDefaultSensor(Sensor.TYPE_ACCELEROMETER);

                // Register for events.
                sensorManager.registerListener(
                this, accSensor, SensorManager.SENSOR_DELAY_NORMAL);
        }
}
```

Step4

- For activity life cycle management, onResume and onPause need to be overridden.
  - Register a listener when receiving data from accelerometer
  - Turn off the listener when not listening

```
Class AccActivity extends Activity implements SensorEventListener {
        protected void onResume() {
                super.onResume();

                mSensorManager.registerListener(this, mAccelerometer,
                SensorManager.SENSOR_DELAY_NORMAL);
        }

        protected void onPause() {
                super.onPause();

                mSensorManager.unregisterListener(this);
        }
}
```

unregister the listener to save energy

Reference

- http://developer.android.com
- Komatineni, S., MacLean, D., and Hashimi, S. (2011). *Pro Android 3*. Apress, 2011. Retrieved from http://books.google.com/books

Thank you