

Reading and Responding to Sensors

Point your phone at the sky, and Google Sky Map tells you which stars you're looking at. Tilt your phone, and you can control the game you're playing. Take your phone on your daily run, and an app records your route. All of these apps are possible because the mobile devices we carry have high-tech sensors for detecting our location, orientation, and acceleration.

In this chapter, you'll explore the App Inventor components LocationSensor, OrientationSensor, and AccelerometerSensor. Along the way, you'll learn about the global positioning system (GPS); orientation measures such as pitch, roll, and azimuth; and some math for processing accelerometer readings.



Creating Location-Aware Apps

Until the popularization of the smartphone, computing was on desktop lockdown. Yes, laptops are mobile, but not in the same sense as the tiny devices we now carry around in our pockets. Computing has left the lab and the office, and is now taking place out in the world, beyond the constraints of four walls.

One significant effect of carrying our computing with us is a new, very interesting piece of data for every app: a current location. Knowing where people are as they move about the world has far-reaching implications and the potential to help us greatly in our lives. It also has the potential to invade our privacy and be a detriment to humanity.

The Android, Where's My Car? app ([Chapter 7](#)) is an example of a *location-aware* app that provides a personal benefit. It lets you remember a previous location so that you can get back to it at a later time. That app is private, meaning that your location information is stored only in your device's database.

Groups can also use location sensing. For instance, a group of hikers might want to keep track of one another's whereabouts in the wilderness, or a group of business associates might want to find one another at a large conference (or a bar). Some people use such "check-in" apps everyday.

Another type of location-aware app uses *augmented-reality* tools. These apps use your location and the phone's orientation to provide overlay information that augments the natural setting. So, you might point a phone at a building and see its price on the real-estate market, or you might walk near an exotic plant in a botanical garden and an app can tell you its species.

The Global Positioning System

To create a location-aware app, you first need to understand how the *global positioning system* (GPS) works. GPS data is generated via a series of geosynchronous satellites maintained by the United States government. As long as you have an unobstructed sight line to at least three satellites in the system, your phone can get a reading. A GPS reading consists of your latitude, longitude, and altitude. Latitude is how far north or south you are relative to the equator, with values for north being positive and south being negative. The range is -90 to 90 . **Figure 23-1** shows a Google map of a spot near Quito, Ecuador. The latitude shown on the map is -0.01 , just barely south of the equator!



Figure 23-1. Quito, Ecuador, is on the equator

Longitude is how far east or west you are of the Prime Meridian; east coordinates have positive values and west coordinates are negative. The Prime Meridian, which stretches north-south, is located in Greenwich, a town near London that is the home of the Royal Observatory, the organization that originally established the Prime Meridian as a basis for measurement for astronomers and navigators alike. The map in **Figure 23-2** shows Greenwich and its longitude of 0.0 .



Figure 23-2. The Royal Observatory in Greenwich shoots a beam of light along the Prime Meridian

Longitude values range from -180 to 180 . Figure 23-3 shows a spot in Russia, very close to Alaska, that has a 180.0 longitude. You might say that a location like this is halfway around the world from Greenwich (0.0 longitude).



Figure 23-3. A point near the Russian-Alaskan border has longitude 180

Sensing Location with App Inventor

App Inventor provides the `LocationSensor` component for accessing GPS information. The component has properties for Latitude, Longitude, and Altitude. It also communicates with Google Maps, so you can get a reading for your current street address.

`LocationSensor.LocationChanged`, pictured in Figure 23-4, is the key event handler for the `LocationSensor`.

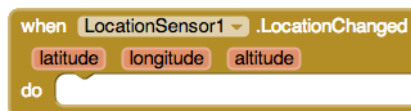


Figure 23-4. The `LocationSensor1.LocationChanged` event handler

This event is triggered the first time the sensor establishes a reading and each subsequent time the phone is moved enough so that new data is read. There's often a delay of quite a few seconds before an app's first reading, and sometimes the device can't get a reading at all. For instance, if you're indoors and not connected to WiFi, the device might not get a reading. Your phone also has settings by which you can turn GPS reading off to save battery life; this is another potential reason the component can't get a reading. For these reasons, you shouldn't assume that the `LocationSensor` properties have a valid setting until the `LocationSensor.LocationChanged` event occurs.

One way to deal with the unknowns in location sensing is to create a variable `lastKnownLocation`, initialize it to "unknown," and then have the `LocationSensor.LocationChanged` event handler change the value of that variable, as shown in [Figure 23-5](#).

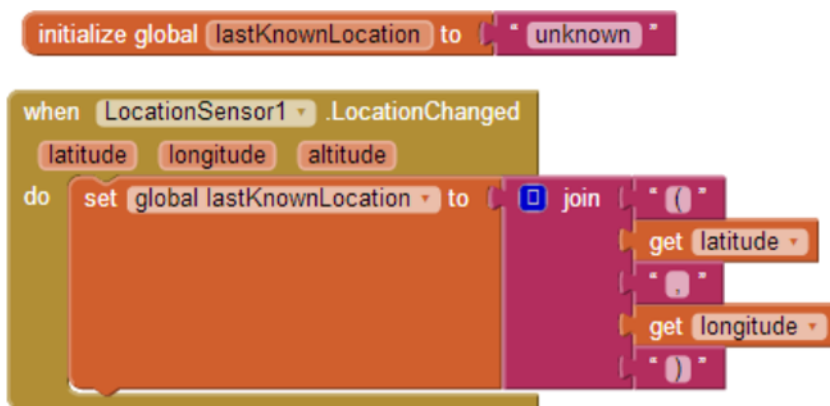


Figure 23-5. The value of the `lastKnownLocation` variable changes whenever the location changes

By programming the `LocationSensor.LocationChanged` event handler in this way, you can always display the current location or record it in a database, with "unknown" appearing until the first reading. This strategy is used in the No Texting While Driving! app ([Chapter 4](#)); that app auto-responds to SMS texts and includes either "unknown" or the last reading taken in the response.

You can also ask explicitly whether the sensor has a reading by using the `LocationSensor.HasLongitudeLatitude` block illustrated in [Figure 23-6](#).



Figure 23-6. Testing whether the sensor has a reading by using the `HasLongitudeLatitude` block

Checking Boundaries

One common use of the `LocationChanged` event is to check whether the device is within a *boundary*, or a set area. For example, consider the code in [Figure 23-7](#), which vibrates the phone each time a new reading shows that a person has moved farther than 0.1 degree longitude from the Prime Meridian.

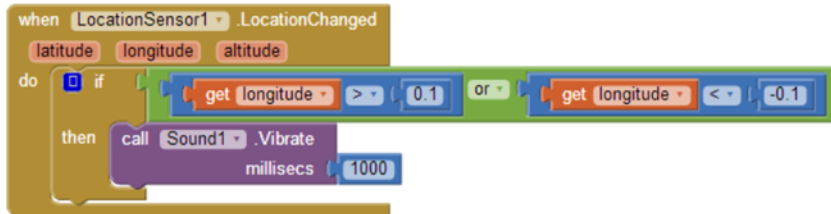


Figure 23-7. If a reading isn't close to the Prime Meridian, the phone vibrates

Such boundary checking has numerous applications; for example, warning parolees if they're nearing a legally specified distance from their home, or alerting parents or teachers if a child leaves the playground area. If you'd like to see a slightly more complex example, see the discussion in [Chapter 18](#) on conditional blocks.

Location Information Providers: GPS, WiFi, and Cell ID

An Android device can determine its own location in a number of ways. The most accurate method—within a few meters—is through the GPS satellites. You won't get a reading, however, if you're inside or there are skyscrapers or other obstructions around you; you need a clear path to at least three satellites in the system.

If GPS isn't available or the user has disabled it, the device can obtain its position through a wireless network. You must be near a WiFi router, of course, and the position reading you'll get is the latitude/longitude of that WiFi station

A third way a device can determine positioning is through *Cell ID*. Cell ID provides a location for the phone based on the strength of signals from nearby cell phone towers. It is generally not very accurate unless you have numerous cell towers near you. However, it does use the least amount of battery power compared to GPS or WiFi connectivity.

Using the Orientation Sensor

You can use the `OrientationSensor` for game-like apps in which the user controls the action by tilting the device. It can also be used as a compass to find out which direction (north/south, east/west) the phone is pointing.

The `OrientationSensor` has five properties, all of which are unfamiliar to most people other than aeronautical engineers:

Roll (*Left–Right*)

Roll is 0 degrees when the device is level, increases to 90 degrees as the device is tilted toward its left side, and decreases to –90 degrees when the device is tilted toward its right side.

Pitch (*Up–Back*)

Pitch is 0 degrees when the device is level, increases to 90 degrees as the device is tilted so that its top is pointing down, and increases further to 180 degrees as it is turned over. Similarly, as the device is tilted so that its bottom points down, Pitch decreases to –90 degrees and then down to –180 degrees as it is turned all the way over.

Azimuth (*Compass*)

Azimuth is 0 degrees when the top of the device is pointing north, 90 degrees when it is pointing east, 180 degrees when it is pointing south, and 270 degrees when it is pointing west.

Magnitude (*Speed of a rolling ball*)

Magnitude returns a number between 0 and 1 that indicates how much the device is tilted. Its value indicates the force exerted by a ball rolling on the surface of the device.

Angle (*Angle of a rolling ball*)

Angle returns the direction in which the device is tilted. That is, it indicates the direction of the force that would be exerted by a ball rolling on the surface of the device.

The `OrientationSensor` provides the `OrientationChanged` event, which is triggered every time the orientation changes. To explore these properties further, let's write an app that illustrates how the properties change as the user tilts the device. Just add five heading labels, and five other labels to show the current values of the properties in the preceding list. Then, add the blocks shown in [Figure 23-8](#).

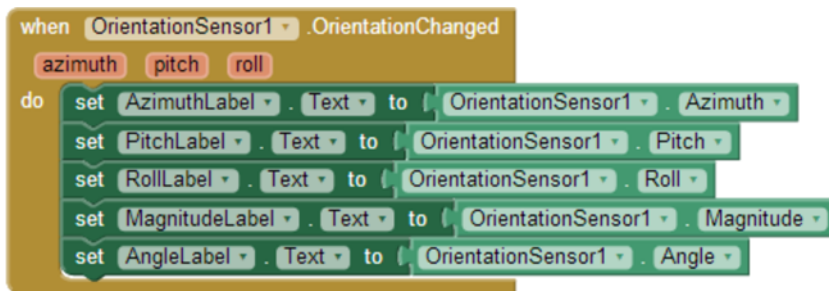


Figure 23-8. Blocks to display the `OrientationSensor` data

Using the Roll Parameter to Move an Object

This time, let's try to move an image left or right on the screen based on the user tilting the device, as you might do in a shooting or driving game. Drag out a Canvas and set the Width to "Fill parent" and the Height to 200 pixels. Then, add an `ImageSprite`

or Ball within the Canvas, and add a Label named RollLabel under it to display a property value, as shown in [Figure 23-9](#).

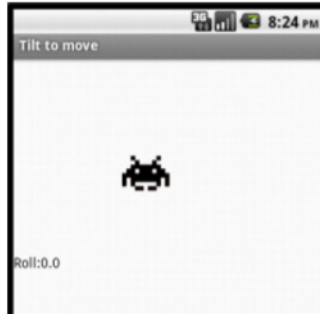


Figure 23-9. A user interface for exploring how you can use roll to move an image

The Roll property of OrientationSensor will indicate if the phone is tilted left or right—if you hold the phone upright and tilt it slightly to the left, you’ll get a positive reading for the roll; if you tilt it slightly right, you’ll get a negative reading. Therefore, you can let the user move an object with an event handler such as the one shown in [Figure 23-10](#).

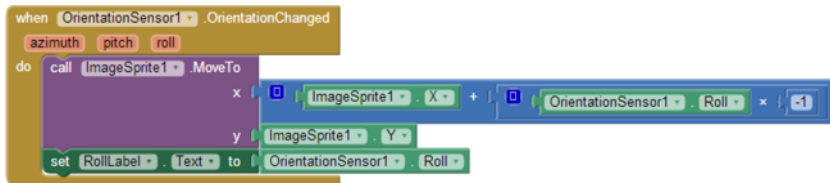


Figure 23-10. Responding to changes in the Roll property with the OrientationChanged event

The blocks multiply the roll by -1 , because tilting left gives a positive roll and should move the object left (thereby making the x coordinate smaller). For a review of how the coordinate system works in animated apps, see [Chapter 17](#).

Notice that this app works only when the device is in Portrait mode (upright), not in Landscape mode. As is, if you tilt the phone too far, the screen will change into Landscape mode and the image will stay marooned on the left side of the screen. The reason is that if the device is on its side, it is tilted left and thus will always get a positive reading for the roll. A positive roll reading, as shown in the blocks in [Figure 23-10](#), will always make the x coordinate smaller.

Note that App Inventor does provide the Screen.ScreenOrientation property, which you can use to lock the orientation if you don’t want it to switch between modes.

Moving in Any Direction by Using Heading and Magnitude

The example in the previous section moves the image left or right. If you want to allow for movement in any direction, you can use the `Angle` and `Magnitude` properties of the `OrientationSensor`. These are the properties used to move the ladybug in the game described in [Chapter 5](#).

In [Figure 23-11](#), you can see the blocks for a test app in which the user tilts the device to move a character in any direction (you need two labels and an image sprite for this example).

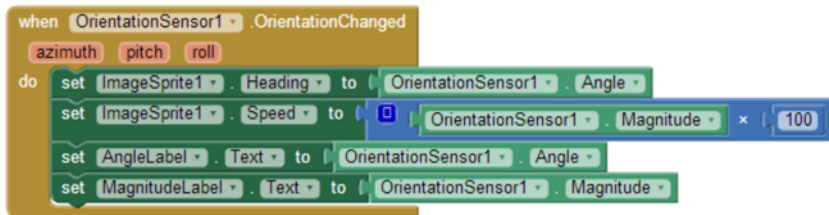


Figure 23-11. Moving a character by using angle and magnitude

Try this one out. The `Magnitude` property, a value between 0 and 1, indicates how much the device is tilted. In this test app, the image moves faster as the value of magnitude increases.

Using the Phone As a Compass

Compass apps and apps such as Google Sky Map need to know the phone's orientation in the world, east/west and north/south. Sky Map uses the information to overlay information about the constellations at which the phone is pointing.

The `Azimuth` reading is useful for this type of orientation. `Azimuth` is always between 0 and 360 degrees, with 0 being north; 90, east; 180, south; and 270, west. Thus, a reading of 45 means the phone is pointing northeast, 135 means southeast, 225 means southwest, and 315 means northwest.

The blocks in [Figure 23-12](#) are for a simple compass that displays in text which direction the phone is pointing (e.g., northwest).

As you might have noticed, the blocks show only one of four possibilities: northwest, northeast, southwest, and southeast. As a challenge, see if you can modify it to show just a single direction (north, south, east, or west) if the reading specifies that you are pointing within a few degrees of it.

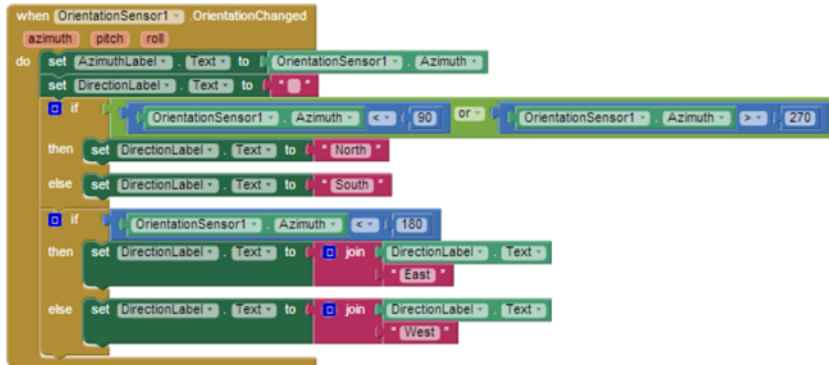


Figure 23-12. Programming a simple compass

Using the Accelerometer

Acceleration is the rate of change of velocity over time. If you press your foot to the gas pedal of your car, the car accelerates—its velocity increases at a particular rate.

An accelerometer like the one in your Android device measures acceleration, but its frame of reference is not the device at rest, but rather the device in free fall: if you drop the phone, it will register an acceleration reading of 0. Simply put, the readings take gravity into account.

If you want to know more about the physics of the matter, you'll need to consult your Einstein-related books. But in this section, we'll explore the accelerometer enough to get you started. We'll even examine an app that could help save lives!

Responding to the Device Shaking

If you've completed the Hello Purr app in [Chapter 1](#), you've already used the `AccelerometerSensor`. In that app, you used the `AccelerometerSensor.Shaking` event to make the kitty meow when the phone was shaken, as shown in [Figure 23-13](#).



Figure 23-13. Playing a sound when the phone is shaken

Using the AccelerometerSensor's Readings

Like the other sensors, the accelerometer has an event for when the readings change, `AccelerometerSensor.AccelerationChanged`. That event has three arguments corresponding to the acceleration in three dimensions:

xAccel

Positive when the device is tilted to the right (that is, its left side is raised), and negative when the device is tilted to the left (its right side is raised).

yAccel

Positive when the device's bottom is raised, and negative when its top is raised.

zAccel

Positive when the device display is facing up, and negative when the display is facing down.

Detecting Free Fall

We know that if all the acceleration readings are near 0, the device is free-falling to the ground. With this in mind, we can detect a free-fall event by checking the readings in the `AccelerometerSensor1.AccelerationChanged` event. You could use such blocks, with lots of testing, to detect when an elderly person has fallen and automatically send an SMS message out in response.

Figure 23-14 shows the blocks for an app that simply reports that a free-fall has occurred (and lets the user click a Reset button to check again).¹

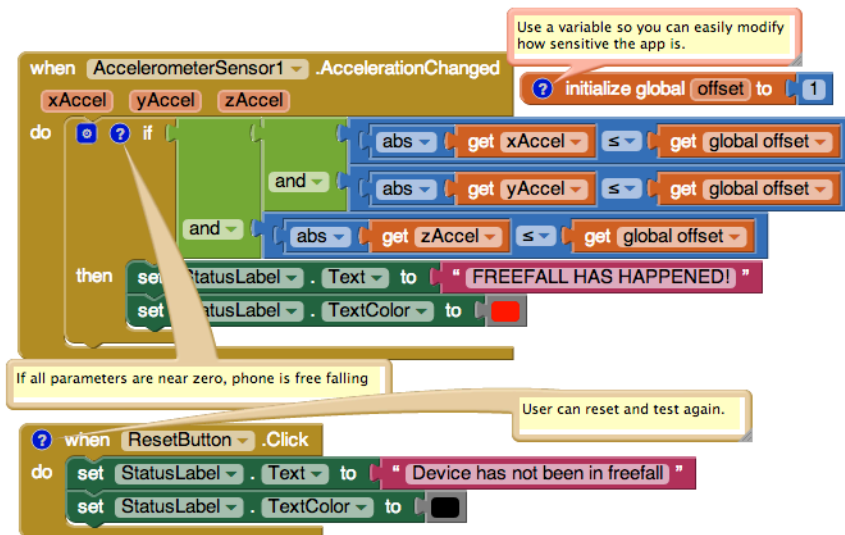


Figure 23-14. Reporting when a free-fall has occurred

¹ You can right-click a block and choose “Inline inputs” to change the way blocks appear. This was done for the blocks in this example to reduce the width of the event handler.

Each time the sensor gets a reading, the blocks check the x, y, and z dimensions to see if they're near 0 (if their absolute value is less than 1). If all three are near 0, the app changes a status label to denote that the phone is in free-fall. When the user taps the `ResetButton`, the status label is reset to its original state ("Device has NOT been in free fall").

Summary

Sensors are of great interest in mobile apps because they make it possible for your users to truly interact with their environments. By taking computing mobile, you are opening up a whole world of opportunities in user experiences and app development. However, you'll need to think carefully about how, where, and when you use sensors in your apps. Many people have privacy concerns, and they might not use your app if they're worried about what you're doing with their sensor data. Still, with all the options in games, social networking, travel, and more, the possibilities for positive implementations are nearly endless.

