

Mobile Computing Assignment 1

Android Application to find 3D orientation of device

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Angle Calculations:

Calculating angles using Gyroscope:

As the gyroscope measures the change in position with respect to time. So, multiplying the value of gyroscope reading with change in time stamp of two readings should give us the angular displacement of the device.

Suppose, the g_1 and g_2 are the two consecutive gyroscope readings with t_1 and t_2 as the timestamp respectively and if initially the angular displacement of the device is 0 then,

Total angular displacement = Initial displacement + $(t_2 - t_1) * g_2$ (this will give angle in radians)

Gyroscope only gives the relative angles with initial position instead of absolute.

Calculating angles using Accelerometer and Magnetometer:

It is necessary to combine the Magnetometer readings as the Accelerometer readings alone are not sufficient to determine the absolute orientation of the device in all 3 axes.

Let a_x , a_y and a_z be the accelerometer readings and m_x , m_y , m_z be the magnetometer readings for X, Y and Z respectively.

To calculate rotation around X axis - $\tan_{\text{inv}}(a_x / \sqrt{a_z^2 + a_y^2})$ radians

To calculate rotation around Y axis - $\tan_{\text{inv}}(a_y / \sqrt{a_z^2 + a_x^2})$ radians

To calculate rotation around Z axis - $\tan_{\text{inv}}(m_y / m_x)$ radians

Since the data is noisy low pass filter is used to remove any large change in the consecutive readings.

Fusing the data from the sensors:

Since the Gyroscope data is less noisy compared to the accelerometer and magnetometer readings. Therefore, high percentage of gyroscope and low percentage of accelerometer and magnetometer readings should be used as shown below:

$\text{final_angle} = \text{ALPHA} * \text{gyro_angles} + (1 - \text{ALPHA}) * \text{accelerometer_magnetometer_angles};$

Where $\text{ALPHA} \geq 0.9$;

Also, If we are measuring the relative rotation then there is no need to fuse the data of the sensors as gyroscope is enough to find the relative orientation of the device.

For this application I am using only Gyroscope to measure the change in angle and using the accelerometer and magnetometer to initialize the gyroscope reading initially with absolute angles.

Android Application:

The UI of the application is as below:

There are two modes **Relative** and **Absolute**.

Absolute: This mode measures the angles X, Y and Z with current frame of reference which is nothing but the device frame of reference.



Relative: This mode measures the angle with respect to absolute frame of reference which is fixed and coincides with earth's frame of reference.

While using this mode make sure you keep the device flat on the surface first and then click on the change to relative button. Otherwise yaw readings will not be accurate.



Rot-X – rotation around X axis in Degrees.

Rot-Y – rotation around Y axis in Degrees.

Rot-Z- rotation around Z axis in Degrees.

The earth displayed in the app rotates as the mobile rotates. And clicking on Start/Stop button will start/stop collecting data from sensors.