Document serial number: 000004892117

libmotion Overview

000004892117

PlayStation®Vita Programmer Tool Runtime Library Release 3.50

Document serial number: 000004892117

© 2014 Sony Computer Entertainment Inc.
All Rights Reserved.
SCE Confidential

Document serial number: 000004892117

Document serial number: 000004892117

Table of Contents

000004892117

Document serial number: 000004892117

Document serial number: 000004892117

Document serial number: 000004892117

1 Library Overview

Scope of This Document

The purpose of this document is to provide an overview of the libmotion and describe its use from a developer's point of view.

Purpose and Characteristics

libmotion provides functionality for obtaining orientation and motion sensor values from PlayStation®Vita. libmotion also provides support for enabling and disabling filtering features used in the library's orientation calculations.

Sensor Device Specifications

The hardware specifications for the gyro sensor and accelerometer are as follows.

Specification	Description
Maximum angular velocity	+/- 1000 degrees/second
Maximum acceleration	+/- 3G

Embedding into a Program

The files listed in Table 1 are required to use libmotion:

Table 1 Prerequisite Files

File Name	Description
libSceMotion_stub.a	Stub library file
motion.h	Header file

Include motion.h in the program.

Link libSceMotion_stub.a when building the program.

Sample Programs

The following sample programs are examples of how to use libmotion.

sample_code/input_output_devices/api_motion/BasicSample/

This sample shows the basic procedure for using the quaternion output of libmotion to control the orientation of a 3D model.

sample_code/input_output_devices/api_motion/DigitalCompass/

This sample shows the basic procedure for using the NED (North East Down) matrix output from libmotion to create a digital compass.

sample_code/input_output_devices/api_motion/BasicOrientation/

This sample shows the basic procedure for using the basic orientation output from libmotion.

sample_code/input_output_devices/api_motion/MotionCamera/

This sample shows the basic procedure for using the rotation matrix output of libmotion to control a camera in a shooting game sample.

000004892117

Document serial number: 000004892117

Document serial number: 000004892117

Document serial number: 000004892117

2 Usage Procedure

Basic Processing Procedure

(1) Set the libmotion Filtering Modes

libmotion provides support to enable and disable various filtering modes used to calculate the PlayStation®Vita orientation vector. The filtering modes are as follows:

Gyro Dead-Banding Filter

This filter creates a low-pass effect on the gyro sensor signals. This filter eliminates any high frequency noise when the PlayStation®Vita is not moving; however, it may also lower sensitivity to the angular movements when the PlayStation®Vita is moving at low speeds.

- The default value for this filter is enabled.
- Disabling this filter is recommended when applying the orientation calculation output values to fine operations such as aiming in an FPS.
- Since the gyro sensor output values are corrected by the gyro bias correction filter, in many cases there will not be any major problems when this filter is not enabled.
- To disable this filter, use `sceMotionSetDeadband(0)`.
- To enable this filter, use `sceMotionSetDeadband(1)`.
- To confirm whether the filter is enabled/disabled, use `sceMotionGetDeadband()`.

Accelerometer Tilt Correction Filter

This filter uses the output values from the accelerometer to correct the orientation calculation output values for pitch and roll in the PlayStation®Vita. As a result, the pitch and roll directions will always be corrected in the world coordinate system. If the filter is disabled, libmotion calculates orientation from the gyro sensor values only.

- The default value for this filter is enabled.
- Enable this filter in applications such as AR (Augmented Reality) applications where it is desired to use the orientation calculation output values in the world coordinate system.
- On the other hand, disabling this filter is recommended when it is desired to use the orientation calculation output values in the local coordinates in an application (in many cases, it is disabled in scenes such as FPS aiming).
- To disable this filter, use `sceMotionSetTiltCorrection(0)`.
- To enable this filter, use `sceMotionSetTiltCorrection(1)`.
- To confirm whether the filter is enabled/disabled, use `sceMotionGetTiltCorrection()`.

Gyro Bias Correction Filter

The gyro sensor is known to have drift in the bias value due to temperature and other environmental conditions. This filter provides functionality for automatically correcting this drift.

- The default value for this filter is enabled.
- When the bias correction filter for the gyro sensor is disabled, the gyro sensor output may drift due to internal temperature and individual differences. As a result, the orientation calculation output values will also drift, and there is a possibility that this will cause a severe decrease in output value accuracy.
- For the aforementioned reasons, it is strongly recommended that this filter is always enabled.

000004892117

Document serial number: 000004892117

Document serial number: 000004892117

Document serial number: 000004892117

(2) Reset the PlayStation®Vita Direction

To reset the PlayStation®Vita direction, use the function `sceMotionReset()`.

- If the accelerometer tilt correction filter is disabled, the orientation calculation output values will be reset to the unit matrices.
- If the accelerometer tilt correction filter is enabled, corrections will be performed on the current tilt orientation for the roll/pitch direction after the orientation calculation output values are reset to the unit matrices.

(3) Start Sampling

To start the sampling of the motion sensors, use `sceMotionStartSampling()`.

If you wish to use the NED matrix *`nedMatrix`* output, you must also use `sceMotionMagnetometerOn()` which turns the magnetometer sensor sampling on.

(4) Obtain the Current State

To receive the PlayStation®Vita current state and motion sensor values, use `sceMotionGetState()`.

To receive the current motion sensor state, use `sceMotionGetSensorState()`.

To receive the PlayStation®Vita current basic orientation, use `sceMotionGetBasicOrientation()`.

(5) Stop Sampling

If you wish to stop only the magnetometer sensor sampling, use `sceMotionMagnetometerOff()`.

To stop the sampling of all the motion sensors, use `sceMotionStopSampling()`.

000004892117

Document serial number: 000004892117

Document serial number: 000004892117

Document serial number: 000004892117

3 Motion Data

This chapter explains the motion data output by libmotion.

Quaternion Output

Quaternion output is represented as `<x,y,z,w>` and provides the orientation of the PlayStation®Vita as calculated by libmotion, in reference to gravity and the yaw zero reference when libmotion was initialized.

Rotation Matrix Output

The rotation matrix output is represented in a 4 x 4 matrix. It provides the orientation of the PlayStation®Vita as calculated by libmotion, in reference to gravity and the yaw zero reference when libmotion was initialized.

NED Matrix Output

The NED (North East Down) matrix output is a matrix representing the 3D orientation of the PlayStation®Vita in reference to the magnetic North/East vector and gravity.

Basic Orientation Output

The basic orientation output is a vector that represents the basic orientation of the PlayStation®Vita in reference to gravity.

SceMotionState

Data output provides the filtered output, raw data output, a timestamp (microseconds), and a host timestamp (microseconds).

The timestamp is local to libmotion, set to 0 at the beginning of sampling, and overflows at the value 0xFFFFFFFF.

The host timestamp is a 64-bit timestamp measured in microseconds, which represents the time when a data packet is received from a sensor device by the host.

SceMotionSensorState

Data output provides the raw data output from the sensors, a timestamp (microseconds), and a host timestamp (microseconds).

The timestamp is local to libmotion, set to 0 at the beginning of sampling, and overflows at the value 0xFFFFFFFF.

The host timestamp is a 64-bit timestamp measured in microseconds, which represents the time when a data packet is received from a sensor device by the host.

000004892117

Document serial number: 000004892117

Document serial number: 000004892117

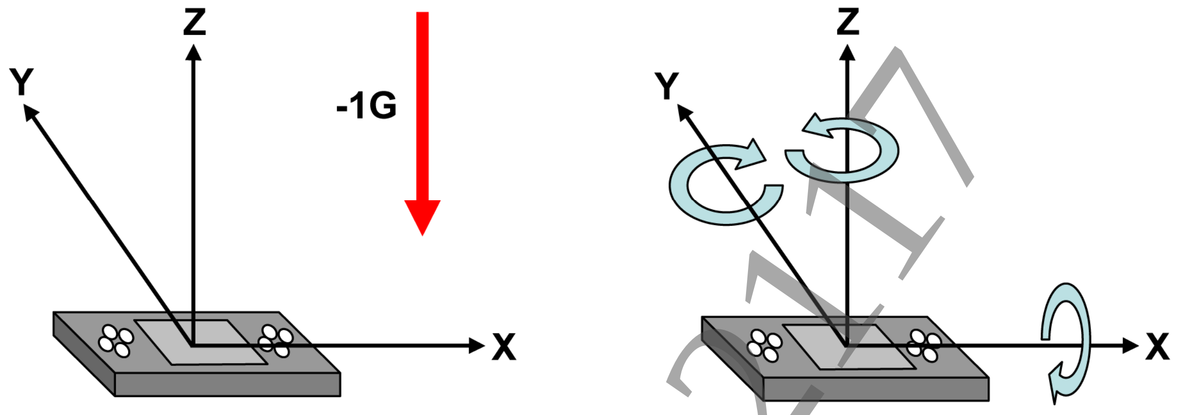
Document serial number: 000004892117

4 Coordinate System

libmotion Coordinate System

The sensor output for each sensor type and output is shown in Figure 1. The libmotion coordinate system is a coordinate system based on the sensors when the PlayStation®Vita is held horizontally by the user.

Figure 1 libmotion Coordinate System



Quaternion output is represented as `<x,y,z,w>` and provides the orientation of the PlayStation®Vita as calculated by libmotion, in reference to gravity and the yaw zero reference when libmotion was initialized.

Basic Orientation Output

The basic orientation output will be represented by the gravity value -1, 0, or 1 in an `SceFVector3` format <x, y, z>.

The output is based on the direction of the PlayStation®Vita screen's orientation in reference to gravity. For example, if the PlayStation®Vita is lying on the table with the screen facing up, the output will be < 0, 0, 1 >. However, if the PlayStation®Vita is lying on the table with the screen facing down, the output will be < 0, 0, -1 >. If a value of 0 is output for either the X or Y axes, this represents that the screen is facing the direction of gravity or the opposite direction.

Basic Orientation Output Example

Figure 2 shows an example of basic orientation output.

000004892117

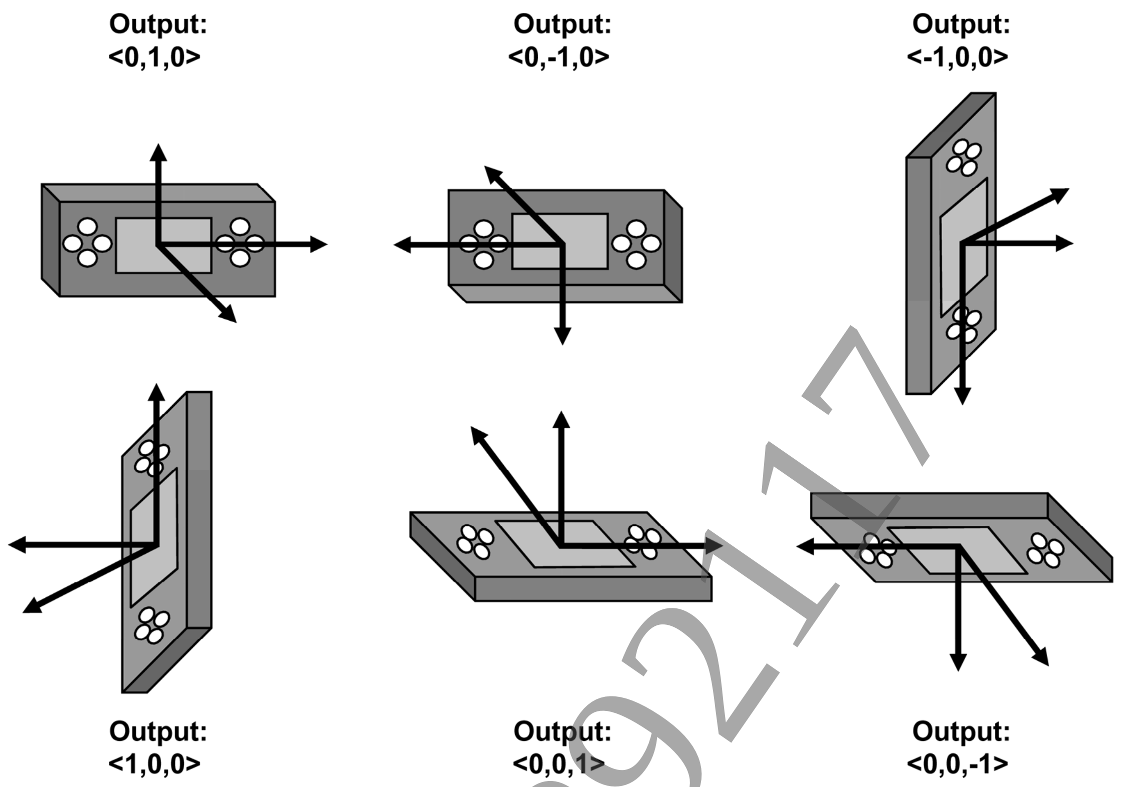
Document serial number: 000004892117

©SCEI

Document serial number: 000004892117

Document serial number: 000004892117

Figure 2 Basic Orientation Output Example



000004892117

Document serial number: 000004892117

©SCEI

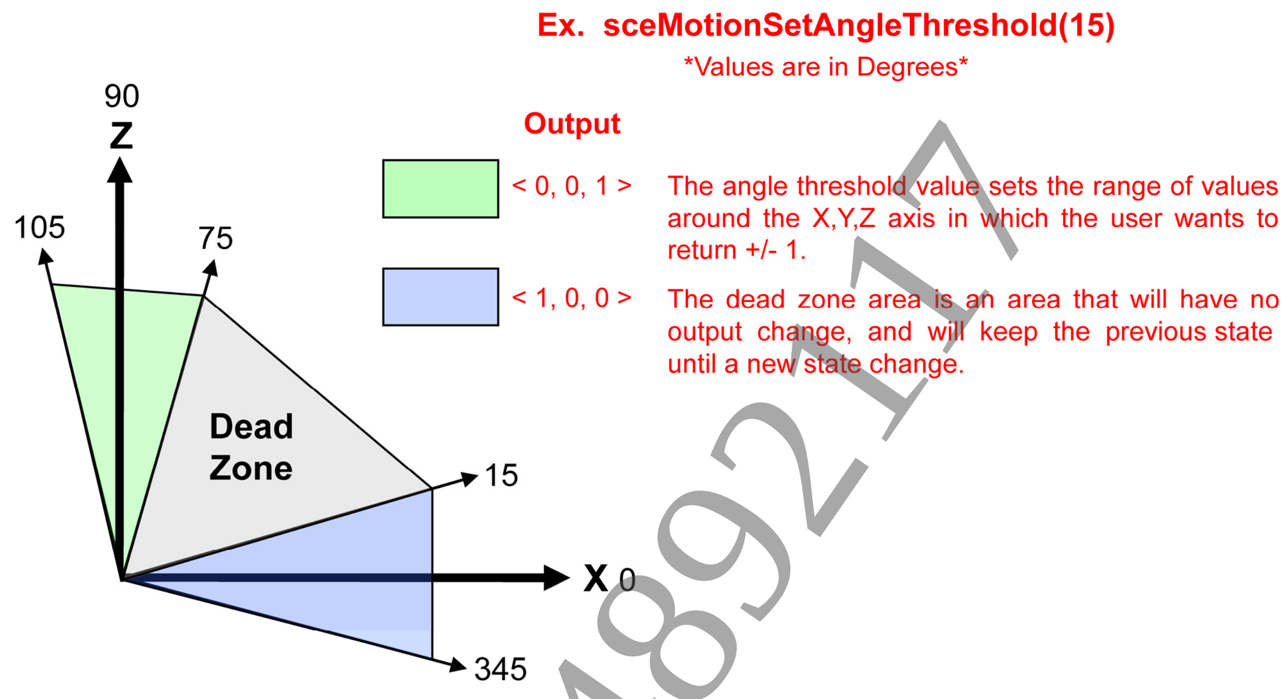
Document serial number: 000004892117

Document serial number: 000004892117

Basic Orientation Output Threshold Setting

The angle threshold can be set using `sceMotionSetAngleThreshold()` to decide when to change the basic orientation output. However, be aware that all three axes will be set to the same angle value. An explanation of how the output changes based on the user settings is shown in Figure 3.

Figure 3 Basic Orientation Output Angle Threshold Setting



The angle threshold value sets the range of values around the X,Y,Z axis in which the user wants to return +/- 1.

The dead zone area is an area that will have no output change, and will keep the previous state until a new state change.

000004892117

Document serial number: 000004892117

Document serial number: 000004892117

Document serial number: 000004892117

5 Sensor Device Location API

Depending on the application, the physical location of the motion sensors may be required. We provide an API that will return the physical location of the motion sensors in relation to the center of the PlayStation®Vita (in mm), with a resolution of +/- 1 mm. The range of values is +/- 300mm.

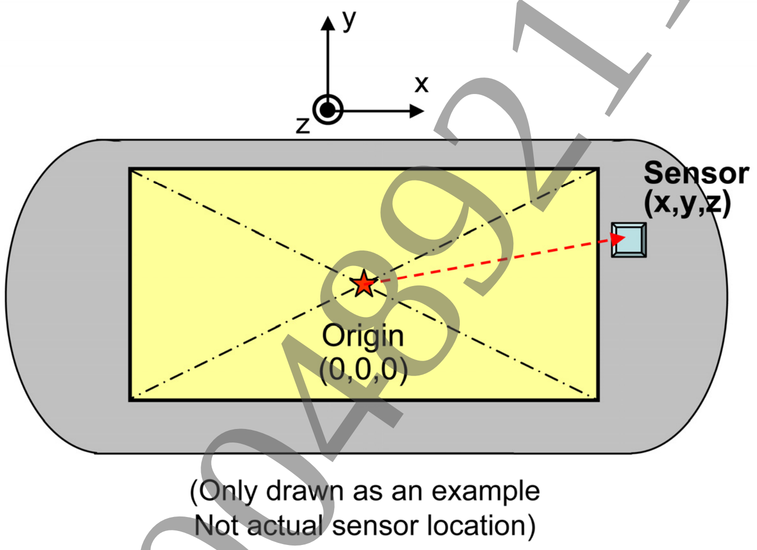
Note that the physical location of the sensors in relation to the center of the PlayStation®Vita may change along with hardware revisions for Development Kits/Testing Kits/retail units.

API Usage

```
sceMotionGetDeviceLocation(SceMotionDeviceLocation *devLocation)
```

Calling this function will load the `SceMotionDeviceLocation` structure with the physical location of the motion sensors.

Figure 4 Motion Sensor Physical Location Example



000004892117

Document serial number: 000004892117

©SCEI

Document serial number: 000004892117

Document serial number: 000004892117

6 Power Saving Mode

libmotion provides a number of options for decreasing the power usage that results from sampling the sensors. Whenever possible, the use of this API is encouraged to reduce wasteful energy consumption with the mobile PlayStation®Vita device and ensure a longer battery life.

sceMotionStartSampling()/sceMotionStopSampling()

These two functions control the sampling starts/stops for all the motion sensors. Once `sceMotionStartSampling()` is called, the sampling of the accelerometer and gyro sensor will begin. Since the sensors are continuously being polled, leaving on the sensor device sampling will reduce battery life. Take this into consideration.

sceMotionMagnetometerOn()/sceMotionMagnetometerOff()

These two functions control the sampling on/sampling off of the magnetometer sensor only. When the sampling is turned off when the magnetometer sensor is not in use, the battery life will increase.

000004892117

Document serial number: 000004892117

Document serial number: 000004892117

Document serial number: 000004892117

7 Timestamp

Two timestamps are available from libmotion. They are the device timestamp (*`timestamp`*) and the host timestamp (*`hostTimestamp`*), and they are both measured in microseconds. When the sensor devices are sampled, each individual sample is given a device timestamp. The collected data is then placed in a packet and sent to the host controller. When the host controller receives the data packet, a host timestamp is placed on the packet. By using both timestamps it is possible to calculate, in relation to the system, when the sensor was sampled.

Device Timestamp (timestamp)

The device timestamp represents the sampling time from the sensor device. For each state in libmotion the device timestamp should be different, incremented with the sampling time. This timestamp should be used when integrating raw data given by libmotion.

Host Timestamp (hostTimestamp)

The host timestamp represents the time at which the sensor data packets are received by the host controller. This data is used to calculate when in time the data was received, relative to the rest of the system.

000004892117

Document serial number: 000004892117

©SCEI

Document serial number: 000004892117

Document serial number: 000004892117

8 Magnetic Field Stability

Outside magnetic fields will constantly be affecting the magnetometer sensor output of libmotion. Because of this, we have provided an auto-calibration method that will recalibrate the magnetic field sensors as the user uses the PlayStation®Vita. However, in some circumstances the magnetic field sensor is not able to calibrate automatically and will require the user to rotate the PlayStation®Vita around to recalibrate. This will only happen when the magnetometer sensor output is unstable.

magnFieldStability

This variable for `SceMotionState` is a description of the stability of the magnetic field. When the stability is read as `SCE_MOTION_MAGNETIC_FIELD_UNSTABLE`, since the NED matrix *`nedMatrix`* output is unreliable it should not be used. On the other hand if the stability is read as `SCE_MOTION_MAGNETIC_FIELD_STABLE`, the *`nedMatrix`* output is reliable within +/- 20 degrees and can be used. If you see any inaccuracies in the output, try rotating or waving the PlayStation®Vita around to auto-calibrate.

Usage Caution

The NED matrix output from libmotion is based on the output from the magnetometer sensor, and therefore it will also be affected by any magnetic field interference. When using the PlayStation®Vita indoors, in vehicles, or near large steel structures the PlayStation®Vita could be interfered with by outside magnetic fields and not produce an accurate North reading. If you notice the PlayStation®Vita is inaccurate, try to rotate the PlayStation®Vita in a rowing motion or wave the PlayStation®Vita around to force an auto-calibration. If after being calibrated, the device still produces unwanted output, check the area with a magnetic compass to find any possible magnetic interference.

Because some areas have magnetic interference (vehicles, trains, indoors, near steel structures, near electronic equipment), the output from libmotion will not be accurate to within +/- 20 degrees when used in such an environment. When designing the application, be sure to take it into consideration that the magnetometer sensor cannot be used in all environments.

000004892117

Document serial number: 000004892117

©SCEI

Document serial number: 000004892117

Document serial number: 000004892117

9 Notes

Yaw Error

The PlayStation®Vita is particularly subject to errors during yaw rotation; that is, the rotation of the PlayStation®Vita in the horizontal plane perpendicular to gravity.

The error in yaw becomes especially noticeable when the user performs a rowing type of motion. In this motion, the gyro sensor axes are being constantly swapped with one another, causing integration errors to accumulate due to the differences in sensitivity and calibration between the sensors.

Understanding Hardware Specifications

Keep in mind the sensor device hardware specifications when designing the motion input of your application. Particularly quick rotational movements will saturate the sensor's signal and will produce a large amount of error in the orientation output of libmotion. Examples of motions that will saturate the gyro sensor are flipping or vigorously rotating the PlayStation®Vita.

Usage of libmotion When Riding in Vehicles

libmotion's output is based on rotational velocity (gyro sensor data) and acceleration (accelerometer data), and using libmotion while riding in vehicles will produce undesired output. While riding in vehicles, any sudden acceleration, deceleration, or turning will produce unknown results. Take this into consideration when designing your application.

000004892117

Document serial number: 000004892117

Document serial number: 000004892117

Document serial number: 000004892117

10 Notes for PlayStation®TV

Behavior when libmotion is Used with PlayStation®TV

It is not possible to use motion sensors with PlayStation®TV.

When the following APIs are called with PlayStation®TV, they will return `SCE_OK` or `SCE_TRUE`, but it will not be possible to obtain valid data since the motion sensors cannot be used.

- `sceMotionGetState()`
- `sceMotionGetSensorState()`
- `sceMotionGetBasicOrientation()`
- `sceMotionGetDeviceLocation()`
- `sceMotionGetMagnetometerState()`
- `sceMotionGetTiltCorrection()`
- `sceMotionGetDeadband()`
- `sceMotionGetAngleThreshold()`
- `sceMotionGetGyroBiasCorrection()`

When the following APIs are called with PlayStation®TV, they will return `SCE_OK`, but they will not have their intended functionality since the motion sensors cannot be used.

- `sceMotionStartSampling()`
- `sceMotionStopSampling()`
- `sceMotionRotateYaw()`
- `sceMotionSetTiltCorrection()`
- `sceMotionSetDeadband()`
- `sceMotionSetAngleThreshold()`
- `sceMotionMagnetometerOn()`
- `sceMotionMagnetometerOff()`
- `sceMotionSetGyroBiasCorrection()`
- `sceMotionReset()`

000004892117

Document serial number: 000004892117

©SCEI

Document serial number: 000004892117