Sphero Collision Detection Feature

Revision 1.2

Introduction

Sphero collision detection is a firmware feature that generates a collision async message when an impact is detected. The detection criteria is based on threshold parameters set via the phone.

Detection Features

The collision detection feature detects impacts on the X and Y axis of Sphero.

The Y axis runs through the forward/backward line of Sphero. The X axis runs from side to side. The Z axis run up and down, but is not a factor in the current FW implementation.

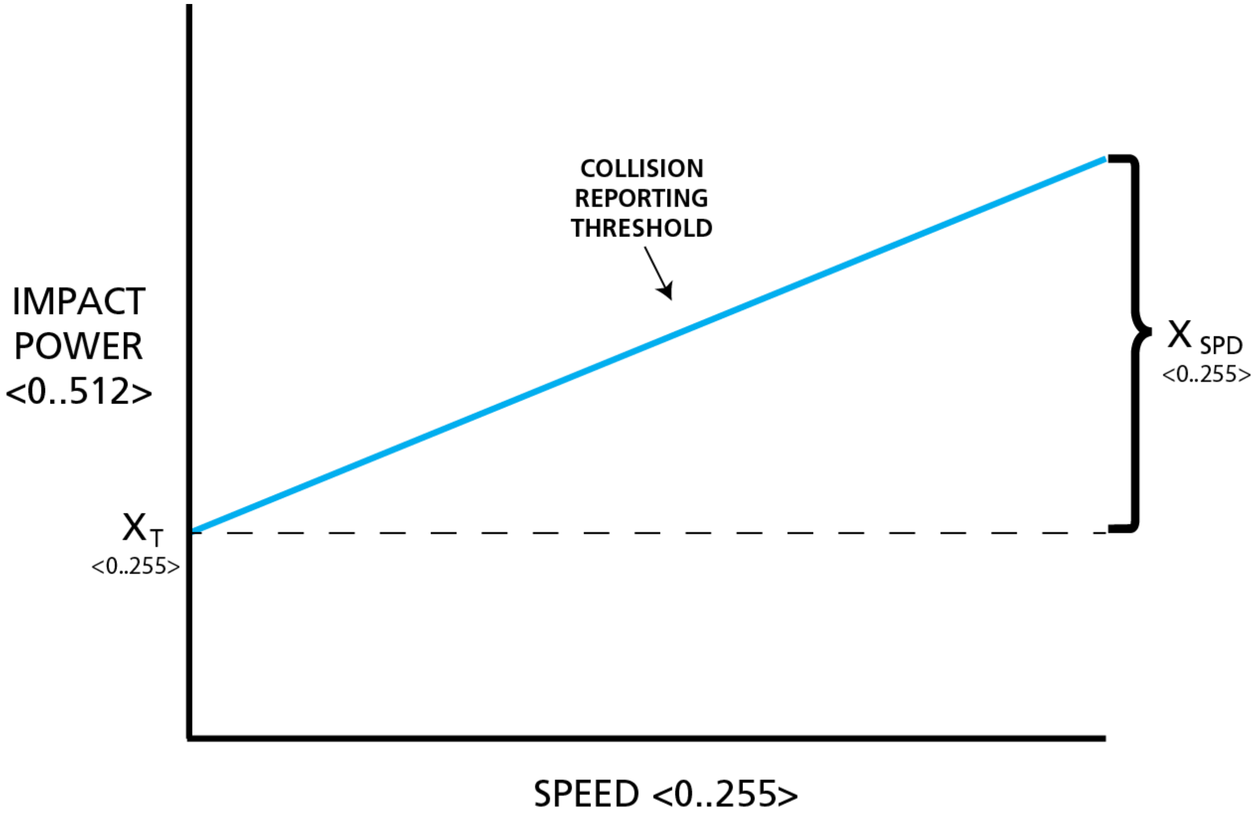
This feature detects collisions by measuring the accelerometer values and calculating the power (energy) of the signal in real time. When the power exceeds a threshold value, a collision is reported.

NB: This feature relies on the default accelerometer range setting of ±8Gs; if altered to one of the other settings this feature will exhibit indeterminate results.

Detection Thresholds

The X and Y axis impact thresholds are controlled independently. Each axis has two threshold values, based on the speed of the ball.

Xt is the threshold for the X axis at a speed of zero. The Xspd setting is added to Xt and becomes the threshold at the maximum speed.



Enabling Collision Detection

The feature is enabled via the Configure Collision Detection (12h) API command (see Appendix A). The Method field should be set to non-zero, and the X and Y axis impact thresholds should be set. Typical values are in the 100-140 range.

The Deadtime value should be set to a typical value of around 1 second (a value of 100).

Reporting

An impact is reported via an asynchronous API message to the phone (again, refer to Appendix A for the format).

The impact report contains data expressed in two different methodologies.

First, the actual power impact value is given in xMagnitude and yMagnitude. These values are the power that was detected in the impact and were compared to the threshold to determine a reportable collision. The Axis field indicates which (or both) axis crossed the threshold and is being reported.

Second are the impact values read from the accelerometer at the highest peak of impact. X and Y are the "flattened" values given by the accelerometer, and are calculated by removing the Z axis influence. In other words, they represent impact values only on the plane of the surface that Sphero is running on. X and Y have both positive and negative values. Positive values are based on the front (Y) and right (X) side of the ball. The Z reported value is always zero.

The speed of the ball at the time of the reported impact is given by the Speed output.

The Timestamp can be used to synchronize collisions in a multi-ball scenario.

Interpreting the Reported values

An example of a front impact against a still ball is:

X = 1450, Y = 5018, Z = 0, Axis = Y, xMagnitude = 43, yMagnitude = 146, Speed = 0. TimeStamp = Days:0, Hours:0, Minutes:4, Seconds:58, Milliseconds:186

The X and Y values show a front impact. The X value is non-zero due to the coupling of the sensor axis in the package. All hard impacts affect both axis due to the sensor mechanics.

The power magnitudes indicate a significant higher value for the Y axis and is a good indicator of where the impact occurred.

An example of a right impact against a still ball is:

X = 4322, Y = -1015, Z = 0, Axis = X, xMagnitude = 130, yMagnitude = 75, Speed = 0, TimeStamp = Days:0, Hours:0, Minutes:12, Seconds:40, Milliseconds:443

The X and Y values show a right side impact.

An example of a front impact of a driving ball against a wall is:

```
X = 2220, Y = 6100, Z = 0, Axis = Y, xMagnitude = 80, yMagnitude = 215, Speed = 106, TimeStamp =
Days:0, Hours:0, Minutes:18, Seconds:46, Milliseconds:763
```

Appendix A

Configure Collision Detection – 12h

	DID	CID	SEQ	DLEN	Meth	Xt	Xspd	Yt	Yspd	Dead
Command:	02h	12h	<any>	07h	<val>	<val>	<val>	<val>	<val>	<val>

Response:	**Simple Response**

Sphero contains a powerful analysis function to filter accelerometer data in order to detect collisions. Because this is a great example of a high-level concept that humans excel and – but robots do not – a number of parameters control the behavior. When a collision is detected an asynchronous message is generated to the client . The configuration fields are defined as follows:

param	description
Meth	Detection method type to use. Methods 01h and 02h are supported as of FW ver 1.42. Use 00h to completely disable this service.
Xt, Yt	An 8-bit settable threshold for the X (left/right) and Y (front/back) axes of Sphero. A value of 00h disables the contribution of that axis.
Xspd, Yspd	An 8-bit settable speed value for the X and Y axes. This setting is ranged by the speed, then added to Xt, Yt to generate the final threshold value.
Dead	An 8-bit post-collision dead time to prevent retriggering; specified in 10ms increments.

nb: Method 02h simply applies post-trigger filtering of a few components to further gate the asynchronous message. These thresholds were created experimentally by the application group and are therefore not intended for use outside of Orbotix.

Asynchronous Collision Detection Response

The format of asynchronous packets originating from Sphero when a collision is detected is:

SOP1	SOP2	ID CODE	DLEN-MSB	DLEN-LSB	data	CHK
FFh	FEh	07h	00h	11h	<data>	<cmp>

The data payload of the async message is 10h bytes long and formatted as follows:

X	Y	Z	Axis	xMagnitude	yMagnitude	Speed	Timestamp
<16-bit val>	<16-bit val>	<16-bit val>	<8-bit field>	<16-bit val>	<16-bit val>	<8-bit val>	<32-bit val>

The fields are defined as:

param	description
X, Y, Z	Impact components normalized as a signed 16-bit value. Use these to determine the direction of collision event. If you don't require this level of fidelity, the two Magnitude fields encapsulate the same data in pre-processed format.
Axis	This bitfield specifies which axes had their trigger thresholds exceeded to generate the event. Bit 0 (01h) signifies the X axis and bit 1 (02h) the Y axis.
xMagnitude	This is the power that crossed the programming threshold Xt + Xs.
yMagnitude	This is the power that crossed the programming threshold Yt + Ys.
Speed	The speed of Sphero when the impact was detected.
Timestamp	The millisecond timer value at the time of impact; refer to the documentation of CID 50h and 51h to make sense of this value.

Revision History

Revision	Date	Who	Description
1.2	Feb 25 2013	Dan Danknick	Added detection method 02h.
1.1	June 25 2012	Dave Hygh	Clarified response packet
1.0	Feb 28 2012	Dave Hygh	Initial release.