Accelerometer test for MultiWii

Compiled January, 2011 by Bo Jonsson, Sweden. Point65 @ RcGroups

This document is the result of testing and comparison of 5 accelerometers for the MultiWii open source code project. More information and all links you need to get started is available from the author's web site at URL http://radio-commande.com/category/international/ .

Accelerometers measure amount of static acceleration due to gravity, you can find out the angle the sensor is tilted at with respect to the earth. By sensing the amount of dynamic acceleration, you can analyze the way the device is moving. Results are presented as values for the x, y, and z-axis. More reading here: http://www.dimensionengineering.com/accelerometers.htm

For the Multiwii project, vibrations from motors, propeller wash and wind turbulence at different frequencies affect the sensors in a negative way. I wanted to compare the current set of sensors to evaluate which sensor would show the best properties for the MultiWii project on my tricopter.

Tested sensors

Overview					
Sensor	**Supplier**	**Selectable Range**	**Sensitivity @2g range**	**I2C addr 7/8-bit**	**Price (approx)**
BMA180	Sparkfun	1g to 16g	4096 LSB/g	x41/x82	USD 29,95
BMA020	ELV	2g to 8g	256 LSB/g	x38/x70	USD 7,90
Wii NK	Nintendo	unknown	unknown	x52/xA4	USD 21,00
MMA7455L	Seed Studio	2g to 8g	64 LSB/g	x1D/x3A	USD 15,00
ADXL345	Sparkfun	2g to 16g	256 LSB/g	x1D/x3A	USD 27,95

Note1: Wii Nunchuck price is based on original version (clones available) and at retail outlet (SEK 150)

Note2: Price of BMA020 breakout is EUR 5,95

MultiWii implementation

The following table gives some guidance on how the sensors are implemented in the MultiWii code and what values to expect in the GUI with the sensor connected.

MultiWii implementation									
Sensor	**Supported by version**	**Base I2C**	**Sensor I2C**	**Typical GUI**	**"Normal" GUI-values**			**Sensor setting in code**	
					L -> (0) -> R	**U - > (0) -> D**	**@1g**		
BMA180	1.6pre	100	400	4460	-254 0 +285 +/- 0	-280 0 +266 +/- 1	1g 275 +/- 1	range 3g	10 Hz low pass filter
BMA020	1.6pre	100	400	3850	-232 0 +220 +/- 1	-233 0 +234 +/- 1	1g 60 +/- 1	range 2g	25 Hz filter bw
Wii NK	1.1	100	100	6000	-215 0 +205 +/- 0	-210 0 +215 +/- 0	1g 200 +/- 1	default	default
MMA7455L	beta	100	400	4420	-190 0 +185 +/- 1	-185 0 +170 +/- 2	1g 190 +/- 3	range 2g	125 Hz filter bw
ADXL345	1.5	100	400	3770	-264 0 +255 +/- 0	-256 0 +257 +/- 0	1g 255 +/- 1	range 16g	200 Hz rate 100 Hz filter

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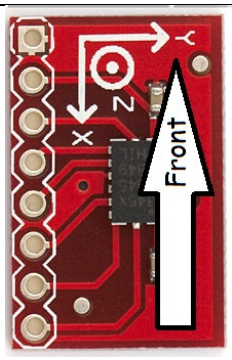
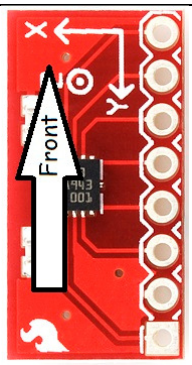
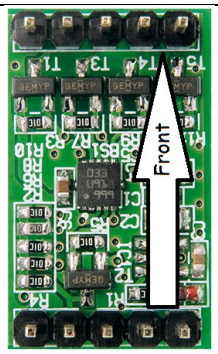
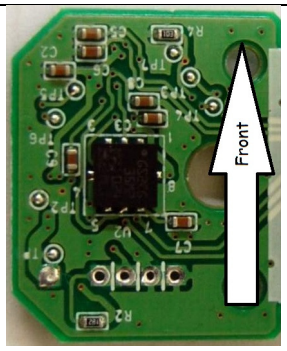
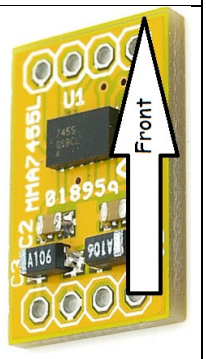
Sensor orientation

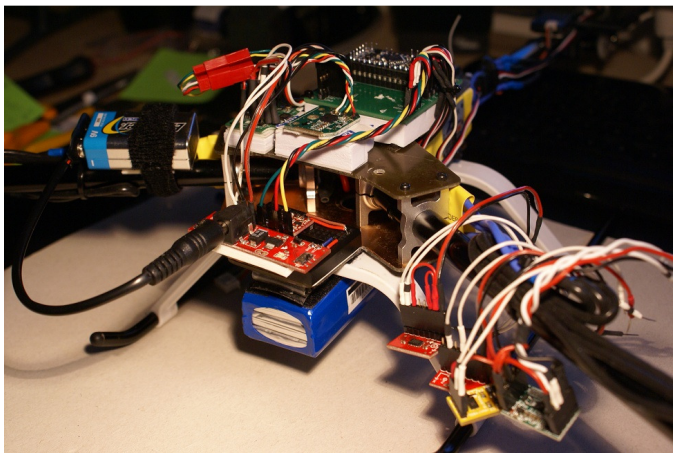
The following orientation was used during the tests, please verify in your configuration before using.

ADXL345	BMA180	BMA020	Nunchuck	MMA7455L
				

The test

The test was done on my Tricopter with MultiWii version 1.6pre. All sensors except the Nunchuk where connected to 3.3V power and used a logic level converter between the Arduino 5V side and and the sensor 3.3V side.

Tricopter configuration is Arduino Pro Mini, original WMP, Turnigy 2217/20 860kv, Hobbywing Pentium 18A ESC's, GWS 10x4,7 props. Distance COG to motor center is 38cm. Almost no vibrations.



The MultiWii 1.6pre code was modified to print the raw and smoothed values to the Arduino Serial Monitor with the following code:

```
#if defined(LOGDATA)
  for (i=0; i<3; i++) {
     Serial.print(accADC[i], DEC);     Serial.print(" ");
     Serial.print(accSmooth[i], DEC); Serial.print(" "); }
   Serial.println();
#endif
```

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Calibration of the ACC's was forced at each boot by changing `calibratingA = 0;` to `calibratingA = 400;` in the setup() procudure.
How the test data was collected:

1. Transmitter on, tri connected with the USB cable, sensor power on, main battery connected and Serial Monitor opened. This causes the Arduino to reboot and recalibrate ACC.
2. Autolevel mode on, motors armed, tri held loosely by hand at COG at about 1,5 meters.
3. Trottle raised to hover rate at 50%.
4. Run for 60-70 seconds.
5. Reduce trottle to 0 and disarm motors.
6. Disconnect USB cable, main battery power off sensors.
7. Mark all values in the Serial Monitor window (Ctrl+A).
8. Ctrl+C and Ctrl-V into a text file

The text file was the imported into Excel where data analysis plug-in was used to create a histogram showing the spread of raw and smoothed data for each axis. This data was the used to create graphs for each axis showing raw and smooth data. The percentage of data samples within the critical range for horisontal level was determined to -2 to +2 was also calculated and used to compare the sensors.

Test result summary

Summary of test results							
Sensor	Accel raw data			After smoothing			Rank
	X-axis	Y-axis	Z-axis	X-axis	Y-axis	Z-axis	
BMA180	78%	80%	99%	83%	87%	92%	1
BMA020	57%	78%	80%	91%	90%	79%	2
Wii NK	27%	37%	50%	84%	80%	89%	3
MMA7455L	9%	9%	13%	70%	71%	72%	4
ADXL345	5%	5%	13%	20%	24%	44%	5

The table above shows how many of the data samples (raw and smoothed) occured in the -2 to +2 range. For the Z-axis, a similar range was determined but using the mean value as offset as it differs between the sensors. See "Normal GUI values @1g" in the first table). Interesting phenomena is that the smoothed values on the Z-axis for BMA180 and BMA020 are less than the raw values. Don't understand why, it may be related to some discared data samples that where in error in the Serial Monitor.

Both Bosch sensors are great and I can feel the difference in flight comparing with the Nk and MMA7455L.

A little disclamer…. Tests where done on one multicopter and should be seen as indicative. Test at least 2 on your Multicopter to find what is most appropriate. Personally I'm really happy with the ADXL345 and surprised by the poor results. (It may be due to a faulty sensor and needs to be re-tested with a new sample) Also, sensor performance may be improved by changing settings that needs to be explored.

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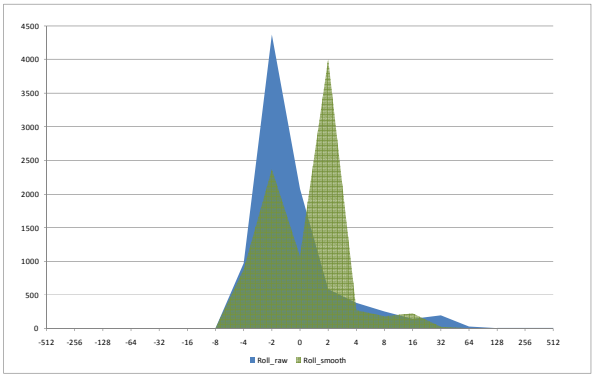
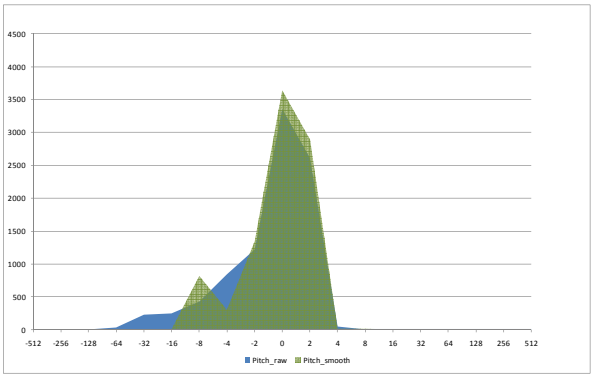
Notes on the graph's

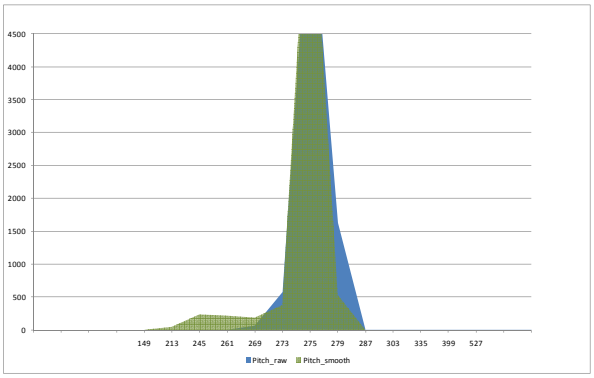
The attached graphs show the spread of raw(blue) and smoothed(green) data samples for the sensors on the order of Roll, Pitch and Z-axis. Graph data on the x-axis are centered on zero and with an exponential range from -512 to +512. The y-axis is 50% of the number data samples so the hight of the curves between the graphs can be compared.

So, my theory is: More data samples around the center and therefore higher peak, the better the sensor and MultiWii smoothing can manage vibrations on my tricopter

BMA180 Graphs







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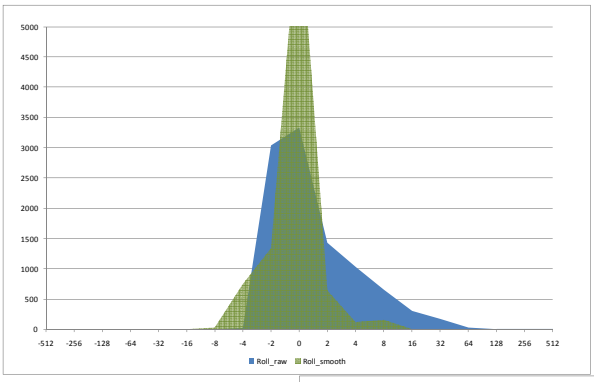
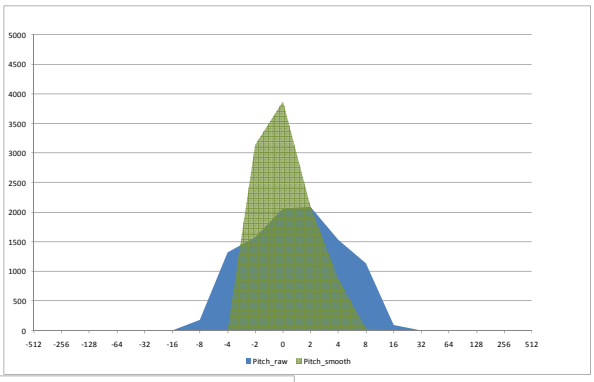
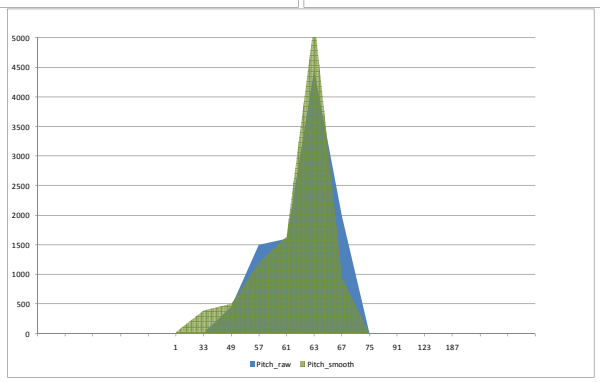
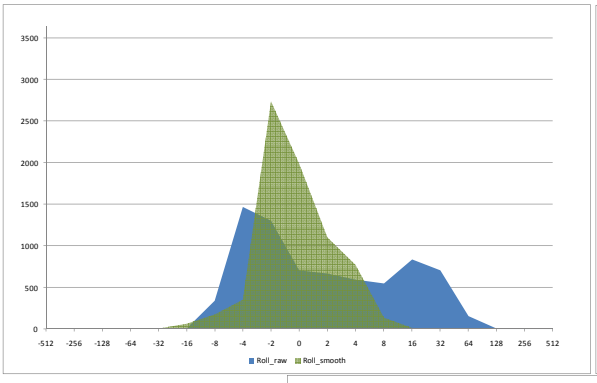
BMA020 Graphs

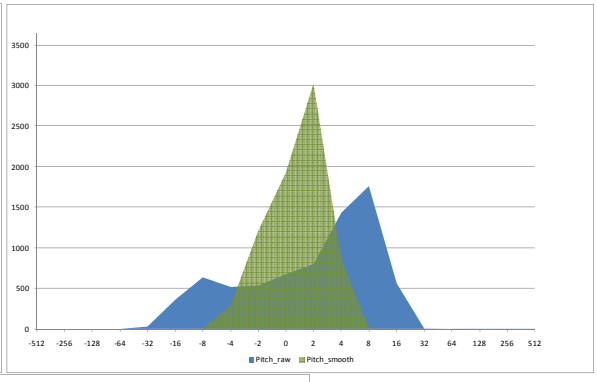


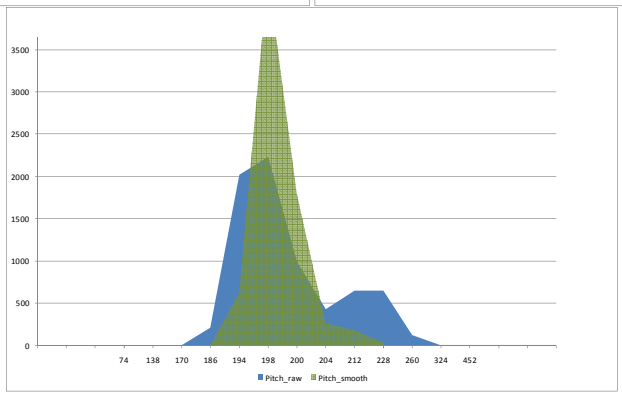




NunChuck Graph's







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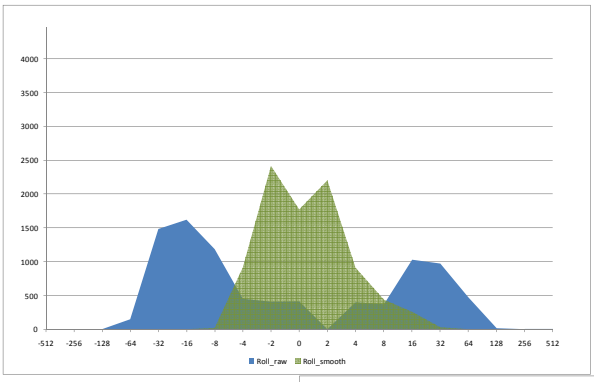
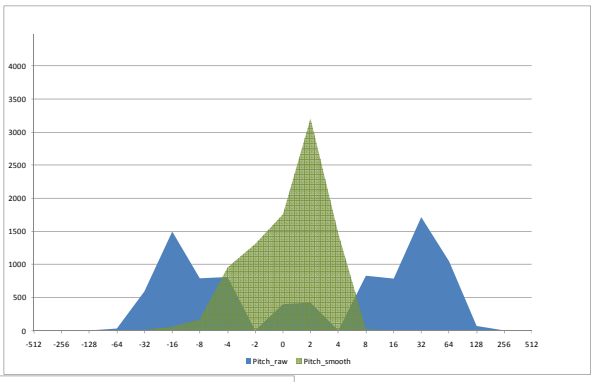
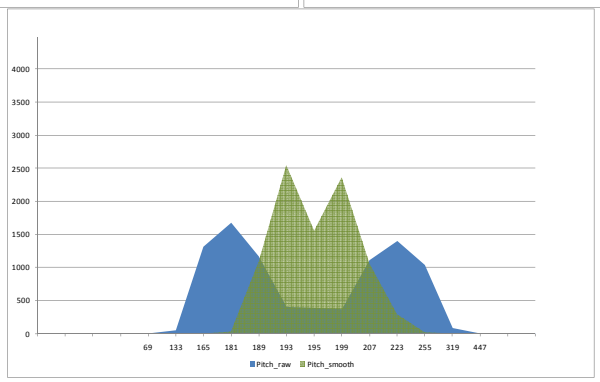
MMA7455L Graph's







ADXL345 Graph's