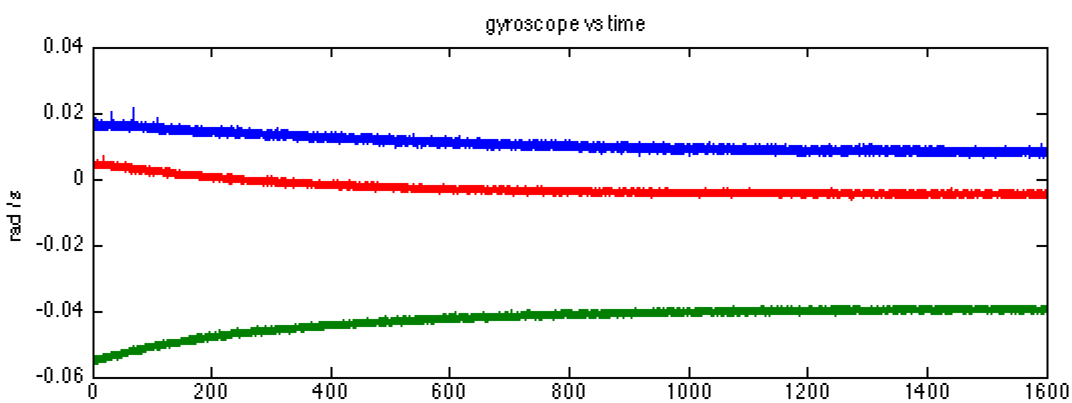
Temperature Correction in MPU6000

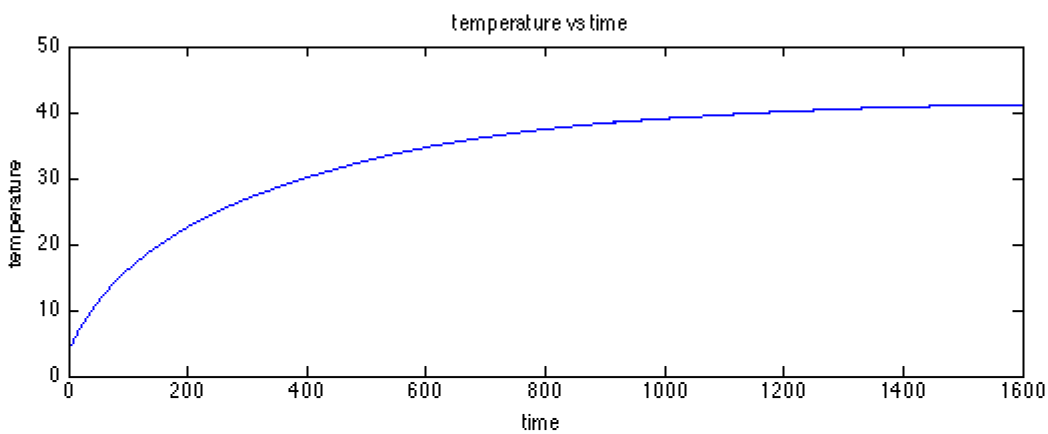
Dataset of MPU6000 sensor readings for 1600 seconds.

Dataset includes:

- gyroscope (x/y/z)
- accelerometer (x/y/z)
- magnetometer (x/y/z)
- timestamp
- temperature

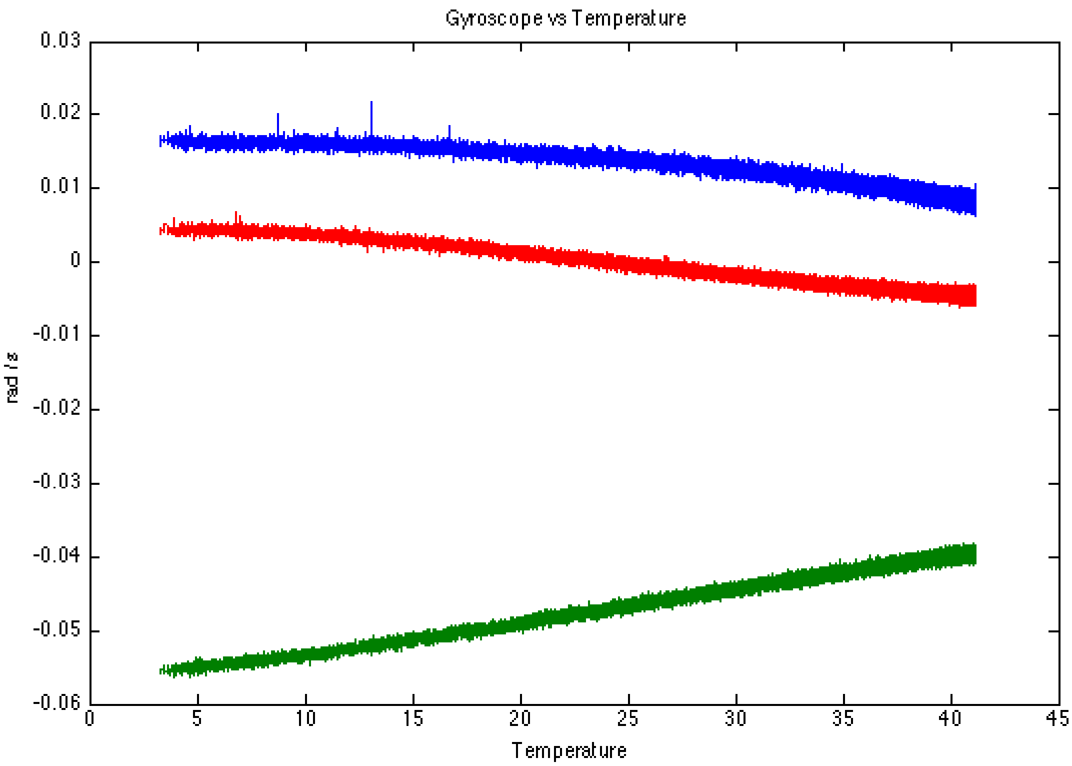
Non moving gyroscope vs time and corresponding temperature.





Non moving gyroscope vs temperature:

(if temperature independent: gyro values should not change and display a horizontal line)



Modelling relation Gyroscope-Temperature

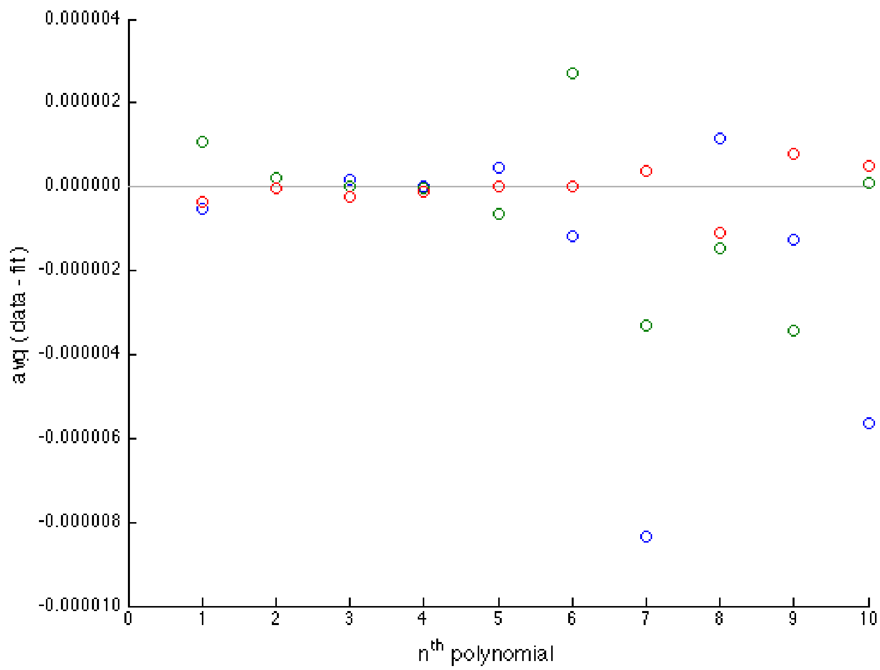
Testing different order of polynomials and their effect on the error;

Mechanism:

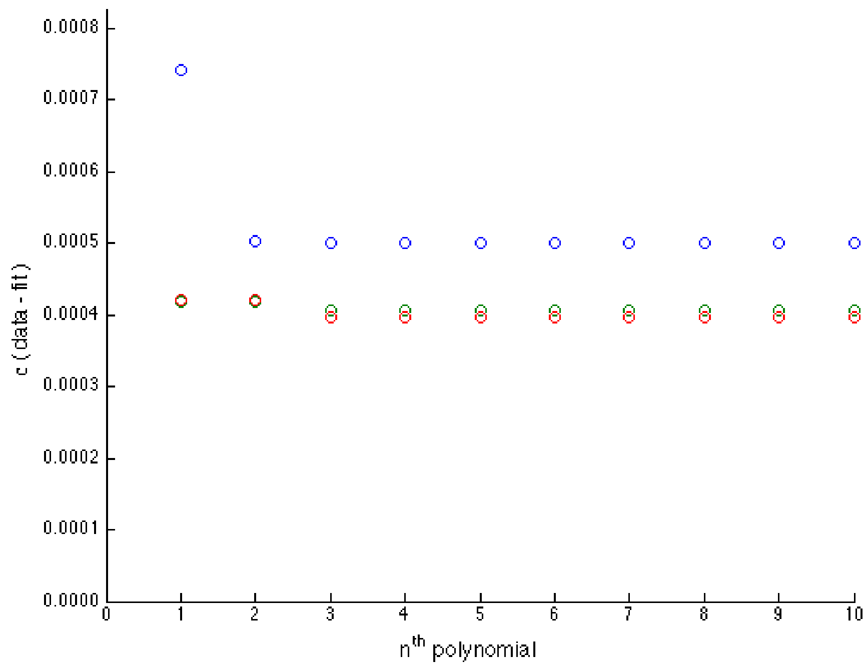
```
function [m s] = fit(xdata, ydata, max)
      m = zeros(1,max);
      s = zeros(1,max);

      %single floating point precision
      s_xdata = single(xdata);
      s_ydata = single(ydata);

      for n=1:max
            %do fit
            p = single(polyfit(s_xdata, s_ydata, n));
            %calc fit values
            f = single(polyval(p, s_xdata));
            %calc fit difference
            df = s_ydata-f;
            m(i) = mean(df);
            s(i) = std(df);
      end
end
```

`single(..)` = cast to single-precision floating point (32bits)

Average error for polynomial fit (gyroscope: radians / second):



Deviation of average error of polynomial fit (gyroscope: radians / second):

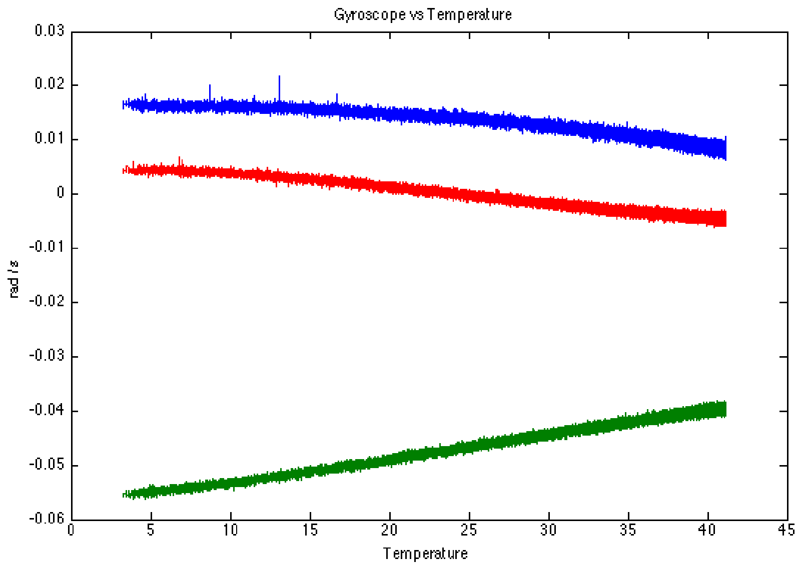


⇒ n = 4th order polynomial seems best (smallest error), but due to noise in measurement-error not statistically significant.

⇒ n > 5th order polynomial results in precision loss due to usage of single-precision floats. (term goes to 0)

Compensating temperature in Gyroscope

Recall:



- Temperature <> gyroscope should show a flat horizontal line.
- Relation is modelled with a (4th order) polynomial.

Simple approach:

- Assume a temperature at which the measurement is not biased ('true-temperature').
- Given a measurement, calculate the difference with respect to 'true-temperature'.
- Correct measurement

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```
%p    = calculated terms of polynomial of temperature fit
%mt   = temperature of IMU when measurement is taken
%tt   = temperature at which no bias is introduced in the measurement
%gyro = taken measurement

gyro  = gyro - ( polyval(p, mt) - polyval(p, tt) )
```

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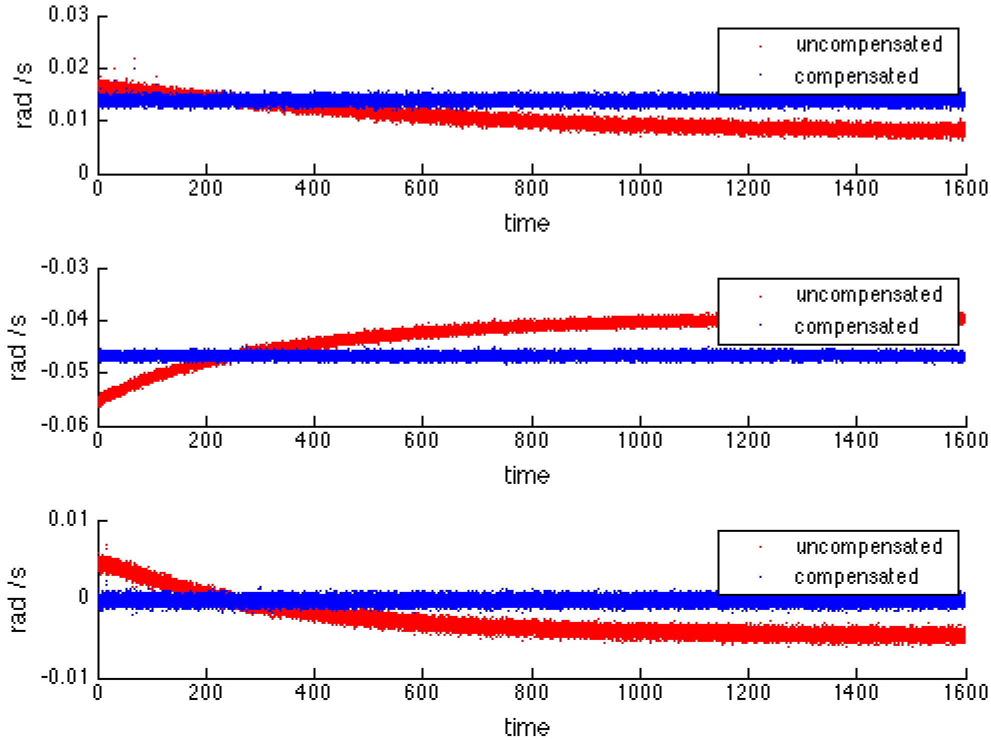
Compensated gyroscope measurements:



To Solve

- Determining ‘true temperature’
- How to do calibration?
    - Data over a large range of temperatures is needed
        - Let users put the px4 in a refrigerator?
        - After cooling: arm and let it sit for 15 minutes?
- Is the temperature curve generic: i.e can the terms be ‘hardcoded’
- Effect of cooling down: in general, the output of an IMU differs when the temperature has risen with +x and cooled down with -x.