Losmandy GM811G Unguided Tracking

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Introduction

This is a test of the unguided tracking performance of my GM811G in early November, 2023, aimed high in the sky, using an iOptron iGuider (120mm focal length, 6.45 arc-seconds per pixel) with PHD2 (guiding corrections turned off).

Data

I extracted the relevant portion from the PHD2 guide log. It is a CSV file and looks like this:

```
Frame,Time,mount,dx,dy,RARawDistance,DECRawDistance,RAGuideDistance,DECGuideDistance,RADurat
1,1.749,"Mount",-0.007,0.075,-0.074,-0.016,0.000,0.000,0,,0,,,,1527,27.11,0
2,3.331,"Mount",0.490,-0.037,-0.008,0.491,0.000,0.491,0,,0,,,,1548,27.44,0
3,4.914,"Mount",0.395,-0.125,0.088,0.407,0.000,0.407,0,,0,,,,1497,26.96,0
4,6.504,"Mount",0.502,0.031,-0.077,0.495,0.000,0.495,0,,0,,,,1498,26.91,0
5,8.095,"Mount",0.141,-0.116,0.102,0.154,0.000,0.154,0,,0,,,,1473,26.62,0
6,9.647,"Mount",0.192,-0.101,0.082,0.202,0.000,0.202,0,,0,,,,1499,26.93,0
```

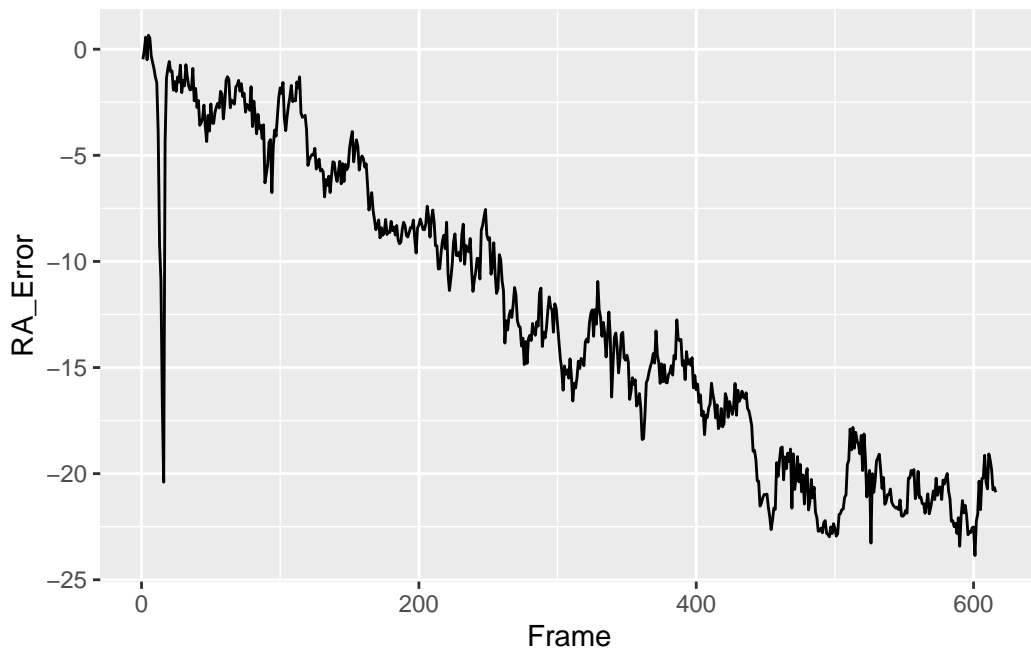with, of course, many lines of data following.

First look at the data

```r
d = read.csv("GuideLogExtract.csv")
dd = data.frame(Frame=d$Frame, RA_Error=6.45*d$RARawDistance)
# 6.45 arcsec per pixel is in calibration data from PHD2
```

```r
require(ggplot2)
```
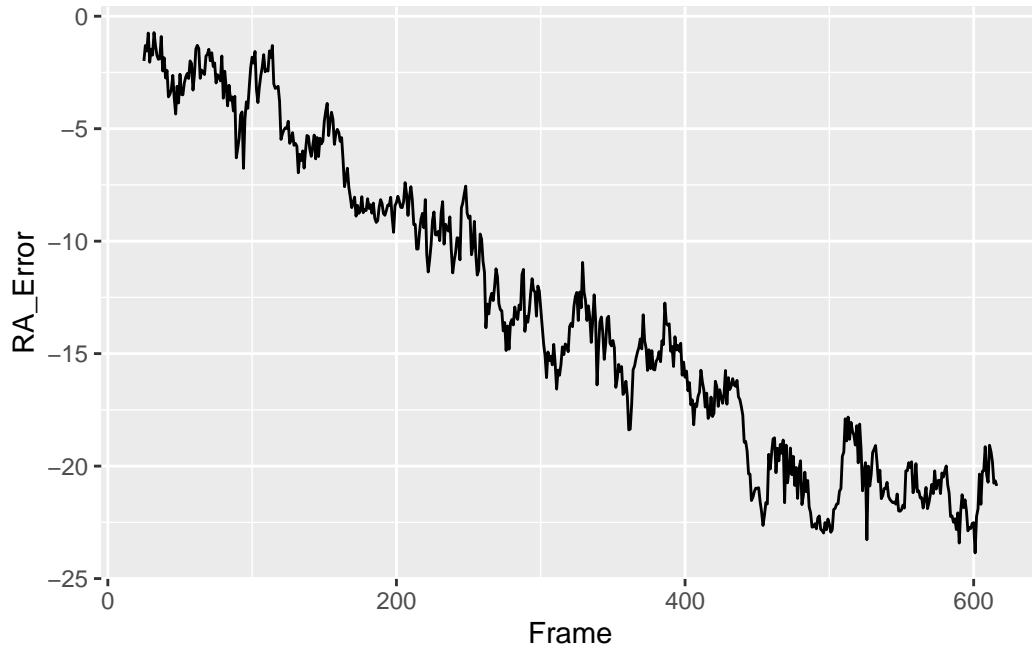
Loading required package: ggplot2

```r
ggplot(dd, aes(Frame,RA_Error)) +
        geom_line()
```


Clearly, something bumped the telescope somewhere around the 20th frame, so let's cut off the first 25 frames and try again:

```r
ddd = dd[seq(25,nrow(dd)),]
ggplot(ddd, aes(Frame,RA_Error)) +
        geom_line()
```

Now we see a steady downward trend, caused by polar axis misalignment, flexure, refraction, or some combination of the three, and we need to remove it.
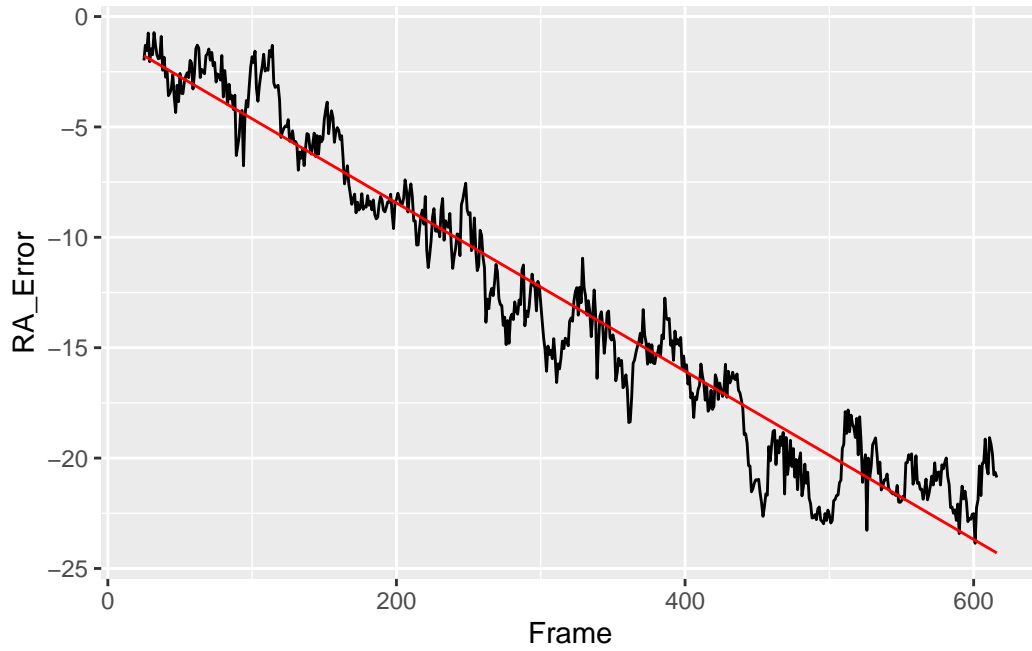
Detrending

We can fit a line to the data using linear regression:

```
model = lm(RA_Error ~ Frame, data=ddd)
ddd$Trend = predict(model, newdata=ddd)
```
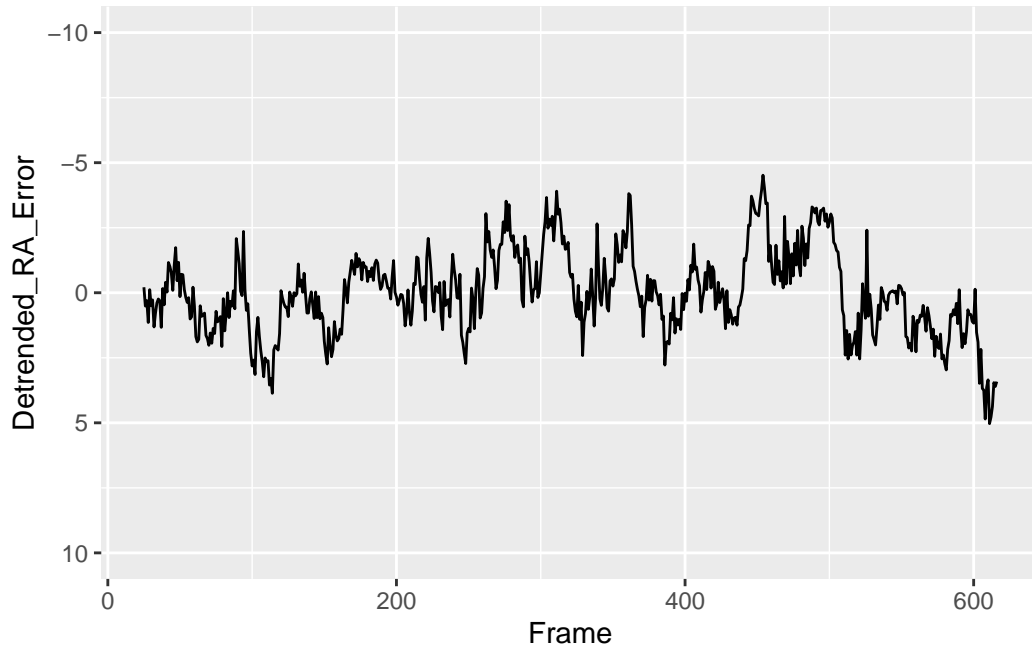
Let's look at it:

```
ggplot(ddd, aes(Frame,RA_Error)) +
        geom_line() +
        geom_line(color="red",aes(Frame,Trend))
```

That looks good. Now subtract it:

```
ddd$Detrended_RA_Error = ddd$RA_Error - ddd$Trend
ggplot(ddd, aes(Frame,Detrended_RA_Error)) +
  geom_line() +
  ylim(c(10,-10))
```

That is the quantity we actually want to study. It is about 10 arc-seconds peak-to-peak. If it were a sine wave, its RMS value would be $10/(2\sqrt{2}) = 3.5$ arc-seconds. But in fact most of it is flatter than a sine wave, so let's do the calculation that we set out to.

The RMS error is simply the standard deviation:

```
sd(ddd$Detrended_RA_Error)
```

```
[1] 1.620077
```

Right, a whopping 1.62 arc-seconds RMS! That is definitely good enough for my 200-mm lens (4-arc-second pixel size) and probably also for my AT65EDQ (about 2-arc-second pixel size). Drift due to misalignment and flexure will affect the image before tracking roughness does. And it's supposed to get even better when I upgrade to Gemini Level 6.