

# Some simple algorithms for detecting anomalous bright pixels

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## Abstract

I describe some simple algorithms I am using for detecting anomalous bright pixels in images taken by a laptop webcam. The webcam lens is covered with black tape and so the visible light is not collected by the sensor; the grey levels different from zero in the image are usually due to the so called *dark current*; sometimes there are bright pixels (and I classify the image as an *event*) and an hypothesis is that the bright pixels are the result of the interaction of cosmic ray muons with the semiconductor sensor of the webcam.

## 1 Algorithms

I am experimenting various algorithms in order to classify an image as an *event*.

I have a sequence of images, let  $I_i$  be the  $i$ -th image in the sequence. The image has  $R$  rows and  $C$  columns. Let  $I_i(r, c)$  be the grey value of the pixel at *row* =  $r$  and *column* =  $c$  in the image  $I_i$ . The program computes  $M_i$  as

$$M_i = \max_{\substack{0 \leq r \leq R-1 \\ 0 \leq c \leq C-1}} I_i(r, c)$$

So  $M_i$  is the maximum grey level in the image  $I_i$ .

The simplest algorithm uses a fixed threshold  $t$  and the image  $I_i$  is classified as an event if

$$M_i > t \tag{1}$$

A different algorithm considers the average grey level  $avg_i$  of the image  $I_i$  and the standard deviation  $sd_i$  of the grey levels of the image  $I_i$ , the image  $I_i$  is then classified as an event if

$$M_i > avg_i + n \cdot sd_i \tag{2}$$

In a third algorithm, the program keeps running statistics for  $M_i$ , in particular  $\overline{M}_i$  is the mean of the maximum grey levels and it is computed as

$$\overline{M}_i = \frac{1}{i} \sum_{k=1}^i M_k$$

and  $\sigma_{M_i}$  is the standard deviation of the maximum grey level and it is computed as

$$\sigma_{M_i} = \sqrt{\frac{1}{i(i-1)} \left( i \sum_{k=1}^i M_k^2 - \left( \sum_{k=1}^i M_k \right)^2 \right)}$$

The image  $I_i$  is then considered an event if

$$M_i > \overline{M}_i + n \cdot \sigma_{M_i} \quad (3)$$



Figure 1: A crop from an image classified as an event using formula 3 with  $n = 10$ .

## 2 Data

Figures 2 to 14 show data collected in various days. The time between two images acquisition has a mean value of 0.13s and a standard deviation of 8ms. The exposure time is unknown. The images were collected with a laptop webcam, the location is in Northern Italy, the time is local.

The graphs should be considered as a work in progress, in particular I have some issues with them:

1. The range for  $M_i$  in Figures 2 and 3 seems quite different with respect to the remaining Figures.
2. The curve for  $\overline{M}_i$  seems too low in Figure 2 and 3.
3. The curve for  $\overline{M}_i$  does not properly follow the trend of  $M_i$  in Figures 6 and 14.

The above issues could have been caused by some errors in the program collecting the data, I should investigate further.

The summary for the hourly rate event is the following:

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
0.700	1.355	1.840	1.991	2.468	4.460

This table summarize the data collected so far.

events	elapsed time	events per hour
9	03h14m18s	2.78
12	08h03m03s	1.49
23	09h27m57s	2.43
15	06h37m57s	2.26
6	08h37m23s	0.70
10	08h06m30s	1.23
8	09h05m33s	0.88
22	08h44m34s	2.52
17	08h44m33s	1.94
7	05h21m33s	1.31
12	07h16m38s	1.65
11	06h19m07s	1.74
20	08h04m50s	2.48

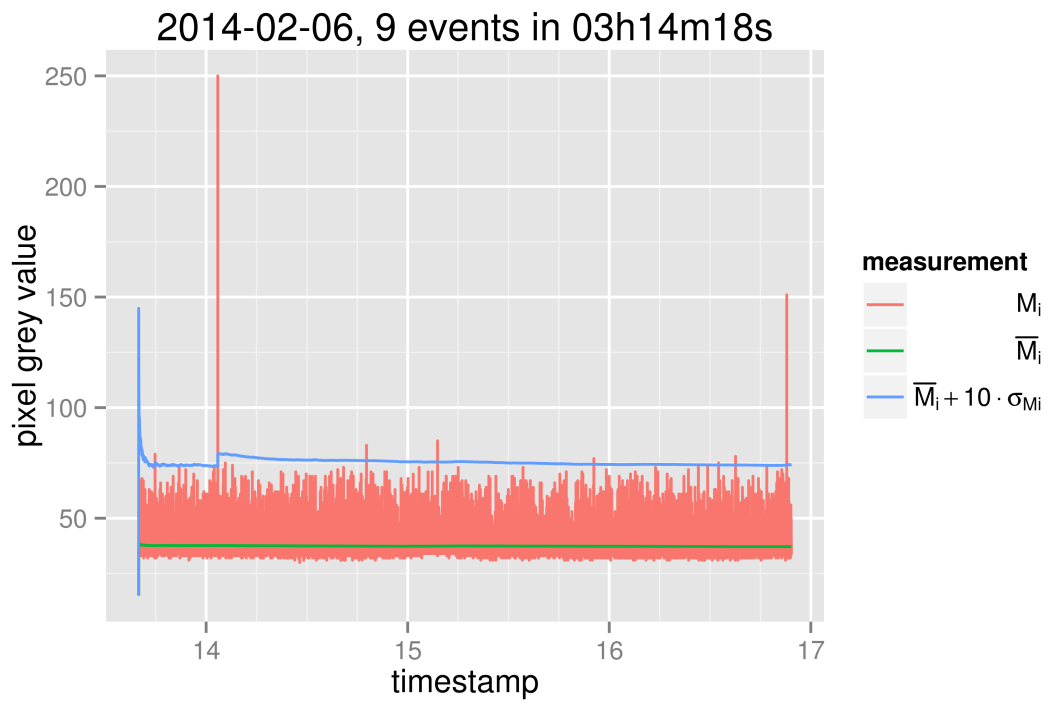


Figure 2: Data collected using formula 3 with  $n = 10$ .

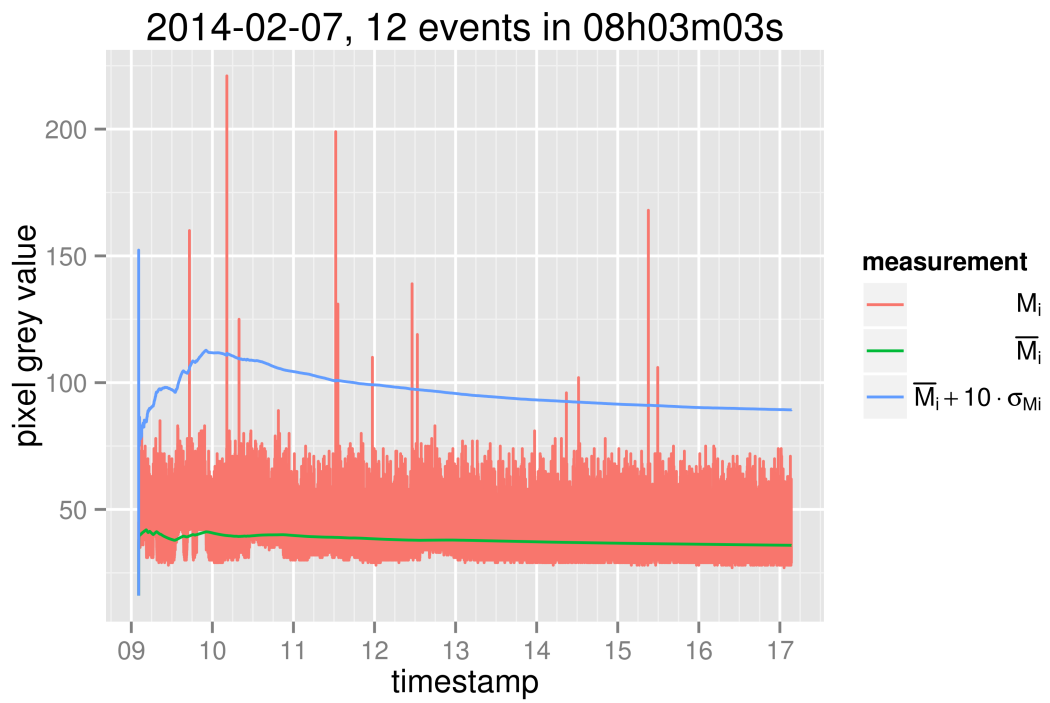


Figure 3: Data collected using formula 3 with  $n = 10$ .

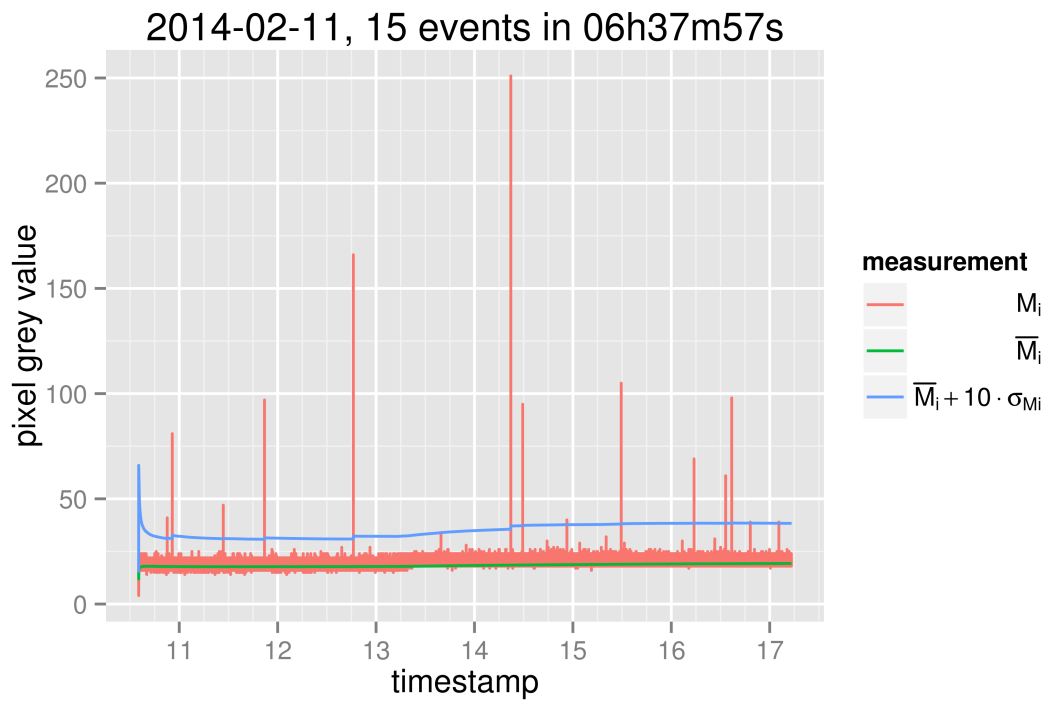


Figure 4: Data collected using formula 3 with  $n = 10$ .

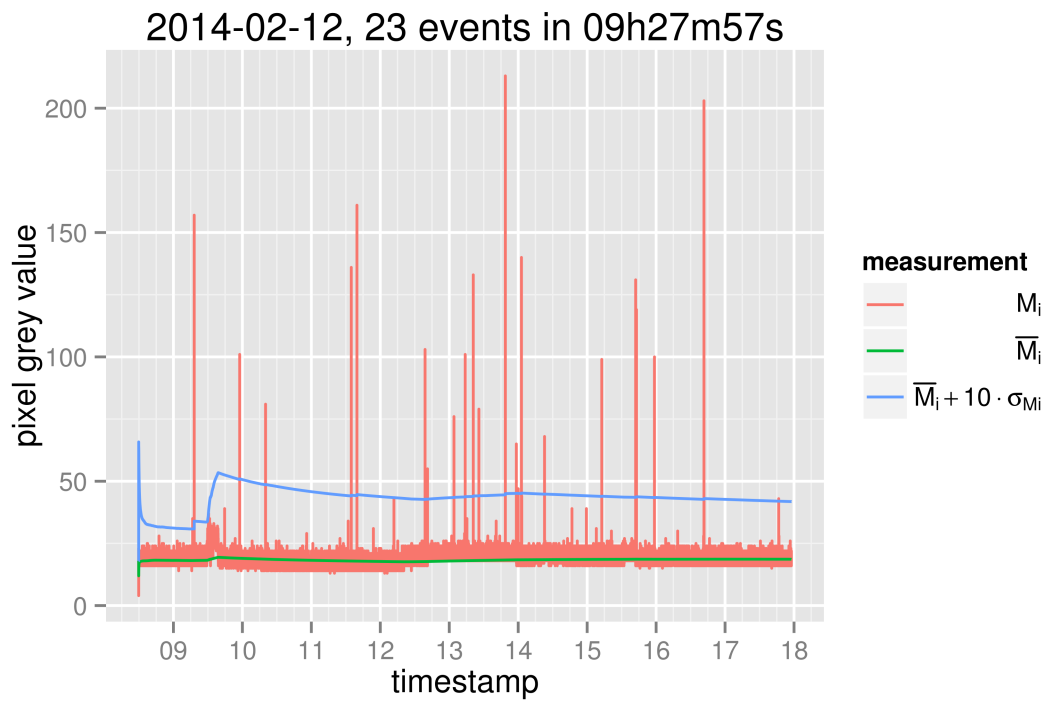


Figure 5: Data collected using formula 3 with  $n = 10$ .

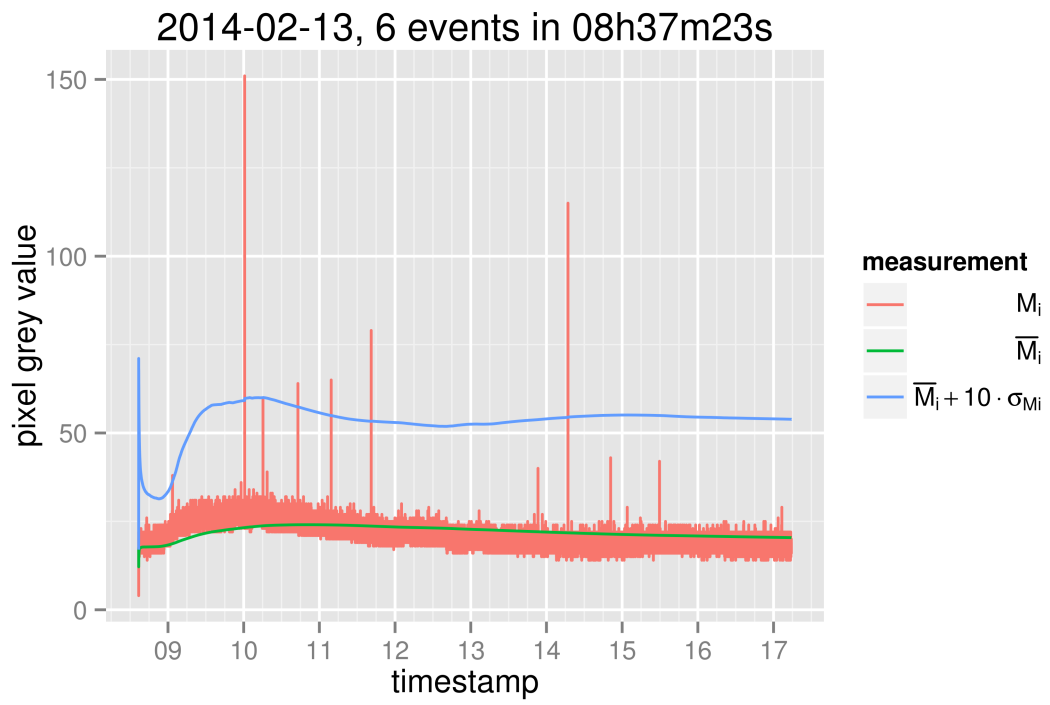


Figure 6: Data collected using formula 3 with  $n = 10$ .



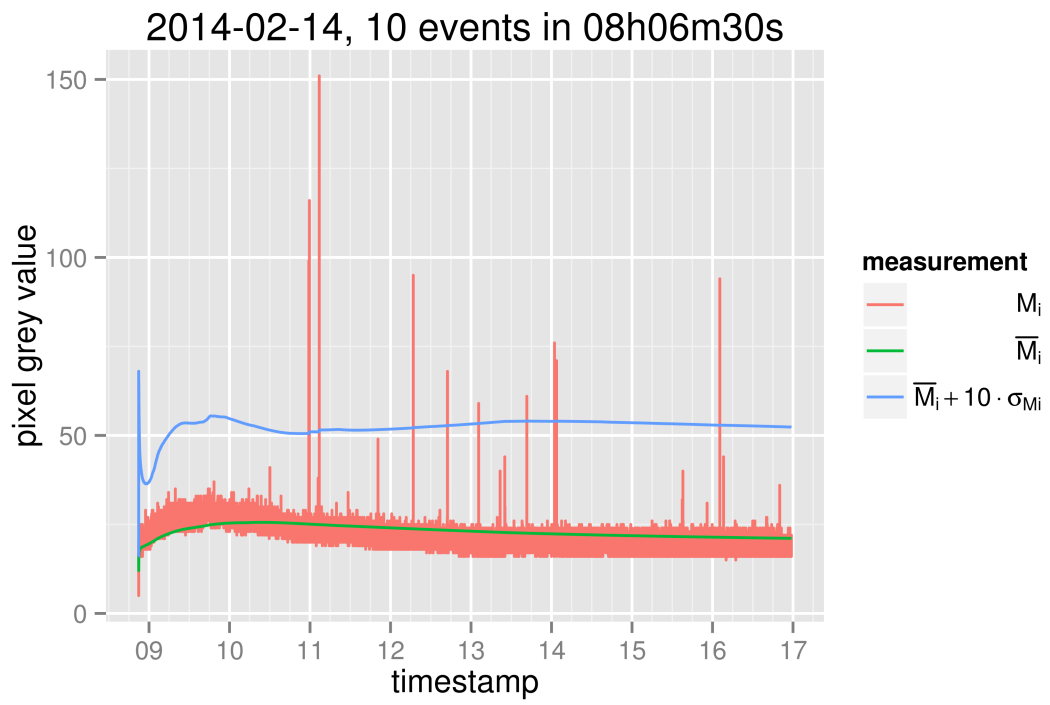


Figure 7: Data collected using formula 3 with  $n = 10$ .

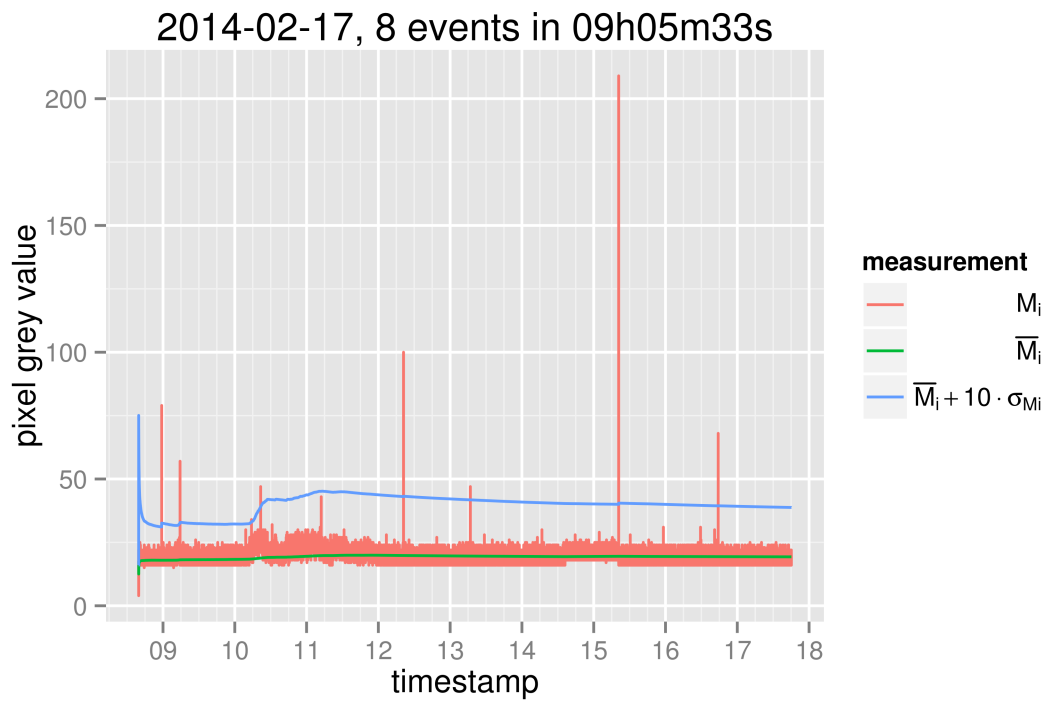


Figure 8: Data collected using formula 3 with  $n = 10$ .

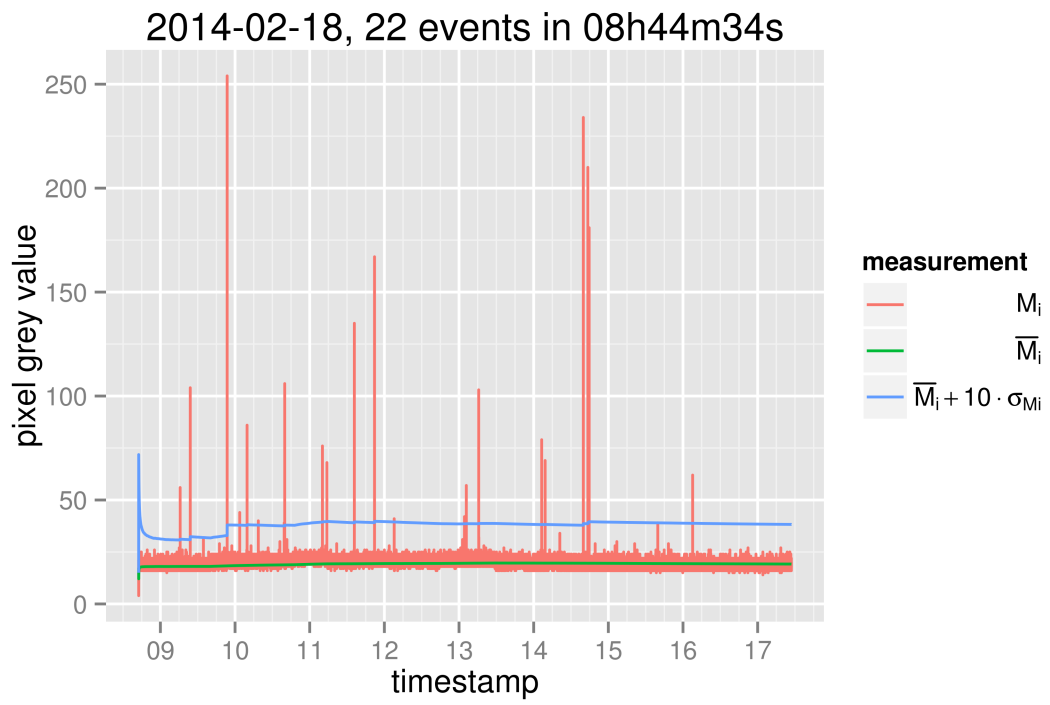


Figure 9: Data collected using formula 3 with  $n = 10$ .

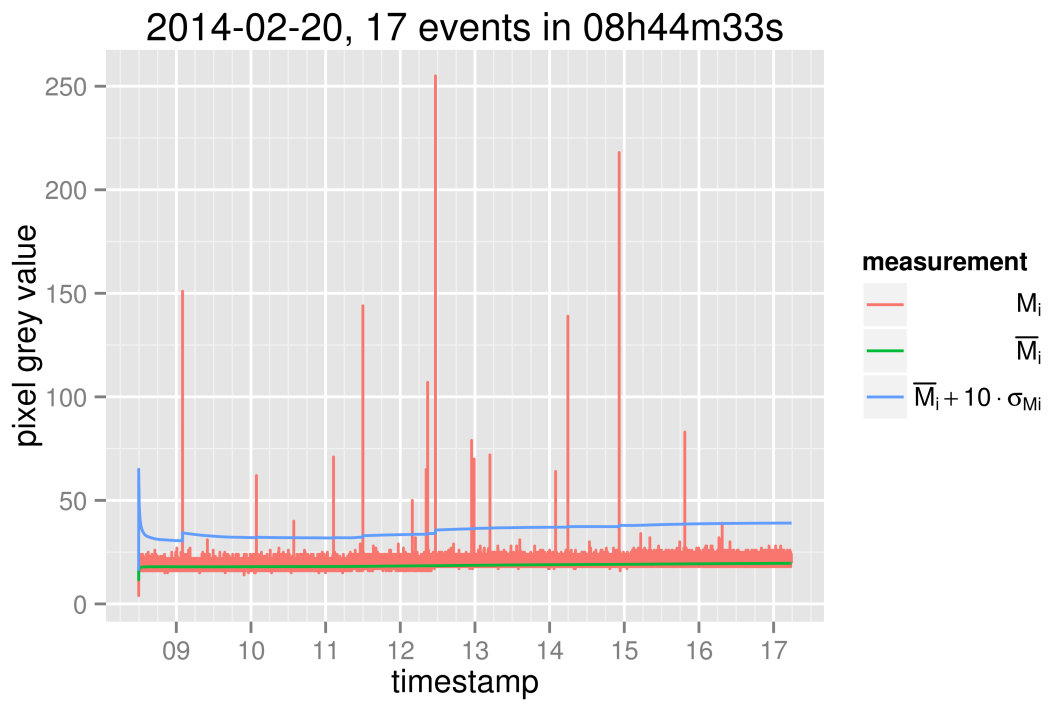


Figure 10: Data collected using formula 3 with  $n = 10$ .

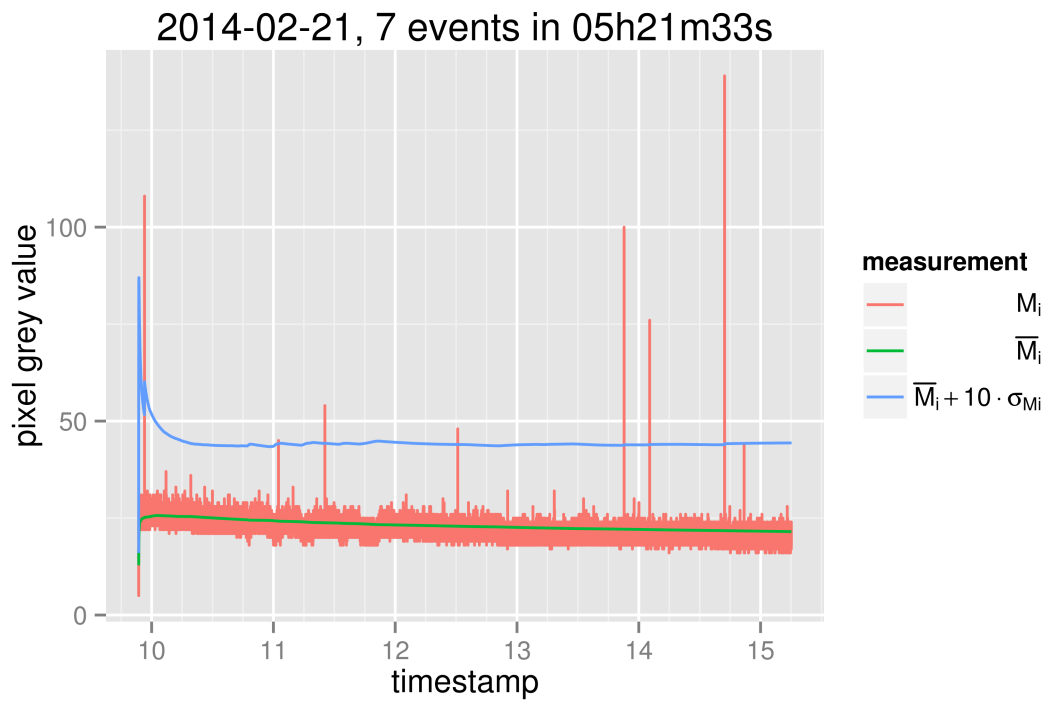


Figure 11: Data collected using formula 3 with  $n = 10$ .

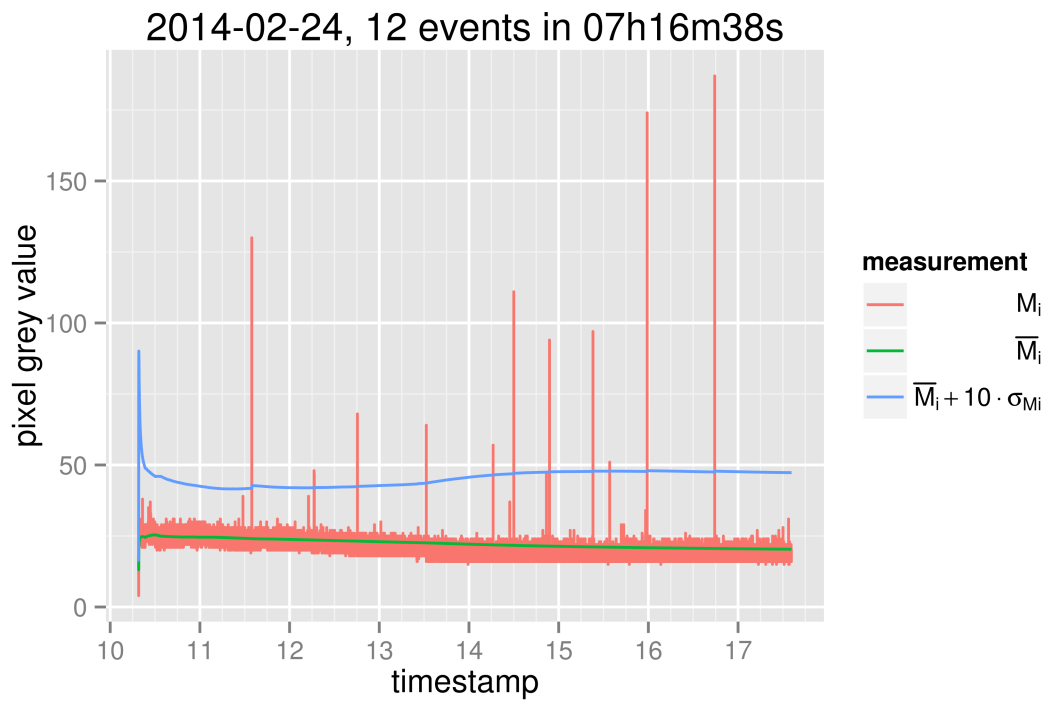


Figure 12: Data collected using formula 3 with  $n = 10$ .

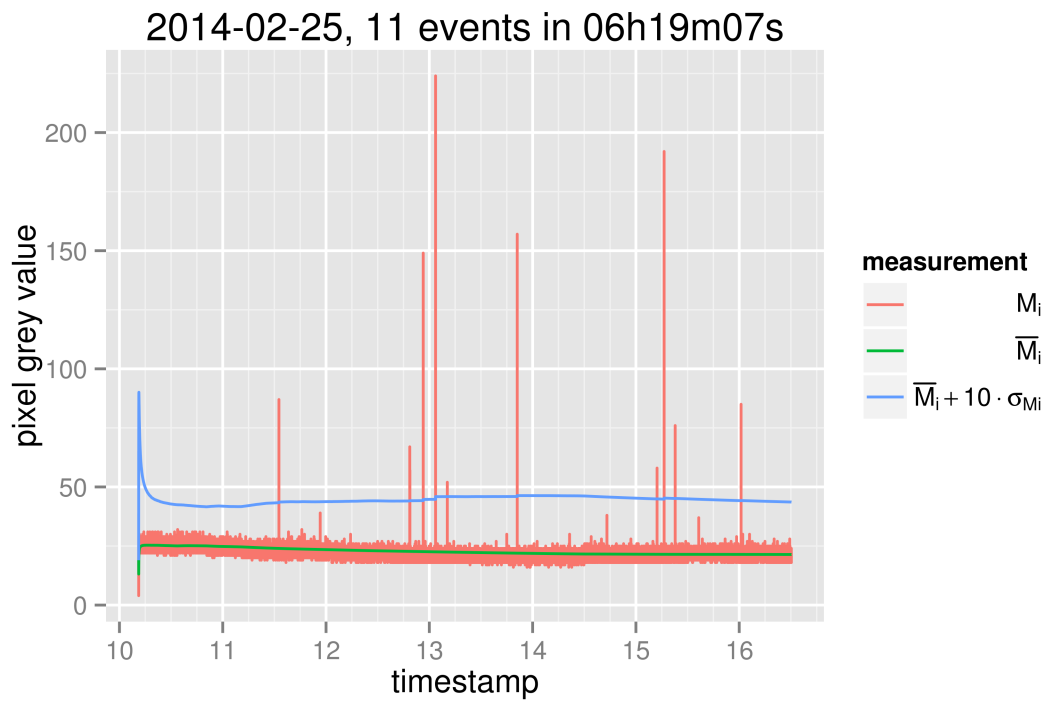


Figure 13: Data collected using formula 3 with  $n = 10$ .

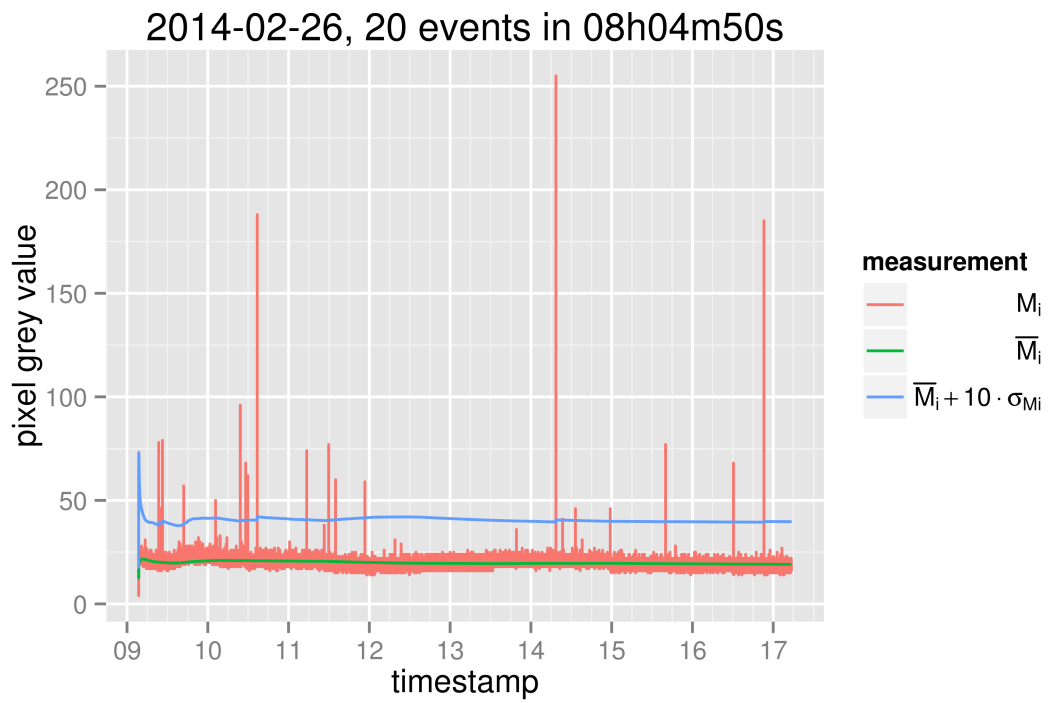


Figure 14: Data collected using formula 3 with  $n = 10$ .