Chapter 8

Second Variation: Vibrations of the Ground and the Double Queue Test

In this chapter, the double queue test is tried in an experiment with induced vibrations of the ground. In this situation the algorithm is found not to work properly, so a new modification is introduced to overcome these deficiencies and then is tried in both cases: with and without vibrations.

8.1 Response with induced vibrations of the ground

Induced vibrations of the ground produce measurements spreading as shown on figure 8.1 after 1700 samples, dealing to higher standard deviation values. Since the *self-adapting test* described in the previous chapter has the ability to deal with different standard deviation values, its behavior in the case of induced ground vibrations would be expected not to be bad, even when the PDF of the reading changes. Nevertheless, results (see figure 8.2) are completely wrong from the moment vibrations start.

The reason lies on the fact that the standard deviation of the sample mean, σ_{mean}, is being estimated using S through:

$$\hat{\sigma}^2_{mean} = \frac{\hat{\sigma}^2_{proc}}{N} = \frac{S^2}{N} \tag{8.1}$$

In this equation it is considered that: $E(S^2) = \sigma^2_{proc}$, while this is only true for a stationary process. As the process is no longer stationary, S^2 cannot be used as estimation of σ^2_{proc} anymore. Thereby $\hat{\sigma}_{proc}$ is wrong.

Figure 8.2 shows that, when vibrations start, $\hat{\sigma}_{proc}$ grows a lot while $\hat{\sigma_{mean}}$ does not seem to grow that much. To explain this behavior of the statistic S, an approach to the increment of both values due to vibrations is developed in appendix B. It can be resumed in a few words saying that the computation of the sample mean has a *low-pass filter* effect over the input. That is the reason that the effect of the oscillations is reduced and only low-frequency-changes take effect

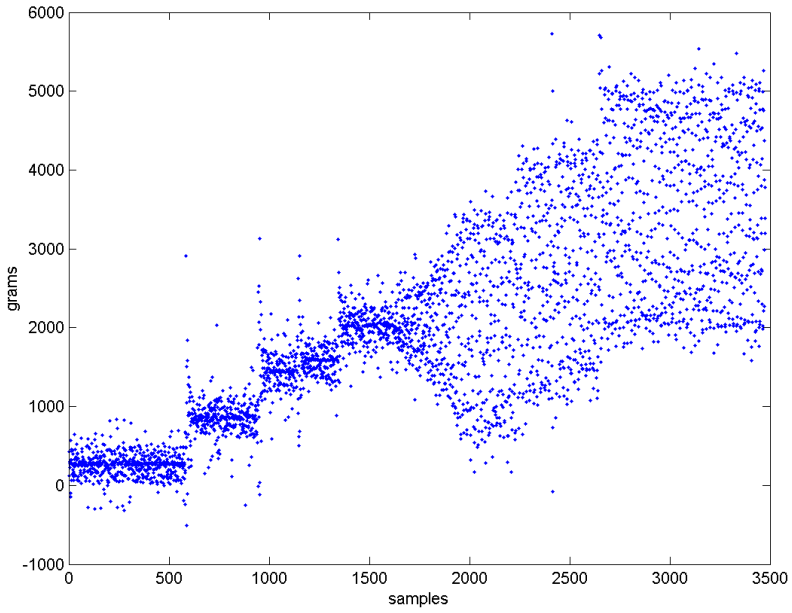

Figure 8.1: Effect of induced ground vibrations on weight measurements. Visible from sample 1700 on.

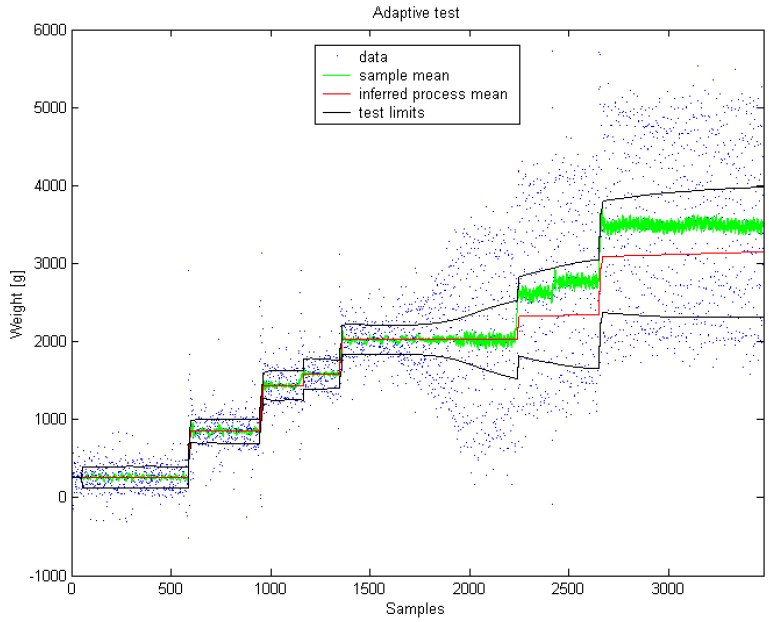

Figure 8.2: Response of the adaptive test with induced vibrations of the ground.

on it.

8.2 Double queue algorithm

Since we are actually not interested in the value of σ_{proc} but in the value of σ_{mean}, we can try to estimate it directly without using $\hat{\sigma}_{proc}$ in the calculations. We are not even interested on the value σ_{mean} would have in the underlying stationary process, but on the value it takes in the actual non-stationary process. Consequently, a good solution would be to directly estimate σ_{mean} by applying the statistic S to a list of sample mean values. Therefore, we have to change the algorithm in order to have such a list. The new implementation is explained on figure 8.3. This means just a small change through which calculated sample mean values are not deleted anymore, but queued to be read later.

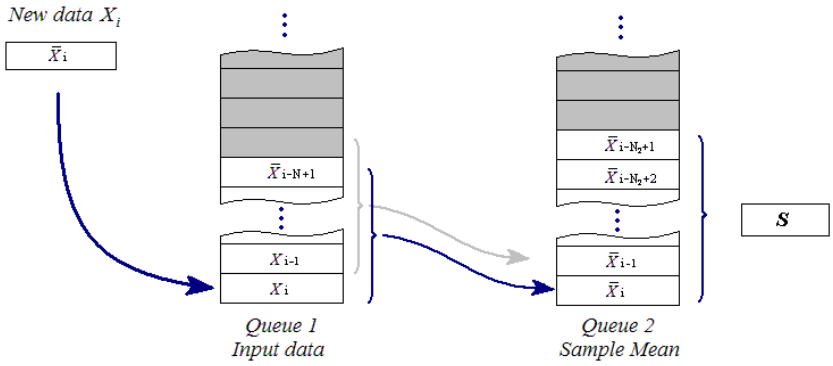

Figure 8.3: Schema of the double queue algorithm for the estimation of σ_{mean}.

Let us remember that optimal N and K values are chosen in the self-adapting test as a function of $\hat{\sigma}_{proc}$. In order to avoid repeating the study of the optimal test parameters and the adaptation rule, a theoretic $\tilde{\sigma}_{proc}$ can be calculated up from $\hat{\sigma}_{mean}$ as: $\tilde{\sigma}_{proc} = \hat{\sigma}_{mean}\sqrt{N}$. This value corresponds to the standard deviation of a stationary hypothetical process whose sample mean's standard deviation is the current σ_{mean}. This mathematical trap enables us to use the same adapting algorithm developed in sections 7.3 and 7.5.

8.3 Results and discussion

Figure 8.4 shows the behavior of the self-adapting test using the double queue algorithm. Results are as good as they were during experiments without induced ground vibrations. Besides, at the left part of the graphic we see the response of the test without vibrations, and it is still the same as previously. In conclusion, the self-adapting test with the double-queue algorithm seems to fulfill all requirements and carries out the goal of this thesis, so it can be considered a succes.

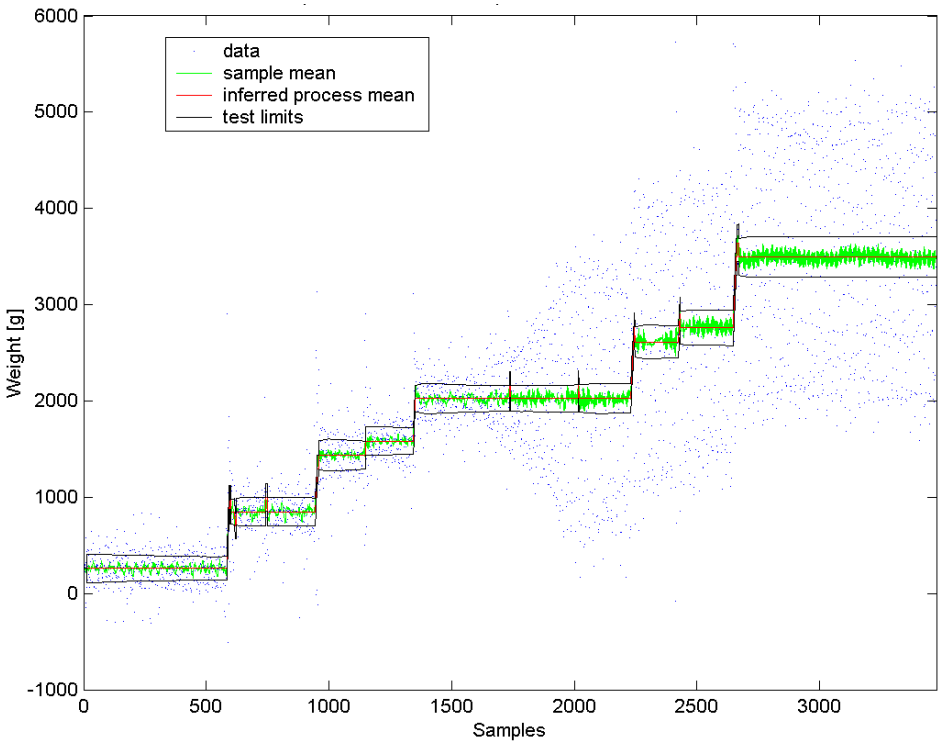

Figure 8.4: Behavior of the self-adapting test using the double-queue algorithm with and without induced ground vibrations.