Chapter 1

Introduction

1.1 Counting scales

When the weight of the output units coming from any manufacturing process is known and, as a consequence of a high turnover, a big amount of them has to be counted, counting scales are commonly used with this purpose. As the goal of counting scales is counting units, for a general case their task should not be limited to weighing and dividing by the unitary weight. On the contrary, *they must register and count the leaps on the reading* during the process. Otherwise, changes or small uncertainties on the unitary weight, nonlinearities of the sensor measurements, falling shaving material or any other accidental change of the final weight would be translated into a wrong result at the final count.

Scales are typically required to fulfill some requirements like a maximal value of the sensitivity threshold and a maximal total weight. The first value (sensitivity threshold) must be much lower than the lowest weight to be measured and the second one (maximal weight) is determined by the maximal number of pieces. Besides, because of technical reasons, absolute accuracy is always inversely proportional to the rank. So, as the rank of a scale increases, the accuracy decreases. As a consequence, the problem of counting similar weight units with a counting scale becomes more difficult as the number of units to be counted increases.

In some cases, when the maximal-to-minimal weight ratio is very high, the weight of a process unit gets closed to the sensibility threshold and the fidelity of the scale (index related to the standard deviation of the measurements) starts playing an important role. In these cases, measurements are found to oscillate under statistical rules altering the results even when the load keeps still. Some techniques like signal filtering or, more commonly, statistical computation are used to solve this problem. Existing solutions nowadays need to be improved, when not completely developed from the basics and, anyway, they must be adapted to the particular characteristics of each installation.

This thesis has been worked out in the laboratories of the HTWG Konstanz and deals with an industrial counting scale located in these laboratories as a part of a common general project between the already mentioned HTWG Konstanz and the companies DigiSens AG and Georg Fischer AG. The aim is to implement a counting scale for Georg Fischer AG. using DigiSens weight sensors for the counting of output units pertaining a gear box manufacturing process.

1.2 Description of this document

Chapter 2 contains a description of the installation, the counting scale itself and the measurement electronics. The goal of the thesis is explained in chapter 3 with more detail than in this introduction. After that, different existing solutions are proposed and briefly analyzed in chapter 4.

Before any solution is selected and developed, chapter 5 shows a statistical analysis of the measurements. Results serve as support for all calculations in the rest of the document.

Then, in the next three chapters, an algorithm is elaborated, tried out and improved. More concretely, in chapter 6 a solution from chapter 4 is selected and adapted to perform a basic algorithm. Chapter 7 introduces an important modification on the test (self-adaptive parameters based on the on-line estimation of the variance) to overcome the big uncertainty about the variance of the process. Finally, chapter 8 introduces the *"double-queue"* algorithm to make the test work as well under induced ground vibrations.

Some interesting statistical tools we found during the performance of this thesis are explained in chapter 9.

Lastly, chapter 10 contains the summary, discussion and outlook where the thesis is situated in a global frame concerning the general project between the HTWG Konstanz, DigiSens AG and Georg Fischer AG and where some further studies are proposed.

At the last part of the document, appendices A, B and C can be found containing mathematical developments and Matlab codes used during this work.