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Modyfing an Attribute Control Chart: Daudin's Methodology

E. Pérez-Bernabeu[1], M.A. Sellés[2], A. Carrión[3], J. Jabaloyes[3]

[1]Departamento de Estadística e Investigación Operativa aplicadas y Calidad, U. Politècnica de Valencia, Alcoy. E-mail: elenapb@eio.upv.es
[2]Departamneto de Ingeniería Mecánica y de Materiales, U. Politècnica de Valencia, Alcoy. E-mail: maselles@dimm.upv.es
[3]Departamento de Estadística e Investigación Operativa aplicadas y Calidad, U. Politècnica de Valencia, València.

Abstract. *There are many methods that can be applied to each one of the control charts, for instance, Daudin's methodology, which proposal is to set two stages of decision, and a rule to go on with the second stage. It is always taken two samples and, at first, it is only analyzed the first sample. Then, depending on the rule, it is analyzed the second sample or not, so that a good decision can be made. It is stated that in the existing bibliography there are several studies about variable control charts, concretely, average control charts. On the other hand there are fewer contributions for the attribute control chart.*

Keywords: Statistical tool, control charts, a
PACS: 02.50.-r

INTRODUCTION

Since 1931, when Shewhart[1] proposed the Mean Chart and the so called classical control charts, very different alternatives have been proposed to improve the efficiency of the charts, that is, the ability to detect as soon as possible any unexpected change in the process. The control chart is a graph used to study how a process changes over time. Data are plotted in time order, and different types of control charts can be used, depending upon the type of data. The two broadest groupings are for variable data and attribute data.
We have different Attributes charts: *p* chart (proportion chart), *np* chart, *c* chart (count chart) and finally, *u* chart, the one we are going to modify and study its behavior.
Our main goal was to define a control chart with double sampling strategy that would accomplish improving the power of the classic u chart without increasing the average sample size.
There has been a recent growing interest in applying artificial neural network (ANN) to engineering fields for solving complex problems. In this paper, the neural network model has been developed to predict the lowest force and the best surface quality in ironing. The neural network has been trained with 46 sets of different process parameters. The predicted results have then verified with experimental values.

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PURPOSES AND HYPOTHESIS

The main purpose is to make a comparison between the classic u-chart and a modified u-chart (by now DS-u chart), based on J.J.Daudin's methodology [2]. Daudin modifies the Shewhart chart applying a double sampling, so that way, he improves the behavior of the chart.

In this work, it is applied Daudin's philosophy to the attribute chart, concretely, to the u-chart.

As seen in Figure 1, the modified u-chart has got a two stage scheme, with new control limits and sample size in each stage. With the same sampling scheme in two stages used for the mean by Daudin [2], we propose a new control chart based in the classical u chart (defects per unit), named DS-u chart.

As the target is to improve the power of the chart (ability to detect process changes), the expression we should use for the optimization process is: $MAX[P_{DS-u} - P_u]$

where PDS-u is the power of the DS-u chart and P_u is the power of the classical u chart.

$$
\begin{aligned}
&P_{DS-u}(u_1) = (1-\beta_{DS-u}) = \\
&= \left(1 - \sum_{i=0}^{floor(UCL\cdot n_1)} \frac{e^{-n_1 u_1}\cdot (n_1 u_1)^i}{i!}\right) + \\
&+ \left(\sum_{i=0}^{floor(LCL\cdot n_1)} \frac{e^{-n_1 u_1}\cdot (n_1 u_1)^i}{i!}\right) + \\
&+ \left(\begin{array}{l} \left(\displaystyle\sum_{i=ceil(UAL\cdot n_1)}^{floor(UCL\cdot n_1)} \frac{e^{-n_1 u_1}\cdot (n_1 u_1)^i}{i!}\right)\cdot \\ \cdot\left(1 - \displaystyle\sum_{j=ceil(LCL_1\cdot n_2)}^{floor(UCL_1\cdot n_2)} \frac{e^{-n_2 u_1}\cdot (n_2 u_1)^j}{j!}\right)\end{array}\right) + \\
&+ \left(\begin{array}{l} \left(\displaystyle\sum_{i=ceil(LCL\cdot n_1)}^{floor(LAL\cdot n_1)} \frac{e^{-n_1 u_1}\cdot (n_1 u_1)^i}{i!}\right)\cdot \\ \cdot\left(1 - \displaystyle\sum_{j=ceil(LCL_1\cdot n_2)}^{floor(UCL_1\cdot n_2)} \frac{e^{-n_2 u_1}\cdot (n_2 u_1)^j}{j!}\right)\end{array}\right)
\end{aligned}
$$

EQUATION 1. Power function.

For the DS-u chart, Equation 1 presents the power function that we have obtained, using the exact distribution. Each element in the precedent expression is presented in Figure 1.

To optimize the improvement generated by the new chart, we maximize the difference between these two power expressions. We can change the value of the sample sizes n_1 and n_2, and the positions of the control and attention limits. We used genetic algorithms. For the programming of the optimizations software we have used Borland C++, integrating the GAlib library.

We have to calculate these new parameters, maintaining the most similar false alarm risk, α, and the sample size (or reducing the last one) of the classic u-chart.

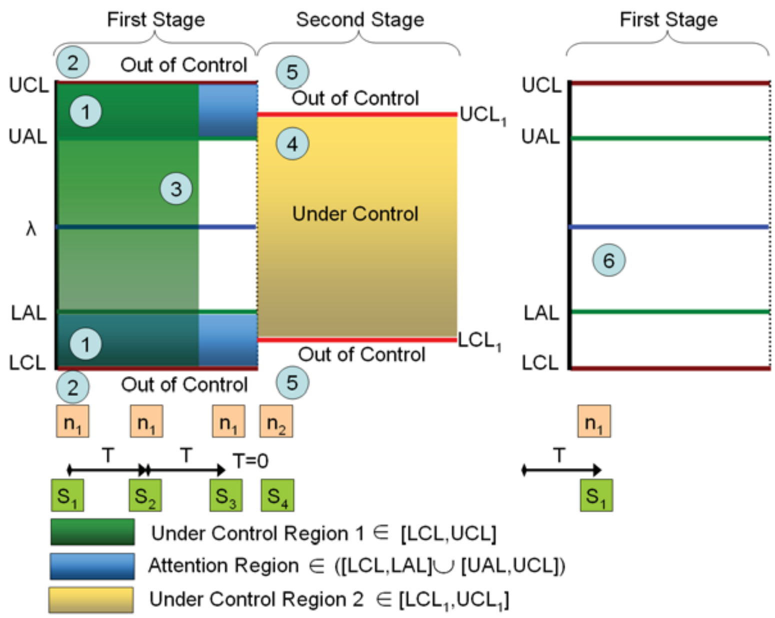

FIGURE 1. Scheme of the new DS-u chart.

METHODS

The method that has been chosen for calculating the new control limits of the two stages of the DS-u chart is software programming in C++.

It has been used Genetic Algorithms to get the better solutions. We used a library of free distribution, GAlib, which contains a set of C++ genetic algorithm objects. This library includes tools for using genetic algorithms to do optimization in any C++ program using any representation and genetic operators.

The parameters of the Genetic Algorithm have been selected following the rules showed in Martorell et al. [4].

As we want to know the behavior of the modified u-chart, we have selected some cases. One of them, showed in the figures below, is for the case that the defects per unit $u_0 = 1$, and three different false alarm risks: α= 0,027, α= 0,01, α= 0,05.

RESULTS

The main results we have obtained are the following:

- We obtain poor power improvements when u_1 is surrounding u_0=1, and the opposite occurs when improving the power at u_1, being much lower o much greater than u_0=1 (Figure 2). We also notice that the results are better at the time we reduce α.

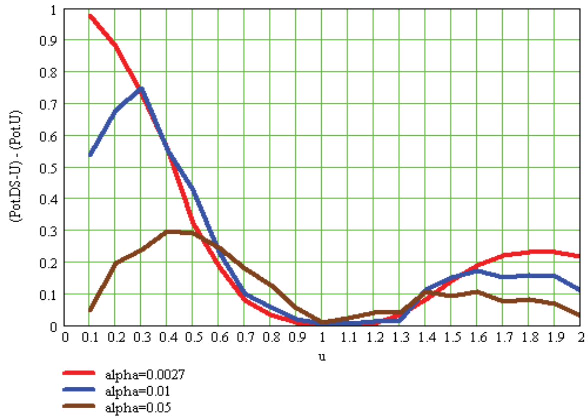

FIGURE 2. Difference of power.

- Even we improve the power curve in u_0=1, the sample size mean is not reduced of the classic u-chart sample size (Figure 3).

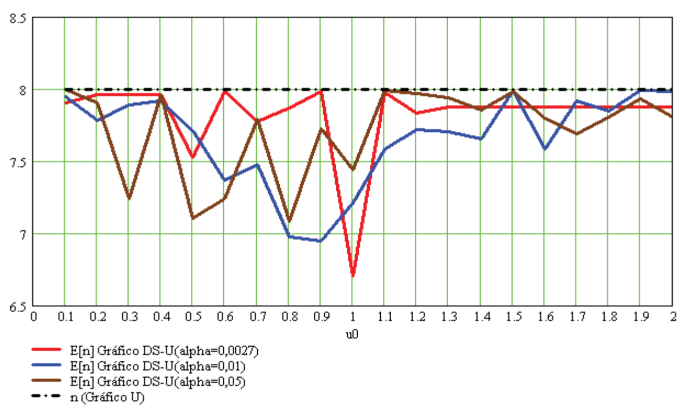

FIGURE 3. Sample size mean of the DS-u chart

- We can distinguish between two patterns of behavior: for values of $u_1 < u_0$, and for values of $u_1 > u_0$ (Figures 4 and 5)
- In the cases that $u_1 < u_0$, the differences between the power are greater than the other case ($u_1 > u_0$), but while we improve the power difference in one value u1, the power curve is worst than the classic u-chart for values of $u_1 > 1$. As we can see in Figure 5, this doesn't happen in the other case. We have lower improvements of power, but we improve the entire power curve, not only in a specific value of u_1.

The use of the simulation software has been essential for the success in the optimization of the new chart performance.

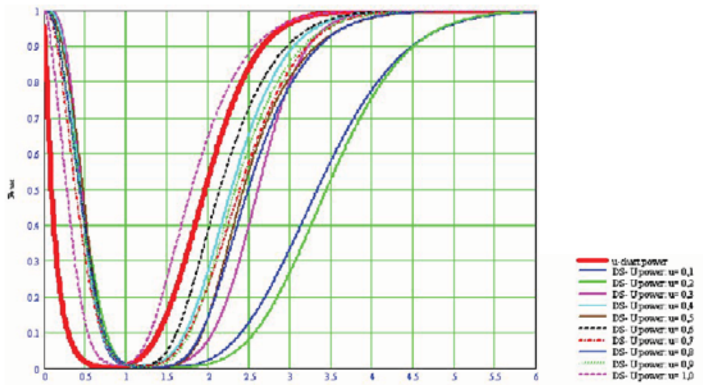

FIGURE 4. Power for values of u_1<1

FIGURE 5. Power for values of u_1>1

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