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An expert system approach to quality control

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Abstract

This paper describes the basic actions proposed for quality inspection. These actions involve structuring a Decision Supporting Expert System (DSES) to help with those decisions related to the preliminary activities for inspection development—most of them relating to determining of the need or convenience of carrying out the inspection itself. Once the opportunity to carry it out is defined, the expert system helps the user to select the type of inspection to adopt from amongst: (1) automatic or sensorial inspection; (2) inspection by samples or complete; (3) acceptance or rectifying and, in the most relevant module, (4) inspection by attributes or by variables. The complementary documentation of the DSES contains the directions to operate it, the rules and qualifiers that make up the system, as well as the results achieved through its experimental implementation. © 2000 Elsevier Science Ltd. All rights reserved.

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1. Introduction

Having the current concept of quality in mind (and the context of Total Quality Management itself), the feasibility process of basic quality control actions is nowadays considered to take place within a well-defined structure, known as quality evaluation system.

Inspection, in turn, is the most important activity in the quality evaluation system of an industrial process. When correctly developed, the inspection makes possible to carry out a precise analysis of how the process operates and serves as a basis for a set of decisions that directly affect it, such as corrective and preventive actions which must be complied with in order to guarantee acceptable quality levels.

Quality inspection has got a number of effective techniques with a wide range of applicability. Since there are several techniques available, there are many options for those who intend to devise an inspection process. Nevertheless, this situation poses difficulties as to the correct use of the different techniques, since most of such techniques have their own utilization particularities and yield results valid only within certain contexts.

The need of choosing the most adequate technique for each situation shows that it is necessary to organize the information related to quality inspection, or else the whole quality evaluation process could be seriously compromised. The present paper highlights this question, which is considered to be a relevant restriction to the perfect use of quality evaluation. A more efficient way of optimizing quality evaluation development is proposed.

We dedicate special attention to quality inspection by attributes, a much more difficult area when it comes to making the correct decision about quality evaluation of services, products and processes.

The literature about quality inspection is plentiful and easily accessible. More often than not, classical texts on quality control deal with this subject by focusing on procedures of sampling for acceptance, whereas rectifying inspection is rather rarely analyzed. The development of the theoretical models of the Operating Characteristic (OC) Curve associated with basic concepts, such as Acceptable Quality Level (AQL), Lot Tolerance Percent Defective (LTPD) and producer's and consumer's risk, is always presented as a means of motivating the analysis of sampling schemes or sampling plans and inducing the procedures which aim at structuring such plans and making feasible their performance analysis, mostly in terms of reliability and costs. Tables suggesting models of sampling plans are just as relevant and are present as well in almost all books of the area. The following authors can be cited as classical in this field: Besterfield (1990), Charboneau and Webster (1997), Juran (1999), and Montgomery (1998), to name a few. Texts of renowned authors, such as Dodge and Deming can be found in more specialized journals. A collection of articles by Dodge about inspection by attributes was made available by the American publication called Journal of Quality Technology in 1977 (see Dodge, 1977). As for the work of Deming, articles on this subject written by him can

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be found in the same journal published in 1985 (Papadakis, 1985).

The types of inspection are manifold, each of them bearing their particularities, specific purposes and restricted adequacy to certain contexts. Such is the case of sampling inspection or complete inspection, as well as inspection by attributes or by variables, for instance.

The choice of the correct type of inspection is extremely relevant for quality evaluation, since the adequacy of the inspection process to the context where it takes place has been considered in many situations and its importance has always been stressed.

Let us consider the inspection of raw materials as an example. An incorrect development of this type of inspection can give the suppliers the impression that quality is not important to their customers and of course the suppliers will not have to regard it as relevant. Such a situation, which can be seen in practice, is to be found in several texts. Horsnell (1988), for example, draws attention to this fact, by showing that the use of inspection by attributes when products enter the factory is of such usefulness that it transcends inspection proper, in addition to being an easily applicable technique. In a broader analysis, one can see that the quality of the process can be significantly (and positively) affected by the mere inclusion of inspection in the process (it has been considered many years ago—see, for instance, Whittle, 1964).

Quality inspection is widely used nowadays. Nonetheless, several problems have been encountered upon using inspection systems and such problems derive for the most part from an inadequate application of the prescribed methodology. This inadequacy results from decisions which ought to be made as regards the way the inspection is to be carried out.

Such decisions are considered here to be intuitive. However, they do deserve detailed investigation. We understand that the lack of an adequate methodology for planning the decision-making process is a fundamental restraint to the use of quality inspection.

This situation justifies the elaboration of a general Decision-Making Support System. Due to its peculiarities, the system was organized under the format of an expert system, which benefits from the advantages of artificial intelligence (AI) in order to carry out an evaluation.

It should be noted that since inspection is the most important part of Quality Evaluation, the expert system proposed here plays a fundamental role in the Total Quality Management area.

It is easy to see that this paper describes a process of interaction between users and computers in industrial companies. The process becomes feasible through the development and application of an expert system related to the area of quality control. This paper describes the developed expert system, its operating methodology and lists the results obtained after its application in the companies we have studied. The interaction between the human resources of the organizations and the computational resources was intense in the last few years. With the advent of AI this interaction has acquired new, rather specific characteristics.

2. Artificial intelligence applied to quality evaluation

A brief review of the specific technical literature reveals that there are many cases of successful applications of Al techniques to the Quality Evaluation area. Such applications were helpful in the resolution of relevant problems.

Below are some examples thereof:

(a) Hosni and Elshennavy (1988) reported the development of a quality control system based on knowledge, suitable to specific procedures of inspection by variables and to the selection of control graphs, both by attributes and by variables.

(b) Eyada (1990) developed an expert system aimed at auditing procedures of Quality Assurance involving both suppliers and products in the process. Some years earlier, in the same field, Gipe and Jasinski (1986) conducted an analysis of expert system adequacy to Quality Assurance problems, showing the feasibility of this application. Another interesting expert system was developed by Crawford and Eyada (1989) with the purpose of planning the allocation of resources for the Quality Assurance program.

(c) There are several expert systems used to select control graphs (see Alexander & Jagannathan, 1986; Dagli, 1990; Dagli & Stacey, 1988). An expert system designed for Process Control at a general level was developed by Moore (1995).

(d) Evans and Lindsay (1987) reported the development of an expert system for Statistic Quality Control, which not only selects control graphs, but also offers interpretations of such graphs and provides conclusions about the control status of a process.

(e) Brink and Mahalingam (1990) developed an expert system which evaluates quality at manufacturing level, so as to detect and correct defects occurring during the productive process.

(f) Pfeifer (1989) reported the development of an expert system to detect defects during the productive process and described its successful application in Germany.

(g) An expert system which makes use of pattern recognition in order to 'visualize' pieces under inspection was developed in 1989 in the United States (see Ntuen, Park & Kim, 1989). This system, called KIMS, was successfully tested in a variety of experiments (one of them is reported by Ntuen, Park & Sohn, 1990), where the performance of the KIMS in image recognition tasks is assessed.

(h) Fard and Sabuncuoglu (1990) developed an expert system which seeks to select sampling by attributes, determining which type of sampling is the most adequate for each case: simple, double or multiple. A project of a