

Chapter 5

Computational Techniques in Statistical Analysis and Exploitation of CNC Machining Experimental Data

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ABSTRACT

Extracting CNC machining data on- or off-line demands thorough and careful planning. Exploitation of this data can be carried out by statistical methods, in order to obtain the most influential parameters along with their respective level of significance. However, significance of machining parameters varies according to the posed Quality Characteristics at each machining phase. In actual experiments, measuring devices and assemblies are used, and data is recorded in computer archives. To shorten the production time and cost, machining processes are planned on CAM software, especially when complex part geometries, such as sculptured surfaces, are involved. Hence, planning machining experiments using CAM software modules is an efficient approach for experimentation on the actual CNC machine tools. Data extraction and statistical analysis methodologies are presented along with respective machining experimental examples.

1. INTRODUCTION

In today's manufacturing environments, demands for high quality and short production time practically drive both small/middle and large-scale enterprises to implement advanced production techniques and integrated manufacturing systems. Soft/technical computing and intelligent systems are now state-of-the-art modules and key elements for proper and reliable preparation of manufacturing processes. Optimization methods like Genetic Algorithms, Simulated Annealing, Evolutionary programming, Tabu Search and so on, are very important elements for developing a modern and integrated manufacturing environment. These strategies need experimental data sets and respective statistical analysis, in order to correspond properly and generate accurate outputs. The main thrust of this chapter is an overview of the statistical techniques with which it is possible to obtain, analyse and evaluate machining experimental data used as inputs in Artificial Intelligence methods for system and process optimization.

2. BASICS OF DATA GATHERING AND PROCESSING IN CNC MACHINING

Several statistical techniques are used in order to summon and evaluate the appropriate information of manufacturing processes that are controlled in terms of quality characteristics and responses. Parameter values are scouted in a pre-determined value ranges that users specify. In terms of reliability and productivity, obtained data sets must conform to predefined technological and economical constraints.

Before one proceeds on performing experimental design, it is essential to understand the philosophy of collecting data in a systematic manner. Some of the basic issues, one should see to, are the following (Faraway J., 2002):

- The data category should be specifically determined, i.e. whether data is a result of observation or of actual experiments. Moreover, it should be clarified whether data sets are "convenient" samples or are obtained by a designed sample survey. The method of data collection has crucial impact on results and conclusions.
- It should be checked whether there is non-response on the data. The data that cannot be observed may be just as important as the observed ones.
- Investigation for missing values. This is a common problem that is troublesome and time consuming to deal with.
- Quantitative representation and data encoding.
- Data normalization (see also Section 2.1.2) and measurement units.
- Performance of data integrity checks and estimation of errors during data entry.

2.1 Experimental Procedure

Each experimental design on computer systems should be enhanced/validated with results of experiments performed on CNC machine tools. This means that evaluation and verification of experimental designs conducted on computer-aided systems should be supported by corresponding results generated from real-life experiments. Actual results and data from manufacturing experimentation should be used as benchmarks, so as to qualitatively assess the effectiveness of computational estimations. However, this statement doesn't undermine the need of computer system for this purpose, since they offer an efficient low cost alternative.

Different measuring devices and instruments are used both in academic and manufacturing laboratories, as well as in industrial shop-floors. This section describes some of the most commonly used measuring devices and assemblies that are implemented on real tryouts. These devices

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