Chapter 4
Signal Processing and Pattern Recognition in Electronic Tongues: A Review

Jersson X. Leon-Medina
Universidad Nacional de Colombia, Colombia

Maribel Anaya Vejar
Universidad Santo Tomás, Colombia

Diego A. Tibaduiza
Universidad Nacional de Colombia, Colombia

ABSTRACT

This chapter reviews the development of solutions related to the practical implementation of electronic tongue sensor arrays. Some of these solutions are associated with the use of data from different instrumentation and acquisition systems, which may vary depending on the type of data collected, the use and development of data pre-processing strategies, and their subsequent analysis through the development of pattern recognition methodologies. Most of the time, these methodologies for signal processing are composed of stages for feature selection, feature extraction, and finally, classification or regression through a machine learning algorithm.

INTRODUCTION

Rapid progress has been made in the advancement of several key areas of science and technology, such as artificial intelligence, design of digital electronic sensors, materials science, microcircuit design, software innovations and electronic systems integration. This has stimulated the development of electronic sensors and intelligent systems applicable to various areas of human activity (Wilson & Baietto, 2011).

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Specifically, the development of systems allows magnifying or at least improving some of the senses in human beings. Although human senses are essential for our common activities, in many cases they are insufficient given their limitations. For this reason, systems based on artificial vision, electronic noses, electronic tongues, among others, have gained popularity and have been applied to various industrial processes where, for example, an operator carried out quality control processes.

Recently, a new concept of sensor application has arisen, which includes the use of a matrix of non-selective sensors along with a mathematical data processing unit using pattern recognition methods. This concept, which imitates human perception, has been applied in the development of analytical tools such as "the electronic nose" (Gardner & Bartlett, 1994) and "electronic tongue". The latter was introduced in 1995 as a result of a Russian-Italian joint research (Vlasov et al., 2000). The electronic tongue is an analytical system applied to the analysis of liquids and is formed by a set of sensors that generate multidimensional information, plus a signal processing tool to extract meaning from these complex data (Del Valle, 2010). Figure 1 illustrates an electronic tongue sensor array composed of several electrodes.

Electronic tongues are used in different fields such as: environmental monitoring, water quality, food industry: adulteration, quality of liquid food, determination of origin, safety to detect hazardous substances, in biomedical topics like the identification of components in biological fluids or in vitro/ in vivo analysis, and finally in pharmaceutical industry. Figure 2 illustrates the different applications of electronic tongues.

Some of the advantages of using electronic tongues for liquid variable monitoring processes include:

- Low cost compared to the use of an expert panel.
- Possibility of validation of results through standard methods used in the food industry.
- Use of instrumentation and precise acquisition systems.
- Portability of the equipment.
- Wide variety of sensors for the analysis of different samples.
- Possibility of process development as an automated system, which allows its constant monitoring and the possibility of online consultation and analysis of the data.
- Possibility of using sensor networks in large processes that require it.

Figure 1. Electronic tongue sensor array
Source: The authors