Visual analytics and its applications to sensors

Visual analytics has become a key area for data analysis and decision making, particularly with the overwhelming amount of digital contents available not only of scientific data but also information embedded in text and image collections. Methods in visual analytics combine data mining and information visualization concepts through interactive interfaces aimed at facilitating analytical reasoning. In this lecture, an overview of information visualization systems will be provided, with the focus on the Projection Explorer (PEx) suite of tools that allow for visualization of sensor data, time series, text and image data in general. More specifically, results will be shown for an electronic tongue based on nanostructured organic films combined with impedance spectroscopy. These electronic tongues are capable of distinguishing among complex liquids such as distinct wines, coffees, etc., and of detecting trace amounts of impurities in a liquid. Sensitivity is so high that it became a problem for the commercial application of electronic tongues, since the response to a given liquid varies from one set of sensing units to another, and the device must be calibrated when the sensor array has to be replaced. Here we propose an approach exploiting artificial intelligence and scientific visualization methods to allow information to be reused as the sensor array is replaced. The electrical response of the sensing units is analyzed with identification of measuring conditions such as frequency that maximize distinguishing ability for a given liquid, and the large amount of data generated in the measurements are processed with visual data mining algorithms based on multidimensional projection techniques. These techniques derive a two-dimensional layout for the data points (describing collected measurements) based on their similarity, so that similar points are positioned close to each other. Interactive visual representations may be created from the 2D layout, and due to their capability of visually grouping data points of similar behaviour (measurements) we are now able to correlate the electrical response of the electronic tongue with human taste. As a proof of concept, we used the data from an electronic tongue to classify samples of Brazilian coffees, which were consistent with the scores assigned by expert human tasters. For samples divided into 4 categories of quality, our system was capable of correctly classifying ca. 83% of the samples. Considering that the system may be further optimized in both sensor arrays and data processing, we believe that electronic tongues are now ready to be used in sophisticated classification tasks, including emulating the human taste.