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Doctoral Abstract
Doctoral Program in Computer Engineering (36^{th}cycle)

Multivariate Analysis in Research and Industrial Environments

By

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Abstract

The proliferation of sensors and Internet of Things (IoT) devices has led to the generation of vast amounts of data. Extracting valuable information from these complex data structures often relies on advanced visualization techniques. When appropriately designed, effective data visualization empowers researchers and analysts to identify and interpret key features of the variables involved intuitively. Examples can be the presence of intricate relationships, repeating patterns, and more. However, in scenarios where the information of interest is not readily visible or discernible, multivariate analysis techniques can be employed to extract relevant insights from the data before creating the visualization itself.

Such techniques, among which it is possible to mention factor, cluster, and discriminant analysis, can help uncover hidden patterns, correlations, and anomalies within large datasets, thereby enabling a more comprehensive understanding of the underlying phenomena. Researchers can create sophisticated and interactive visual representations that effectively communicate complex insights and facilitate knowledge discovery by integrating multivariate analysis techniques with data visualization tools. Moreover, if the information of interest remains elusive or requires a more automated approach, Machine Learning (ML) techniques can be further employed to discover hidden patterns and relationships within the data. ML-based approaches, such as Artificial Neural Networks (ANN), Decision Trees (DT), and Support Vector Machines (SVM), can be used to identify complex, nonlinear relationships within data. ANNs, in particular, are designed to simulate the way the human brain processes information, allowing them to learn and improve automatically from experience without being explicitly programmed. Unlike traditional Artificial Intelligence (AI) techniques, ANNs have been able not only to match but also to outperform humans in specific task-oriented applications.

Multivariate analysis, ML techniques, and data visualization can be applied across various domains, including healthcare, finance, education, and transportation, to

address a wide range of challenges and uncover new opportunities for innovation and growth. In this thesis, such technologies were used to analyze various topics of interest for research and industry. Data from Fiber Bragg Grating (FBG) sensors, image sensors, Photoplethysmography (PPG) sensors, and Supervisory Control And Data Acquisition (SCADA) systems were analyzed in multiple ways to get valuable information. Collaborations between departments of the Politecnico di Torino, such as that between the Department of Control and Computer Engineering (DAUIN) and the Department of Mechanical and Aerospace Engineering (DIMEAS), with student teams of the Politecnico di Torino, such as ICARUS, and with companies, such as Sirius and ReLearn, were crucial to the development of the thesis. The discussion on the different topics was divided according to the type of sensor mainly used. Multiple scientific contributions were made to each of them, which will be explained in detail in the thesis itself.