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Doctor of Philosophy in:
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Human Aspects of Decision-Making in the Industry of the Future:
Engineering Design, Management, and Manufacturing

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Summary of the thesis

The advent of Industry 5.0, marking the latest industrial revolution, has underscored the pivotal role of human-centric innovation, where cutting-edge technologies are seamlessly integrated with human activities. Among these activities, decision-making stands out as a ubiquitous aspect of human life, encompassing a broad spectrum of activities shaped by various conditions and factors.

In industrial environments, these factors can be categorized into four main clusters: problem characterization, information and inputs, context, and the decision-maker. This thesis provides a comprehensive overview of these elements, shedding light on their influence on decision-making processes.

Aligned with the Industry 5.0 paradigm, there is a growing emphasis on understanding the human aspects of decision-making. This involves employing multidisciplinary approaches such as behavioral science, psychology, physiology, and cognitive neuroscience. While each approach offers unique insights into decision-makers, their complementarity enables a broader understanding, with the flexibility to focus on specific aspects, such as cognitive activities.

The primary objective of this thesis is to explore the human factors in decision-making using diverse approaches – behavioral, psychological, physiological, and neurocognitive – applied to various engineering decisions. Different types of decision-making necessitate tailored approaches, leading to the selection of three distinct domains as case studies: engineering design, inventory management, and manufacturing. These domains serve as small-scale versions of the broader Industry 5.0 ecosystem, each presenting decision-making challenges with unique structures.

Employing a range of methodologies, based on experimental studies, the thesis aims to unravel the complexities of decision-making within these domains. Beyond advancing theoretical understanding, the research endeavors to provide practical insights and recommendations for industry practitioners and stakeholders navigating the complexities of Industry 5.0. Leveraging emerging technologies such as artificial intelligence and biometric sensing, the thesis aims to develop more informed decision-making strategies and interventions in industrial settings.

Ultimately, this thesis seeks to enrich scholarly discourse, inform industry practices, and drive innovation in decision-making within the context of Industry 5.0. By fostering a more sustainable, efficient, and human-centric industrial future, it aims to contribute to the ongoing evolution of industrial processes and systems.

Research aims and objectives

This epoch is characterized by the evolution of society according to following the standards and requirements posed by technology that is going to cover more and more areas of human life, to the detriment, for example, of religion. Then, human effort in the evolution of technology increased, leading to faster revolutions. For this reason, the present document focuses on industry 5.0 as a

direct consequence of Industry 4.0. In this context, decision-making represents one of the main characterizing aspects of humans.

Accordingly, the primary goal of the present work is to explore humans' factors in Decision-Making with different approaches (behavioral, psychological, physiological, and neurocognitive) based on different engineering decisions. Engineering Design, Production Planning and Manufacturing are investigated as examples of different types of decisions which require different approaches.

To reach this goal, a comprehensive understanding of decision-making and its aspects is delivered. Additionally, a comprehensive overview of the most adopted methodologies and tools to study human aspects is presented. Finally, the three case-studies aim to show how different decision-making processes require different approaches, showing valuable results.

Research Methodologies

The research methodology involves an iterative process that alternates between reviewing existing literature and analyzing experimental results.

Literature review methodologies primarily include unstructured approaches like snowballing. An example of a structured literature review, focusing on the role of stimuli in engineering design, is provided in Appendix A.

Experimental activities encompass behavioral, psychological, physiological, and neurocognitive approaches. These are not treated as isolated endeavors. Instead, they are integrated to explore decision-making comprehensively, considering the intricate interplay of cognitive, neural, physiological, and psychological factors. Different decision-making domains, such as cognition in engineering design and stress in manufacturing, highlight distinct human aspects. A thorough understanding of these diverse disciplines aids in determining the most suitable approach for investigating specific decision-making scenarios.

By integrating insights from various disciplines, researchers can develop a holistic framework for comprehending decision-making behavior and its implications for individuals, organizations, and societies. Figure 1 provides a general overview of the methodology employed for each experimental activity, differentiated in the data collection for each case study.

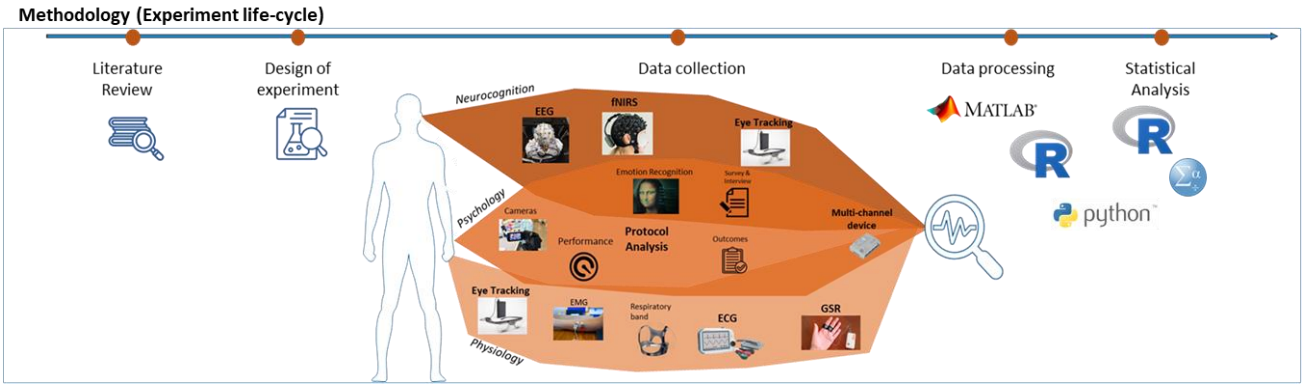

Figure 1. Research methodology

Document structure

The document is divided into seven chapters.

The first chapter introduces the context related to the last industrial revolutions. This chapter delves into the historical evolution of industries, highlighting key technological revolutions such as Industry 4.0 and Industry 5.0. It set the stage for the exploration of decision-making in Industry 5.0.

The second chapter focuses on decision-making. The third chapter explores the concept of decision-making, covering its definition, methodologies, problem characteristics, understanding and inputs, contextual factors, and the role of decision-makers. It also discusses decision-making within the specific domains of engineering design, management, and manufacturing.

The third chapter presents various methodologies used to study human aspects of decision-making, including psychological and behavioral approaches, cognitive neuroscience, physiology, ergonomics, and ethics. It also discusses methodologies specifically tailored to study decision-making within engineering domains.

Then, Chapters 4, 5, and 6 represent the three explored case studies. Indeed, the document includes three in-depth case studies focusing on engineering design, management, and manufacturing. Each case study explores the decision-making processes within these domains, employing diverse methodologies and experimental studies to unravel their complexities.

The final chapter summarizes the key findings and insights gleaned from the research. It discusses the practical implications of the research for industry practitioners and stakeholders navigating the challenges of Industry 5.0. Additionally, it outlines avenues for future research and innovation in the field of decision-making within the context of Industry 5.0.

Then, in the appendices, five studies that have been conducted in parallel with the present work are reported. These studies were crucial to creating synergies for the knowledge and understanding of the entire picture of this research.