# Foreword

In a world where data has become the lingua franca of science, business, and people, the ability to understand, link, and interpret information seems more critical than ever. Between the abundant quantitative data provided by sensors, experiments, and models from our labs and the wealth of qualitative knowledge produced by human expertise lies an imperfect interface that research is attempting to fix. It is exactly here that *Knowledge Engineering for Decision Support in the Food and Bioproduct Industry* comes in, striking a balance between rigorous measurements and nuanced meaning.

Based on an ambitious collective undertaking under the editorial coordination of Patrice Buche, Pierre Bisquert, and Rallou Thomopoulos, researchers at IATE (INRAE–Institut Agro–University of Montpellier), this book is first and foremost the story of a scientific and human adventure. It explores the many paths along which artificial intelligence, well beyond algorithmic performance, can become not only a tool for mediation between disciplines but also undoubtedly a lever of collective intelligence and hopefully a driver of responsible innovation in the agrifood and biobased sectors. This book offers a wide-ranging menu of options.

**An integrative and open approach to knowledge**

The first two chapters lay down the conceptual foundations of this multiauthor book. It presents the vision of open data integration, capable of linking experimental measurements, field observations, and expert knowledge. The authors show how semantic structures and ontologies – subjects on which they have been pioneers – provide the underlying architecture of meaning that guarantees interoperability and what could be called "the sustainability of knowledge."

Chapters 3 and 4 get to the heart of the methodological approach. They describe the techniques of artificial intelligence that are used, such as machine learning, symbolic reasoning, knowledge representations and natural language processing, and above all the way these tools are combined in a hybrid, explainable, and participatory approach, which enhances their potential. Readers will discover the finesse of data engineering that never separates the technique from the human. The fourth chapter in particular illustrates the power of the methodological solutions put forward through a series of tangible applications in food and biobased products. From characterizing biomass to formulating new materials, each case study demonstrates how combining the quantitative and qualitative creates new opportunities for decision-making, traceability, and innovation.

Chapters 5 and 6 explore a common shortcoming faced by many labs and researchers – the organizational and collaborative aspects of a project – and how bridges can be created between labs, companies, and policymakers. These chapters also look at how open platforms can be built where data, knowledge, and preferences can become a common good rather than simply a technical instrument. Reading between the lines,

we can discern the authors' conviction that to be successful, a scientific project depends as much on the quality of the algorithms as it does on teamwork.

Finally, the last chapter expands the conversation to the future. It examines the role of open and smart systems in the digital transformation of the bioeconomy sectors and the ethical responsibility of their designers. More than a conclusion, it is an invitation: an invitation to continue the dialogue between fields and stakeholders, to create tools that are ever more transparent, collaborative, and meaningful.

**A book that encourages dialogue between science and society**

This book goes much further than simply presenting results. It embodies a way of doing science differently, openly, thoughtfully, and firmly rooted in the reality of current transitions and the need for research that seeks solutions to the climate emergency we now find ourselves in. This book is for researchers, engineers, and students, but also business leaders and public policymakers trying to understand how artificial intelligence can drive the sustainable transformation of food and biobased systems.

*Johnny Beaugrand*
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# Foreword

At a time when large neural network models seem to be the solution to all problems and are often considered the only effective contributions of artificial intelligence (AI), I am delighted and honored to preface this book, which perfectly illustrates the richness, diversity, and relevance of AI research far beyond the use or development of these models alone. In the approach put forward through the work of the ICO team at the IATE–INRAE–Institut Agro–University of Montpellier unit, human knowledge and practices are sources of inspiration, objects of transmission, and key elements in the completion of tasks in conjunction with digital resources, whether software, data, or knowledge graphs. The work reported in this book is an exemplary contribution to knowledge engineering, both because it provides insight into a team research process and because it presents remarkable and reusable issues and results. It also contributes to the agrifood domain with a large set of real case studies illustrating how decision-making can be supported for tasks like food processing or food packaging design.

The editors of this book, Patrice Buche, Pierre Bisquert, and Rallou Thomopoulos, are renowned researchers in the field of AI, particularly in knowledge representation and engineering and know-how modeling, mainly in the agrifood sector. Patrice Buche has spent his entire career in this field, first as a lecturer at AgroParisTech until 2002, and since then as a research engineer at the IATE unit. He specializes in ontology alignment and knowledge extraction from texts and tables with a view to constructing ontologies and knowledge graphs used in decision support systems. Pierre Bisquert joined the IATE unit as an INRAE researcher in 2014, bringing his skills in reasoning, logic, and argumentation, mainly existential logic, to develop approaches based on knowledge graphs and rules for data integration. He took over from Buche as head of the ICO team. Finally, Rallou Thomopoulos has been conducting AI research in the agrifood sector since obtaining her PhD from AgroParisTech. As researcher and then research director at INRAE within the IATE unit since 2004, she has focused on the representation and interrogation of fuzzy or imprecise knowledge, then on the representation of chains of arguments in the form of graphs within decision support systems.

The work presented in this book is the result of the efforts of the ICO team at the IATE unit, of which all three editors are members. It contributes to the team's two areas of research: first, the ontology-driven integration of heterogeneous data and knowledge to formalize the knowledge needed for decision-making, and second, argumentation and social choice to integrate the preferences of the actors concerned and manage their different points of view. I should emphasize that it is rare for a research group to be able to capitalize so coherently on the work of each of its members. This book is the result of a long-term and genuine team effort, with each chapter itself a collective achievement. It confirms the complementarity and consistency of the work carried

out over the years, namely the projects and theses conducted within the ICO team. The permanent members of the team, and especially the editors of this book, played a key role in orchestrating, giving meaning to, and choosing a relevant direction for these different contributions, and now in bringing them together in this work. We can also be proud that this English edition reflects the original organizational structure of the French research environment, where a team includes several researchers working on personal scientific projects in conjunction with a team goal. In a way, this book could even be considered an ambassador for this approach. Indeed, it shows us that this way of working, which differs from the more pyramidal and individualistic organization of the English-speaking world, creates specific dynamics, promotes stimulating exchanges, and leads to outstanding results.

The seven chapters that make up this book provide a coherent and incremental reading experience. The authors are current and former members of the ICO team and long-term collaborators. Each chapter describes a building block that illustrates how AI can support decision-making in the agrifood sector, from collecting data and factual knowledge to building models, creating support tools, and evaluating the impact of proposed solutions on individuals, teams, and value chains. The results of one chapter are later reused in more ambitious contributions in subsequent chapters. Reading is made easier by the consistent structure of each chapter, which details the research issues and proposed solutions before presenting the outcomes that can be reused by the scientific community.

Chapter 1 (Domain Ontologies for Food and Biobased Products) presents various research projects that integrate multidimensional data into knowledge graphs and align the vocabularies used in different heterogeneous data sources. These solutions rely on domain ontologies. The importance of the terminological aspect of these ontologies (labels, comments, and definitions) for better validation by domain experts and more efficient alignment with similar resources or domain documents is worth noting. The outcomes of this work are not only the ontologies themselves, but also the methods and tools used to manage them (e.g., the $PO^2$ vocabulary and data manager) and to explore multiple databases (MultiDB explorer), classify data, and align source content.

Chapter 2 (Task Ontologies for Product Processing and Characterization Processes) introduces task ontologies, which are ontologies dedicated to specific tasks. These ontologies focus on the processes studied by the ICO team, such as product processing (e.g., bread or flour production from wheat) and product quality assurance and maintenance. Again, the outcomes include the ontologies, processes, and tools used to design them, as well as how these ontologies are populated to represent both the processing processes described in documents and data tables and the operational know-how that is typically passed on orally in organizations.

Chapter 3 (Methods for Ontology-Guided Extraction of Experimental Data in Scientific Articles) describes methods for the ontology-guided extraction of experimental data from scientific articles, with this work illustrated using scientific papers about food packaging. These methods rely on natural language processing to extract semantic relations. The work makes an original contribution to the extraction of n-ary relations (relations with more than two arguments), which can be used to collect several properties of a target entity. The process involves two steps: identifying the arguments and combining them to represent an instance of an n-ary relation.

Chapter 4 (Reasoning About Process: Experimental Data and Technological Expert Know-how for Decision Support) takes things a step further. Given the ontologies, knowledge graphs, and related methods and tools, the objective is to compile information on how this knowledge is utilized in the reasoning process for decision-making purposes. The three proposed approaches rely on both data and human expertise. They use either tree-based decision-making models, models trained on databases, or flexible queries based on fuzzy sets to combine several expert models. This work is applied to recommendations to correct food defects, select food packaging, and support biocomposite packaging design processes.

In Chapter 5 (Methods for Collective Decision Support that Consider both Preferences and Contradictory Arguments from Agrifood Chain Stakeholders), the objective targets the decision-making process itself. The proposed solution is based on the representation of the process using arguments in accordance with argumentation theory and social choice, and the decision-making process itself is examined. Two tools are presented: DAMN (a methodology for representing formal arguments in a statement graph and computing a decision by traversing this graph) and MyChoice (a web-based application that supports collective decision-making by assessing the acceptability of different alternatives based on several explanatory arguments for these alternatives).

Chapter 6 (Designing Prospective Scenarios at the Scale of a Value Chain) broadens the scope even further, evaluating innovations (i.e., changes in the value chain) by assessing their value to society. Three types of scenario-based methods are proposed to deal with standard situations, adapt to remote contexts, and optimize the evaluation process. The approach considers the technical feasibility and acceptability to humans of the proposed decisions. One example of a project involves improving food safety for children, with an evaluation of the overall impact of the new food chain.

Finally, Chapter 7 (Assessing the Impact of Participatory Interventions at the Individual Level) shifts the focus from the global impact to the local impact on individuals, using personalized food as an example. This assessment is based on a workshop in which visually impaired participants are informed and encouraged to prepare their own food. This has a significant impact on their knowledge, self-efficacy, practical skills, and cooking habits.

In conclusion, I highly recommend reading this book for several reasons, both for the scientific quality of its original contributions and for the rigor of the scientific approach it presents. It demonstrates the need to combine symbolic and more automated learning-based approaches in AI to achieve scalable systems that truly serve their users and provide relevant assistance. It will also be of interest to readers in the agrifood sector, who will find avenues for further work and significant contributions to the transfer of know-how and the advancement of knowledge in this field.

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