World Journal of Information Systems 1(3) 1-16
DOI: https://doi.org/10.17013/wjis.v1i3.15

Review Article

Analysis of Industry 4.0 Taxonomies

Astrid Jaime[1*], Freddy Leonard Alfonso-Moreno[1] and Mariutsi Alexandra Osorio-Sanabria[2]

[1] Faculty of Engineering, Corporación Universitaria Minuto de Dios - Uniminuto, Bogotá, Colombia

[2] Instituto Tecnológico Metropolitano - ITM, Medellín, Colombia

***** Correspondence: mireya.jaime@uniminuto.edu / astrid_jaime@yahoo.com

(Article history: Received June 17, 2024; Received in revised form July 28, 2024; Accepted August 22, 2024; Available online September 15, 2024)

Abstract: The use of advanced digital technologies in manufacturing processes has been called Industry 4.0. Given the significant impact it has had on industrial performance, it has been the object of several studies by the academic community. Some of these works try to represent this field by proposing taxonomies. However, a study of these taxonomies shows a diversity in scopes and viewpoints. Therefore, the authors aim to analyze these taxonomies to provide a basis for a global taxonomy. The results show taxonomies related to technology, specific sectors or themes, the main research areas identified in the literature, and others oriented to the implementation of Industry 4.0. This work contributes to the understanding of the I4.0 concept and its characteristics, shedding light on possible topics that might be convenient to address in future research or for companies interested in transitioning to it.

Keywords: Industry 4.0, taxonomies

1. Introduction

During the past two decades, the academic and entrepreneurial community has grown interest in Industry 4.0 (I4.0). I4.0 has influenced companies' strategic decision-making and processes to create digital ecosystems. These ecosystems allow an understanding of the feasibility of developing technological capabilities with the available resources, allowing the flow of data and information in real time and the implementation of advanced digital and physical technologies that potentiate innovation, meet customer expectations, and renew business models [1].

These benefits of I4.0 are related to increased productivity, revenue growth, and competitiveness, strengthening innovation, meeting customer expectations, and renewing business models [2]. It’s not surprising, then, that when searching for this notion in the Scopus database, this subject has been steadily growing, and even a new subject of Industry 5.0 has appeared since the late 2010s.

As a notion, I4.0 includes several elements and a broad field of technologies and data-driven applications, whose utility has been shown. For that reason, many works focus on a

© 2025 ITMA. All rights reserved.

specific subject and continuously propose new applications that take advantage of the possibilities these innovative technologies open.

I4.0 presents an accelerated and unequal development between the most developed economies and those less developed, and whose adoption by companies around the world presents great challenges. Therefore, understanding what I4.0 is, and what its scope is, becomes a challenge, as the aspects and components are related to this area [2].

The diversity of definitions regarding I4.0 (See section III. A), shows several points of view. Researchers have shown that although digital technologies are central to it, several aspects play a key role in its realization. For that reason, some authors have proposed taxonomies that try to clarify what the abstract concept of I4.0 means. According to Figliè et al. [3], “The term taxonomy can be described as a scheme of classification of concepts to represent the relationships that they have between them” (p. 6). Nazarov and Klarin [4] (p. 537) defined taxonomy as, a "methodology and principles of systematic classification of a studied topic". Oztemel et al. [5] (p. 4) remind us that, according to the Oxford Dictionary, a taxonomy is “a scheme of classification.”. It allows for the description of terms and their relationships in the context of any knowledge area. The respective data within the domain is classified into a hierarchical structure based on their relatedness. Given the increase in the number of studies that address the development of I4.0 and propose a taxonomy, it is essential to present an overview of the scope and viewpoints of these works. For that reason, in this paper, the authors try to do so.

This paper is structured as follows: Section 2 presents the material and methods. Section 3 reports and describes the results of the research questions. Section 4 discusses the relevant findings. Finally, Section 5 presents conclusions, limitations, and future work.

2. Material and methods

This research applied a Systematic Literature Review (SLR) method to identify and synthesize the literature published about I4.0 Taxonomies. This study follows the stages proposed in [6], which include:

2.1. Planning the review

A SLR is a method that allows for identifying, evaluating, and interpreting all information about research relevant to a specific topic [7].

2.1.1. Research questions.

This review aims to answer four research questions:

- What is I4.0?
- What kinds of I4.0 taxonomies exist?
- What are the challenges I4.0 poses?
- What are the recommendations for implementing I4.0?

© 2025 ITMA. All rights reserved.

2.2. Performing the review

To answer the research questions, the authors collect data from studies related to our work. This implies the search and selection of studies published in academic journals and technical reports published by multilateral organizations.

2.2.1. Search Strategy.

In this work, the objective is to find primary studies on taxonomies for I4.0. For this reason, the search strategy was developed based on the construction of a search string consisting of three keywords: taxonomy AND ("industry 4.0" OR "industry 5.0")

2.2.2. Inclusion and exclusion criteria..

These criteria help us filter and select relevant studies to answer the research questions. We considered the following criteria:

- Inclusion criteria. Include studies or technical reports that made explicit reference to an Industry 4.0 or Industry 5.0 taxonomy or classification.
- Exclusion criteria. Papers with a different approach to a taxonomy for Industry 4.0 or that are not available for review.

2.2.3. Study Selection.

Initially, the authors limited the search to articles indexed in the Scopus database because it is a data source with high coverage of peer-reviewed papers. We use the search string and apply the title, abstract, and keyword filters. Subsequently, the authors consulted the Google search engine for technical reports, policies, and other documents associated with I4.0 published by business consultants, governments, and multilateral organizations. The records found were integrated into a spreadsheet and shared online with all authors.

Two of the authors selected the studies. For this, the title and abstract of each paper found in Scopus was manually reviewed and discussed regarding its inclusion in the final list. When no agreement was reached, the document was read in full to decide whether to include it or not. The selected documents were reported in the online archive. Subsequently, the additional documents were included in the shared file and distributed among the three authors for complete reading and compilation of the data to answer the research questions.

2.3. Results of the review.

This stage shows the analysis and classification of the findings that answer the research question, which is described and presented in the next section.

2.3.1. Data Extraction

We carried out the content analysis of each selected document to extract the definition of the I4.0 concept, the methods used to build the taxonomy, the categories or dimensions addressed, the application sectors, the technologies identified, the research topics identified, and other aspects to be highlighted.

© 2025 ITMA. All rights reserved.

2.3.1. Data synthesis

The final list of selected documents includes 15 documents (Table I), of which seven are articles, five are technical documents, two are public policies, and one is an academic poster.

Table 1. Documents selection

Id	Document type	Title	Year	Cite
D01	Article	A Survey on Information and Communication Technologies for Industry 4.0: State-of-the-Art, Taxonomies, Perspectives, and Challenges	2019	[8]
D02	Article	A Taxonomy of Industry 4.0 and Related Technologies	2020	[5]
D03	Article	Analysis and synthesis of Industry 4.0 research landscape: Using latent semantic analysis approach	2019	[9]
D04	Article	Industry 4.0: state of the art and future trends	2018	[1]
D05	Article	Internet of Things and occupational well-being in industry 4.0: A systematic mapping study and taxonomy	2021	[10]
D06	Article	Systematic Literature Review of Industry 4.0 Maturity Model for Manufacturing and Logistics Sectors	2020	[11]
D07	Article	Taxonomy of Industry 4.0 research: Mapping scholarship and industry insights	2020	[4]
D08	Article	Towards a Taxonomy of Industrial Challenges and Enabling Technologies in Industry 4.0	2024	[3]
D09	Article	The artificial intelligence technologies in Industry 4.0: A taxonomy, approaches, and future directions	2023	[12]
D10	Poster	Industry 4.0 - Overview	2022	[13]
D11	Public policies	CONPES 3975 Política Nacional para la Transformación Digital e Inteligencia Artificial - Colombia	2019	[14]
D12	Public policies	Industry 4.0 Analytical Study (European Commission)	2016	[2]
D13	Technical document	Capturing the true value of Industry 4.0 (Mckinsey)	2022	[15]
D14	Technical document	Forces of change: Industry 4.0 - Deloitte	2017	[16]
D15	Technical document	Industry 4.0 Challenges and solutions for the digital transformation and use of exponential technologies - Deloitte	2014	[17]
D16	Technical document	Industry 4.0 at McKinsey's model factories	2016	[18]
D17	Technical document	The Fourth Industrial Revolution - World Economic Forum	2016	[19]

3. Result

3.1. What is Industry 4.0?

I4.0 is a concept that can take on many different forms and names around the world. In the United States, it tends to focus on digital evolution as a digital supply network. In Europe, where the concept originated, it tends to be more factory-based. Several authors have proposed definitions of what is I4.0. Table 2 summarizes some of them.

Table 2. Definitions on Industry 4.0 proposed by some authors.

© 2025 ITMA. All rights reserved.

Authors	Definition of Industry 4.0
Nazarov and Clarin [4] (p. 26)	"The integration of networking capabilities to machines and devices that allows seamless collaboration between the digital and the physical ecosystems for increased efficiencies in the organizational value chains that transform industries and the society for an increased level of productivity and efficiency"
Weber [20]	"Industry 4.0 is about the application of advanced technologies to manufacturing as a 'whole' in a systems perspective"
Deloitte [17]	Industry 4.0 refers to the combination of advanced manufacturing and operations techniques with intelligent technologies that integrate with organizations, people, and assets to communicate, analyze, and use data to drive more intelligent actions.
McKinsey [18] (p. 2)	"Industry 4.0 is a confluence of disruptive digital technologies that are set to change the manufacturing sector beyond recognition: driven by the astonishing rise in data volumes, computational power, and connectivity; by the emergence of advanced analytics and business intelligence capabilities; by new forms of human-machine interaction, such as touch interfaces and augmented-reality systems; by improvements in the transfer of digital instructions to the physical world, such as in advanced robotics and 3-D printing".
Lu [21] in Figliè et al. [3] (p. 1)	Industry 4.0 proposes to merge the digital, physical, and even biological worlds into a single entity referred to as the Cyber-Physical System (CPS) to enable innovative models of personalized production and servicing.

As is shown, although there are several definitions of what I4.0 is, the authors included in Table II posit that it refers to the use of advanced digital technologies in manufacturing processes, through the connectivity between the information infrastructure and the manufacturing infrastructure, allowing the production and analysis of huge volumes of data, to make informed decisions, better suited to lead to higher productivity and competitively levels.

It expresses a new industrial revolution, combining advanced production and operations techniques with smart digital technologies to create a digital enterprise that would not only be interconnected and autonomous, but also able to communicate, analyze and use data to drive more intelligent actions.

I4.0 combines the physical and digital with technologies such as analytics, additive manufacturing, robotics, high-performance computing, natural language processing, artificial intelligence and cognitive technologies, advanced materials, and augmented reality [2]. I4.0 comprises the following interactions:

- From physical to digital: Capturing information from the physical world and creating a digital record physical world and creating a digital record from physical data
- Digital to digital: Share information and uncover meaningful insights using advanced analytics, scenario analysis and artificial intelligence.
- Digital to physical: Apply algorithms to translate decisions from the digital world into effective data, to drive action and change in the physical world.

3.2. What kinds of I4.0 taxonomies exist?

© 2025 ITMA. All rights reserved.

The study of the different taxonomies proposed in the literature led to the identification of four main kinds of taxonomies: Those focused on the enabling technologies for I4.0, those that propose taxonomies for specific sectors or subjects, those that focus on the principal research areas identified within the broader subject of I4.0, and those focused on the implementation phase of I4.0. In what follows, the authors present the works the authors have identified regarding each kind of taxonomy.

3.2.1.Taxonomies related to Technology

Da Xu et al. [1] presented a state-of-the-art focus on the technologies that enable I4.0. According to their work, there are four main technologies:

- Cloud computing
- Cyber-physical systems (CPS): Da Xu et al. [1] (p. 2948) cite Zhou, Liu, and Zhou [22] when saying that "Industry 4.0 applies CPS to build Cyber-Physical Production Systems (CPPS), which connect the physical world with the virtual world, enabling the equipment in smart factories to become increasingly intelligent, which eventually will enable smart production.
- Industrial integration, enterprise architecture and enterprise application integration: Within this area, Da Xu et al. [1] include Service-oriented architecture (SOA), Business process management (BPM), and Information integration and interoperability.
- Internet of Things (IoT) and related technologies: This encompasses a group of technologies as shown in Fig. 1. Within IoT, there are some main technologies: radio-frequency identification (RFID), Wireless Sensor Networks (WSN), and Ubiquitous computing.

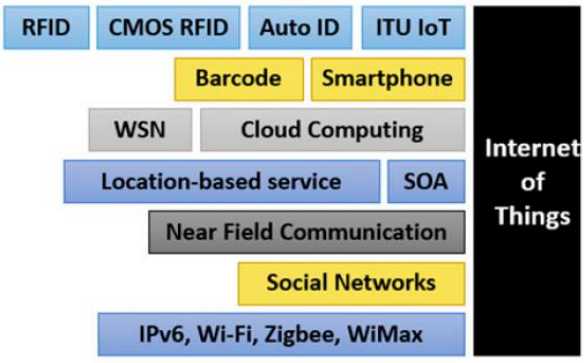


Figure 1. Technologies and devices used to support IoT

In addition, Figliè et al. [3] propose a "list of I4.0 enabling technologies" (p. 13), as a part of a taxonomy that links "industrial needs and challenges with available solutions technologies" (p. 11). Figure 2 presents the proposed list.

© 2025 ITMA. All rights reserved.

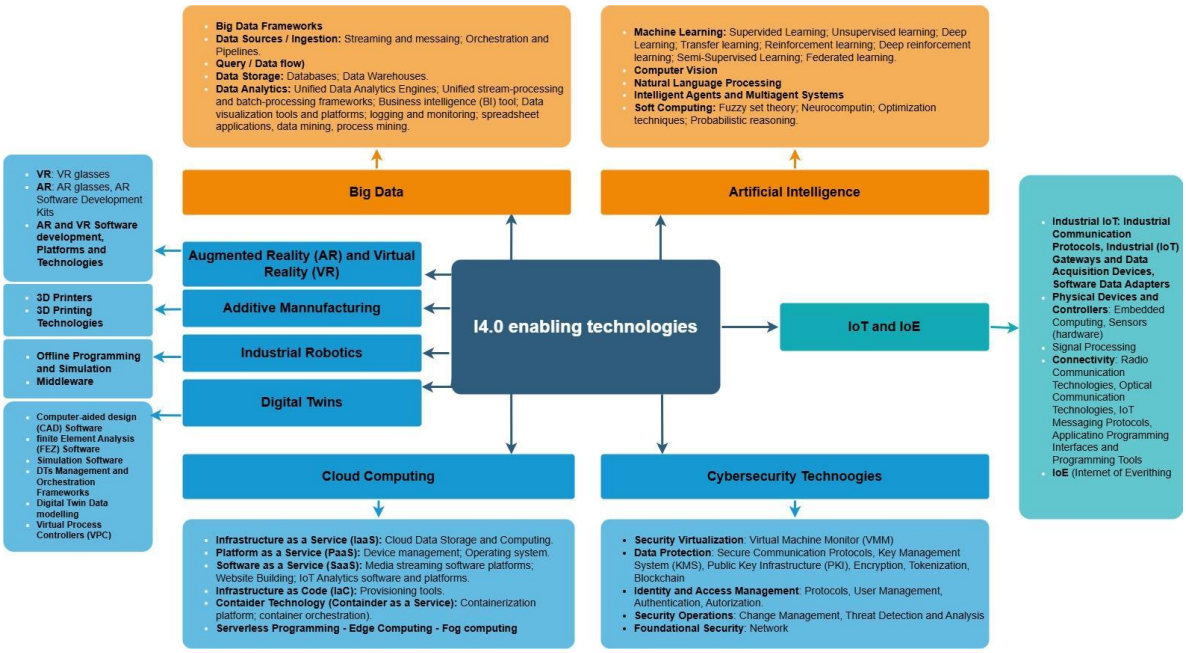


Figure 2. List of I4.0 enabling technologies (Adapted from [3] (p. 13))

3.2.2.Sectorial or thematic Taxonomies

Bavaresco et al. [10] propose a taxonomy of the impact of IoT on occupational well-being, within I4.0 (See Fig. 3).

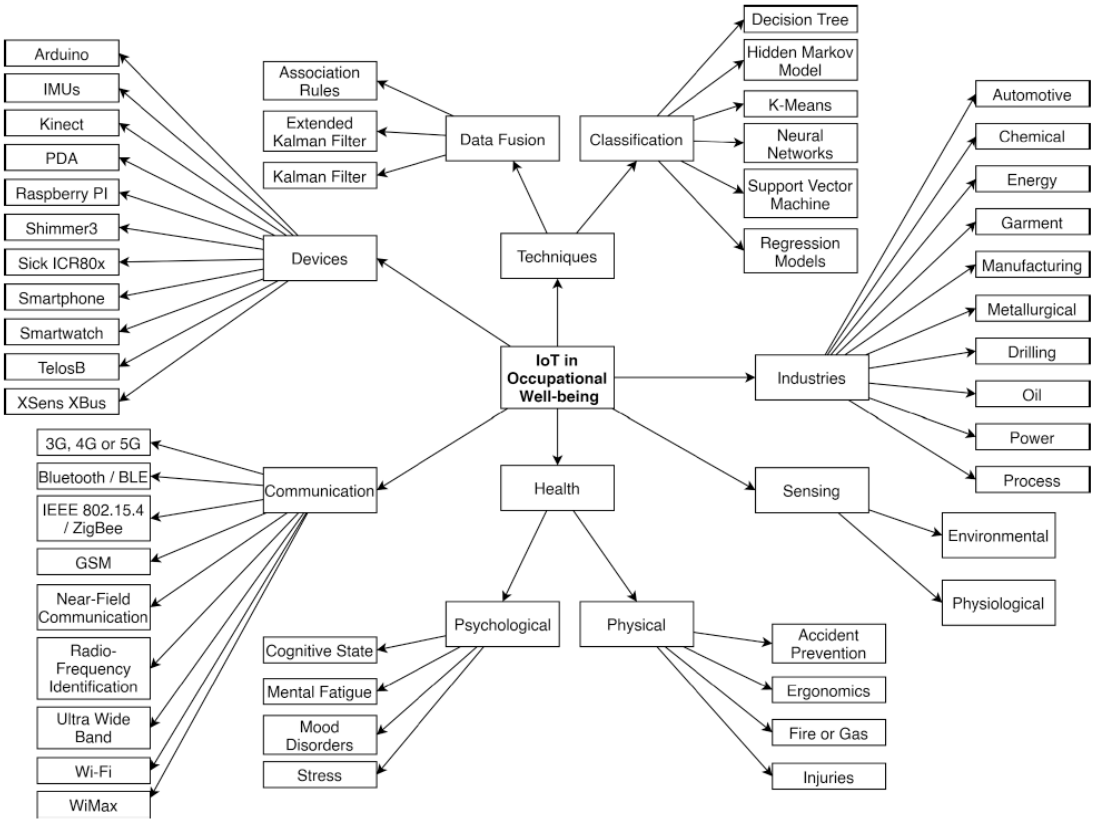


Figure 3. Taxonomy of IoT in Occupational Well-being

3.2.3. Research-Oriented Taxonomies

© 2025 ITMA. All rights reserved.

Wagire, Rathore, and Jain [9] study the main research areas during the period 2011 - August 2018. They identify two principal research areas: smart factories and new business models, among other important ones that emerged from the analysis of the literature. As a result, they propose a taxonomy of the main research areas identified (See Fig. 4).

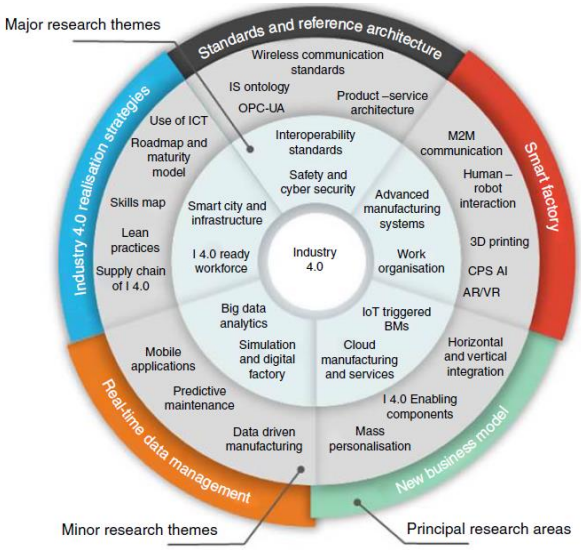


Figure 4. Taxonomy of main research areas identified in the literature from the period 2011 - August 2018 [7]

3.2.4. Implementation-Oriented Taxonomies

Figliè et al. [3] propose “an enhanced tool based on a taxonomy that links industrial needs and challenges with available solutions technologies” (p. 11). They divide industrial needs into two main categories: Process Optimization and Product Innovation. For each one, they specify subcategories, as shown in Figure 5. In addition, to facilitate the implementation of I4.0, they also developed “a web tool through which the interested party can explore the taxonomy and its references” (p. 9). The website is called "Planet4 Taxonomy Explorer" and can be accessed at: http://taxonomy.planet4project.eu/.

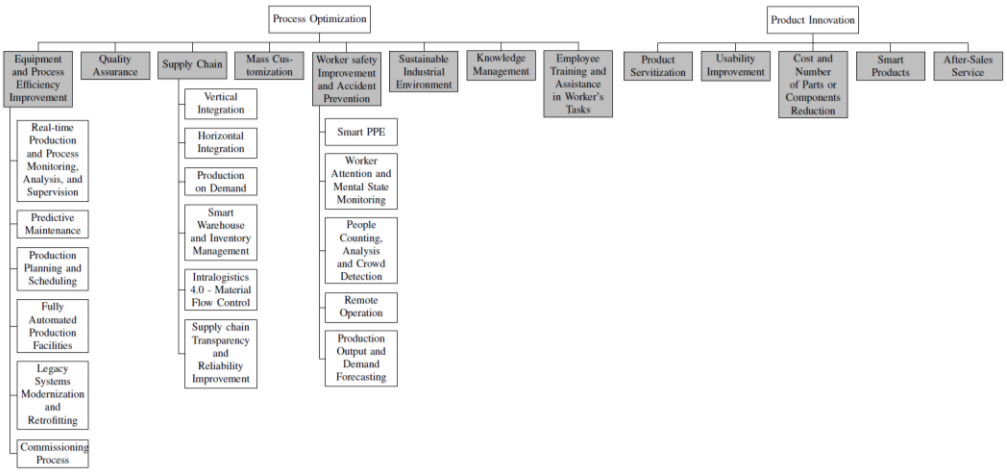


Figure 5. Taxonomy of industrial needs and challenges [3]

© 2025 ITMA. All rights reserved.

Oztemel and Gursev [5] (p. 1) propose a taxonomy aimed at increasing "the speed of the transformation and the respective performance". "The taxonomy is defined through four aspects including strategic understanding, managerial practices, technological infrastructure, and developments, as well as human intervention with respective skills and competencies" [5] (p. 1). Table 3 represents the proposed taxonomy.

Table 3. Taxonomy for transformation

View	Components	Business functions
Strategic	Corporate culture	Knowledge sharing, open innovation Mission, vision, innovator, and total quality management
	Strategic road map	Investments, firm's strategy, corporate approach, resources for realization, implementation roadmap, adaption of business models, innovation management, and value stream.
	Road map of new technology	Biotechnology, green factory, and Industry 4.0 beyond
	Leadership	Management competences, willingness of leaders, existence of central coordination, lean organization
Managerial	Products	Product integration, digitalization of products, individualization of products, data analytics, and ICT.
	Operations	Cloud usage, IT security, autonomous processes, information sharing and interdepartmental collaboration, decentralization of processes, modeling and simulation, and interdisciplinary.
	Business	Mapping business models, Legal and regulatory framework conditions, modeling the rules of the system, orchestration of services, different business process integration
Technical	Smart factory	M2M technology, optimization, dynamic organizations, Equipment infrastructure, effective use of data, Production facilities, flexibility, and proactive maintenance
	Technology	ICT, 3D printing or additive manufacturing, smart sensor, artificial intelligence, Fraud detection, Human-machine interface, location detection technologies, IoT, mobile devices, Augmented reality (AR), and Cloud computing
	Information systems applications	MES, ERP Systems, Big data analytics and advanced algorithms, multilevel customer interaction and customer profiling.
	Digital manufacturing	Digital Modelling, IT systems, new generations quality management, and nanotechnology.
Human Resource	People	Autonomy of employees, openness of employees to new, competencies of employees, employee skill sets, and Skill acquisition
	Law and incentives, government relations	Audits, legal restrictions, protection of intellectual property, Suitability of technological standards

© 2025 ITMA. All rights reserved.

Training	In house training, courses and programs
Human-Machine Interaction	User-centered design, principles of user interface design, and value sensitive design

Source: Oztemel and Gursev [5]

Alenizi et al. [12] designed a taxonomy for AI in Industry 4.0, which provides an overview of practical techniques, current challenges, and emerging issues related to the integration of AI and Industry 4.0 (Fig. 6).

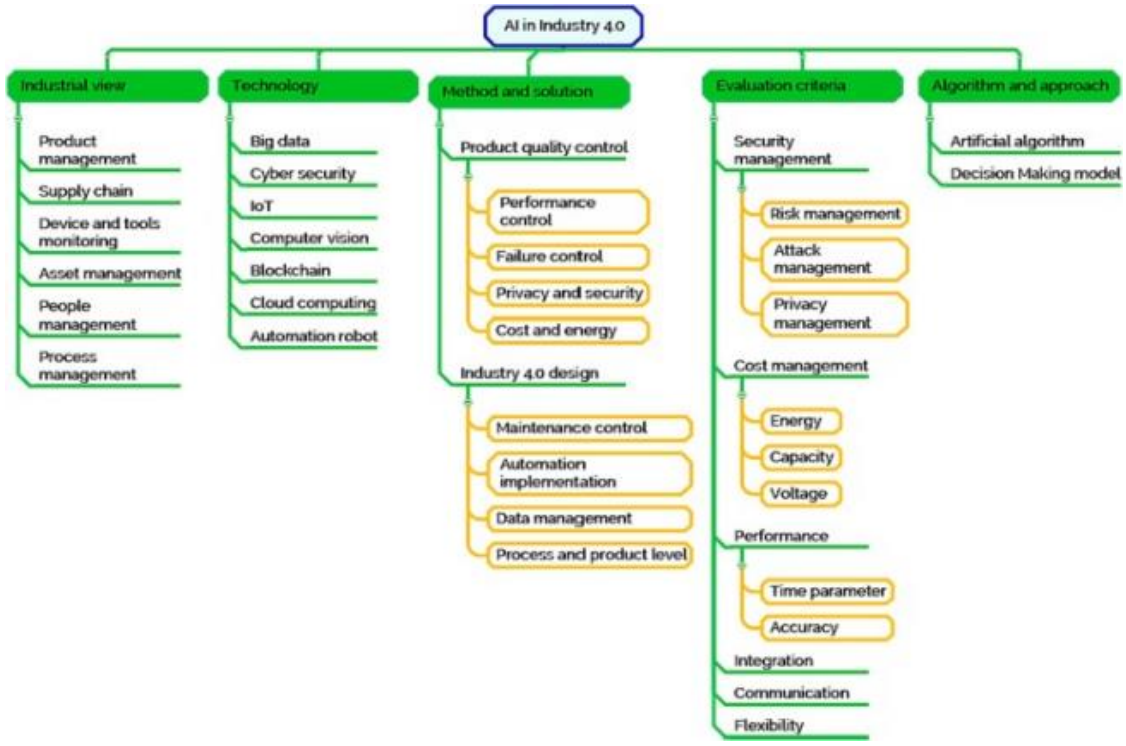
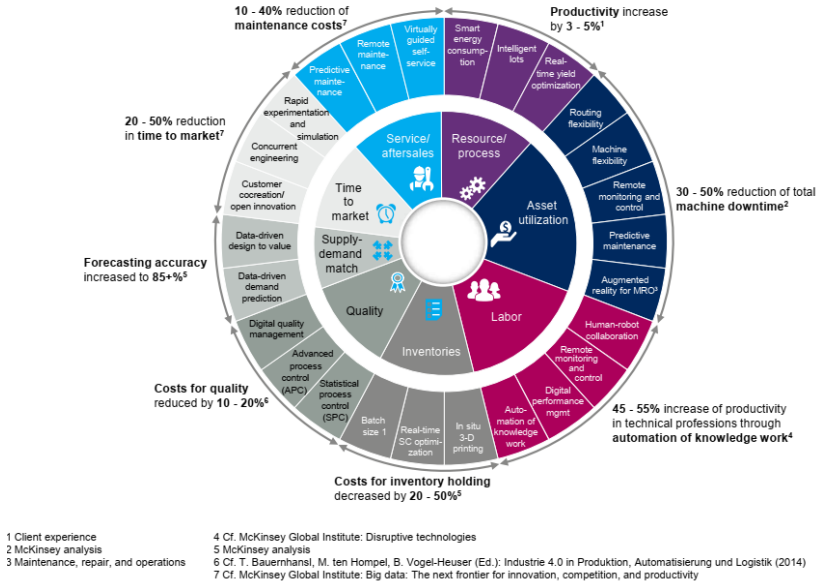


Figure 6. Proposed taxonomy for AI and industry integration [12]

Finally, McKinsey [18] proposes the Digital Compass, intended to orient companies on the tasks that should be prioritized according to the impact sought. Although it is not a taxonomy, it is an interesting point of entrance that could be useful, as it is said to be the result of the projects developed by this company. The proposed Digital Compass is shown in Fig. 7.

© 2025 ITMA. All rights reserved.



1 Client experience
2 McKinsey analysis
3 Maintenance, repair, and operations
4 Cf. McKinsey Global Institute: Disruptive technologies
5 McKinsey analysis
6 Cf. T. Bauernhansl, M. ten Hompel, B. Vogel-Heuser (Ed.): Industrie 4.0 in Produktion, Automatisierung und Logistik (2014)
7 Cf. McKinsey Global Institute: Big data: The next frontier for innovation, competition, and productivity

Figure 7. Digital Compass proposed by McKinsey [18]

3.3. What are the challenges I4.0 poses?

Xu et al. [1] identify some research challenges that should be addressed to deploy Industry 4.0. Among them, there are Technical Challenges, Standardization challenges, Information security and privacy protection challenges, and research opportunities. Among the technical challenges, they include transforming Information and communications technology (ICT) infrastructures, scalability of the technologies, increasing the need for data science and data analytics techniques, and IoT-related technical challenges. Regarding standardization, they state that "A global level of effort is required to develop a standardization process to ensure successful implementation of the strategic vision of Industry 4.0." [1] (p. 2953).

In addition, they [1] state the need for higher information security and privacy protection given the vast amounts of data that are being increasingly collected. Finally, as research opportunities, they identify seven fields: Integration of CPS, Verification and testing of CPS, Blockchain, Smart devices, Resilient Smart Factory, the transformation of ERP (Enterprise Resource Planning), Enterprise Information Systems (EIS) or Enterprise Systems (ES), and I4's other impacts.

3.4. What are the recommendations for implementing I4?

The work revealed two types of recommendations: High-level recommendations aimed at countries interested in fostering I4, and those aimed at companies, to support them in their endeavors towards I4. Regarding the high-level recommendations, the European Union [15] makes some explicit ones regarding I4. Among them, the authors find:

Establishing policies aimed at strengthening I4.

© 2025 ITMA. All rights reserved.

Provide funding for the development of pilot projects, access to education, and support to regional clusters and associations, including support measures targeted at Small and medium-sized enterprises (SMEs), to ensure that they can participate in the evolution to digital manufacturing and its integration into emerging value and production chains.

Raising awareness of the challenges and opportunities in the field of Industry 4.0 and the Industrial Internet.

Supporting the development of a framework conducive to the rapid adoption of standards in this emerging sector, while safeguarding data protection and IT.

Creating forums and platforms for stakeholders to participate and exchange best practices, including chambers of industry, research institutions, etc.

Collaborate with other countries on the matter, e.g., sharing best practices, developing joint initiatives (e.g., for specific sectors).

Regarding the recommendations aimed at companies, Bavaresco et al. [10] (p. 17), posit that "managers should be aware that the usage of technology to workers' care may reduce the number of days away from work, hence, reducing costs, and improving the quality of the workers' life…". In this case, there is an implicit recommendation regarding the use of technology to care for workers' physical and psychological health.

McKinsey [18] presents a different point of view. They give seven recommendations aimed at manufacturers who are "starting out their digital transformation journeys" (p. 8): 1) Communicate well and often, 2) be specific, 3) segment, select and syndicate, 4) formalize the value at stake, 5) Develop a-three-to five-year vision for the network, 6) Develop a digital-manufacturing road map, and 7) Syndicate the vision and secure leadership buy-in. In a similar vein, Oztemel and Gursev [5] (p. 17) state that the change management process involved in transitioning towards I4.0 "could be effectively managed by concentrating and utilizing the components of the defined taxonomy which consider strategic, managerial, technological, and human interactions from various aspects", see Table 3.

4. Discussion

As it was shown, I4, as a concept, refers to the use of advanced digital technologies in manufacturing processes. However, I4.0 goes well beyond the boundaries of the Industrial IoT, it goes beyond the scope of manufacturing and production to focus on the entire ecosystem of partners, suppliers, customers, labor, and operational considerations [5].

Therefore, trying to initiate the transition towards I4.0 may be confusing. Even more so, when observing the different perspectives taxonomies offer. Although the taxonomies centered on the technologies related to I4.0 present some commonalities, such as the importance of IoT, the differences they present may be difficult to internalize and transform into an action plan. Indeed, there are several implementation schemas. Recent works [3], [12] focus on supporting how to implement I4.0 by addressing industrial needs and the technological support needed, although the proposals may still be difficult to put into practice

© 2025 ITMA. All rights reserved.

by SMEs, given the effort and investments they involve. However, the literature analyzed offers some useful learnings regarding how to start advancing the road towards I4. Companies interested in transitioning to I4, should take advantage of the recommendations given by academics and consultancy companies regarding how to tackle this endeavor. For that reason, the implementation-oriented and the sectoral or thematic taxonomies result useful, as their specific scope may support the navigation in the I4.0 field. Research-focused taxonomies may serve a different purpose, as they show the areas on which researchers have been working and may serve as the basis for defining where new research endeavors are needed.

Apart from the taxonomies themselves, the analysis the authors have done has shown some aspects that should be carefully considered in the transition to I4.0. The first one reminds that I4.0 is not only about technology but the human factor must also be carefully considered as new competencies are needed to embrace I4. In addition, since vast amounts of data are constantly being produced and gathered, the ethical use and security of information becomes central. Also, some authors [3, 12] and institutions [15] highlight the need for special attention to SMEs, to allow them to also transition towards I4. For this, specific strategies, policies, and funding are needed.

5. Conclusion

The effects of I4.0 can be felt at multiple levels: in industrial ecosystems, at the organizational, individual, employee, and customer levels. Its importance is highlighted by the market pressures organizations face to, at least, maintain their competitive edge across the production ecosystem, while having to contend with limiting factors such as rapidly evolving technology capabilities, increasing supply chain complexity; and Global fragmentation of production and demand, increased competitive pressures from unexpected sources, organizational realignments resulting from digital and physical technologies, and ongoing talent challenges.

I4.0 offers avenues that can potentially solve some of these problems. The ability to adjust to and learn from data in real-time can make organizations more responsive, proactive, and predictive, and allows the organization to avoid downtime and other productivity issues. The increase in efficiency is one of the main benefits of I4, since it contributes to agility, flexibility, and control of the manufacturing process. I4.0 could also contribute to the reduction in energy consumption, helping to the environmental protection policy that several companies are trying to substantiate. It may also lead to better communication with clients, which could contribute to defining offers better suited to their tastes, wishes, and needs.

Not surprisingly, globally, industries are undergoing a transformation process to I4, which requires not only facing technical and standardization challenges but also information security and privacy protection challenges, as well as state policies, and financial, managerial, and technological support for this migration. These needs are especially important for SMEs

© 2025 ITMA. All rights reserved.

in general and particularly in Latin America, where the authors did not find any works on the subject. In addition, as I4.0 leads to less human intervention, it is expected that it will contribute to the harmony between work and family life and to increase the ability to act in the face of demographic and cultural changes. Nevertheless, transforming industries around the world also requires continuing to pursue multiple research endeavors that would allow I4.0 to reach its full potential.

This study reviews the recent research on I4.0 Taxonomies. The authors first discuss I4.0 and then the kinds of taxonomies identified: Related to Technology, Sectorial or thematic, Research-Oriented, and Implementation-oriented. Next, the authors discuss the challenges posed and the recommendations for implementing them. As this study presents an overview of different perspectives on I4 taxonomies, its main contribution is the support it may give for understanding the I4.0 concept and its characteristics, shedding light on possible topics that might be convenient to address in future research, or for companies needing to define an action plan for transitioning to it. The limitations of the paper lie in the fact that only the Scopus database was searched for the literature review, so other related documents could not have been considered.

Future research endeavors could focus on analyzing in detail the contents of each taxonomy, to identify the aspects they have in common as well as the divergences and complementarities, aiming at identifying, if possible, a macro taxonomy, at least in each category. In addition, the authors pose that, given the evolution of I4, there should be an analysis regarding the changes Industry 5.0 (I5) has introduced, as well as the I4, and even I5, ecosystem, to grasp the different contexts in which they are involved since the study has revealed I4.0 in much more than digital technology.

Acknowledgments: This work was funded by the Corporación Universitaria Minuto de Dios - Uniminuto (032515035-2023-311) and the Fundación Universitaria María Cano (032515035-2023-311)..

Conflicts of Interest: The authors declare no conflict of interest.

References

[1] L. Da Xu, E. L. Xu, and L. Li, “Industry 4.0: state of the art and future trends,” Int. J. Prod. Res., vol. 56, no. 8, pp. 2941–2962, Apr. 2018, doi: 10.1080/00207543.2018.1444806.

[2] J. Smit, S. Kreutzer, C. Moeller, and M. Carlberg, “Industry 4.0 analytical study,” Cham, 2016. [Online]. Available: https://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf

[3] R. Figliè et al., “Towards a taxonomy of industrial challenges and enabling technologies in Industry 4.0,” Nov. 2022, Accessed: Feb. 16, 2024. [Online]. Available: https://arxiv.org/abs/2211.16563v1

© 2025 ITMA. All rights reserved.

[4] D. Nazarov and A. Klarin, "Taxonomy of Industry 4.0 research: Mapping scholarship and industry insights," Syst. Res. Behav. Sci., vol. 37, no. 4, pp. 535–556, Jul. 2020, doi: 10.1002/sres.2700.

[5] E. Oztemel and S. Gursev, "A taxonomy of Industry 4.0 and related technologies," in Industry 4.0 - Current Status and Future Trends, J. H. Ortiz, Ed., London: IntechOpen, 2020. doi: 10.5772/intechopen.90122.

[6] R. Gacitua, H. Astudillo, B. Hitpass, M. Osorio-Sanabria, and C. Taramasco, "Recent models for collaborative E-Government processes: A survey," IEEE Access, vol. 9, pp. 19602–19618, 2021, doi: 10.1109/ACCESS.2021.3050151.

[7] B. Kitchenham, O. Pearl Brereton, D. Budgen, M. Turner, J. Bailey, and S. Linkman, "Systematic literature reviews in software engineering - A systematic literature review," Inf. Softw. Technol., vol. 51, no. 1, pp. 7–15, 2009, doi: 10.1016/j.infsof.2008.09.009.

[8] G. Aceto, V. Persico, and A. Pescape, "A survey on information and communication technologies for Industry 4.0: State-of-the-art, taxonomies, perspectives, and challenges," IEEE Commun. Surv. Tutorials, vol. 21, no. 4, pp. 3467–3501, 2019, doi: 10.1109/COMST.2019.2938259.

[9] A. A. Wagire, A. P. S. Rathore, and R. Jain, "Analysis and synthesis of Industry 4.0 research landscape," J. Manuf. Technol. Manag., vol. 31, no. 1, pp. 31–51, Jun. 2019, doi: 10.1108/JMTM-10-2018-0349.

[10] R. Bavaresco, H. Arruda, E. Rocha, J. Barbosa, and G. P. Li, "Internet of Things and occupational well-being in industry 4.0: A systematic mapping study and taxonomy," Comput. Ind. Eng., vol. 161, p. 107670, Nov. 2021, doi: 10.1016/J.CIE.2021.107670.

[11] L. S. Angreani, A. Vijaya, and H. Wicaksono, "Systematic literature review of Industry 4.0 maturity model for manufacturing and logistics sectors," Procedia Manuf., vol. 52, pp. 337–343, Jan. 2020, doi: 10.1016/J.PROMFG.2020.11.056.

[12] F. A. Alenizi, S. Abbasi, A. Hussein Mohammed, and A. Masoud Rahmani, "The artificial intelligence technologies in Industry 4.0: A taxonomy, approaches, and future directions," Comput. Ind. Eng., vol. 185, p. 109662, Nov. 2023, doi: 10.1016/J.CIE.2023.109662.

[13] K. Umachandran, "Industry 4.0 - Overview." 2022. Accessed: Feb. 14, 2023. [Online]. Available: https://www.researchgate.net/publication/363432415_Industry_40_-_Overview

[14] DNP and MinTIC, "CONPES 3975 Política nacional para la transformación digital e inteligencia artificial," Bogotá, D.C., Nov. 2019.

[15] E. Gregolinska, R. Khanam, F. Lefort, and P. Parthasarathy, "Capturing the true value of Industry 4.0," Apr. 2022. Accessed: Feb. 14, 2023. [Online]. Available: https://www.mckinsey.com/capabilities/operations/our-insights/capturing-the-true-value-of-industry-four-point-zero

[16] Deloitte, "Forces of change: Industry 4 . 0," 2017.

[17] Deloitte, "Industry 4.0 challenges and solutions for the digital transformation and use of exponential technologies," 2014. Accessed: Oct. 08, 2022. [Online]. Available:

© 2025 ITMA. All rights reserved.

https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/manufacturing/ch-en-manufacturing-industry-4-0-24102014.pdf

[18] E. Feige, M. Hammer, R. Ulrich, D. Iacovelli, and J. Bromberger, “Industry 4.0 at McKinsey’s model factories get ready for the disruptive wave,” 2016. Accessed: Feb. 14, 2023. [Online]. Available: http://sf-eu.net/wp-content/uploads/2016/08/mckinsey-2016-industry-4.0-at-mckinseys-model-factories-en.pdf

[19] K. Schwab, “The Fourth Industrial Revolution,” Switzerland, 2016. Accessed: Feb. 14, 2023. [Online]. Available: https://law.unimelb.edu.au/__data/assets/pdf_file/0005/3385454/Schwab-The_Fourth_Industrial_Revolution_Klaus_S.pdf

[20] A. Weber, “Industry 4.0: Myths vs. Reality Digital convergence is ushering in a new era of smart factories,” Assembly Magazine, Nov. 03, 2006. https://www.assemblymag.com/articles/93619-industry-40-myths-vs-reality (accessed Feb. 17, 2023).

[21] Y. Lu, “Cyber Physical System (CPS)-Based Industry 4.0: A survey,” https://doi.org/10.1142/S2424862217500142, vol. 2, no. 3, Nov. 2017, doi: 10.1142/S2424862217500142.

[22] K. Zhou, T. Liu, and L. Zhou, “Industry 4.0: Towards future industrial opportunities and challenges,” 2015 12th Int. Conf. Fuzzy Syst. Knowl. Discov. FSKD 2015, pp. 2147–2152, Jan. 2016, doi: 10.1109/FSKD.2015.7382284.

Graphic Abstract



© 2025 ITMA. All rights reserved.