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The Synergy of Society 5.0 and Industry 5.0 Transforming Work, Society, and Collaboration

Semail Ülgen
Head of Department of Industrial Engineering
Professor Industrial Engineering
Antalya Bilim Univeristy
Antalya, Turkey
sulgen@antalya.edu.tr

Mohammad Muneeb
Senior Student Department of Industrial Engineering
Antalya Bilim University
Antalya, Turkey
mohammad.muneeb@std.antalya.edu.tr

Abstract

In the wake of the fourth industrial revolution (Industry 4.0), the world was on the verge of a new beginning, characterized by a profound synergy of technological advancements and societal transformation. At its core, Society 5.0 envisions a harmonious coexistence of humans and advanced technologies, wherein the integration of digital and physical principalities redefines the very fabric of our daily lives. This vision transcends industrial boundaries and extends its influence across sectors, influencing healthcare, education, transportation, and urban development. Primarily, societal evolution is the dynamic interplay between Society 5.0 and Industry 5.0, where the metamorphic forces of advanced manufacturing technologies and automation interact with the broader societal objectives of inclusivity, sustainability, and quality of life. As Industry 5.0 fosters human-machine collaboration, optimized industrial processes, and smart-manufacturing, it becomes increasingly evident that these advancements are integral for procuring Society 5.0's overarching goals.

Keywords
Industry 5.0, Society 5.0, Collaboration, Human-Machine Collaboration, Optimized Industrial Processes.

1. Introduction
The advent of Industry 4.0, marked by a technology-driven industrial revolution (Daniel Paschek, 2022), encapsulates the swift transformations in technology, industries, and societal dynamics over the recent decades. This paradigm shift aims to elevate production efficiency and quality through the integration and advancement of key technologies such as big data analytics, artificial intelligence (AI) , and digital twin to enhance human capabilities (Amit Kumar Tyagi, 2023). Despite its strides, Industry 4.0 is not exempt from limitations; it tends to prioritize enhancing industry efficiency and flexibility over considerations for sustainable industrial applications and workforce prosperity.

As a blueprint centered around human collaboration with collaborative robots (co-bots), Industry 5.0 has garnered intriguing curiosity in recent years. Its primary objective is to tackle the challenges revealed by Industry 4.0. Concurrently, another concept, Society 5.0, has emerged to address contemporary societal issues. Envisioned as a futuristic, highly intelligent society, Society 5.0 aims to provide a high-quality and comfortable life for everyone by

seamlessly integrating cyberspace and physical space through the comprehensive utilization of Information and Communication Technology (ICT). Industry 5.0 and Society 5.0 represent analogous hypothesis for the future of industry and society, respectively. Although this coexistence may be simultaneously discussed, their interaction may introduce some level of complexity and potential chaos.

The key message from this discourse underscores the critical importance of highlighting valid insights on Industry 5.0 and Society 5.0 for the formulation of relevant theories, methodologies, and practical applications. It is imperative to carefully shape the developmental trajectories of Industry 5.0 and Society 5.0 from the outset to effectively bolster the functioning of prospective industrial and societal evolution. See Figure 1. This article seeks to present the authors' perspectives on Industry 5.0 and Society 5.0 by addressing the following inquiries:

• Defining Industry 5.0
• Elaborating on Society 5.0
• Highlighting the distinctions between Industry 5.0 and Society 5.0
• Identifying common principles between Industry 5.0 and Society 5.0
• Exploring the revolutionary course of Industry 5.0 and Society 5.0

1.1 Objectives

Objective approach targeted to with this paper:

- Investigate foundational principles and technologies of Industry 5.0, with a focus on human-machine collaboration, automation, and smart manufacturing.
- Analyzing societal goals and vision of Society 5.0, including inclusivity, sustainability, and the improvement of the quality of life.
- Determine specific areas and domains where Industry 5.0 and Society 5.0 intersect and exhibit synergy
- Investigate how the technological innovations of Industry 5.0 contribute to broader societal advancements in line with the goals of Society 5.0
- Analyze the impact of automation and AI technologies on employment patterns, including job creation, job displacement, and skill development.
- Based on the findings, provide recommendations and insights on how to foster harmonious synergy between Industry 5.0 and Society 5.0.
- Emphasize a central collaboration of Humans and AI for the betterment of Society.

Transforming Work, Society, and Collaboration structures into the intricate relationship between the industrial and societal factors of the impending fifth societal paradigm. This paper seeks to explore the fundamental changes that are reshaping our industries, work environments, and the broader fabric of society as a result of the convergence of these two paragons. By examining how Industry 5.0's principles of human-machine collaboration and smart manufacturing are creating a paradigm shift in industrial processes, we gain insights into the evolving nature of work, employment patterns, and the wide societal advancements associated with Society 5.0. This study will shed light on the dynamic relationship between technology-driven industry and the broader societal context, elucidating how their synergy is driving the creation of a more advanced, inclusive, and sustainable future. Through real-world case studies and best practices, this paper highlights the successful collaborations that exemplify the power of harmonizing Industry 5.0 with the aspirations of Society 5.0. As we stand at the inception of this epitome, a timely exploration of combined impact, shaping a future where technology, industry, and society converge to create an unparalleled era of progress and collaboration is anticipated.

Defining Industry 5.0 ?

Industry 5.0 represents a forward-thinking vision for the future of industry, envisioning a manufacturing system that is human-centric, sustainable, and resilient. Industry 5.0 offers a vision of flourishing development in the industry. This paradigm emphasizes the enhancement of systems' nimbleness and robustness through the adoption of versatile and responsive technologies. Moreover, it strives to take a proactive stance on sustainability (Ghobakhloo, 2020), respecting ecological thresholds, and fostering aptitudes, inclusivity, and empowerment.

The abstraction of Industry 5.0 arose several years ago and has since been a topic of widespread discussion among researchers and sponsoring entities. Thorough investigation has been conducted to explore and compare the benefits

and challenges of transitioning from Industry 4.0 to Industry 5.0, encompassing challenges, facilitating industrial technological advancements. Notably, Industry 5.0 is already making its mark in the business landscape (Figure 1).

Figure 1. Relation of Industry and Society Transition

In 2021, the European Commission recommended that the European industry reposition its role in society and advocate for this concept to articulate the future prosperity of European industry.

Industry 5.0 is recognized as a means to harness the capacity of industry to accomplish societal objectives beyond mere job creation and economic growth, aiming for tenacious prosperity. This entails guaranteeing that manufacturing adheres to the limits of our planet and prioritizes the well-being of industry professionals at the center of the production procedure. Industry 5.0 is founded on the premise that Industry 4.0, with its increased focus on digitalization and AI-driven technologies for improved production efficiency and flexibility, may, at times, compromise the fundamental principles of social justice and sustainability. Consequently, the concept of Industry 5.0 introduces a distinct perspective, highlighting the importance of exploration and inventive developments in guiding the industry for prolonged dedication to serving humanity within global constraints.

Elaborating on Society 5.0

Society 5.0 envisages a forthcoming community influenced by scientific and technological breakthroughs, aiming to create a human-centric, exceptionally intelligent, and streamlined society, as illustrated in the right circle of Figure 2. Initiated by the Japanese government in January 2016, this concept seeks to harmonize economic progress with the resolution of societal challenges, such as an aging population, declining birth rates, and competitiveness deficiency in Japan. Society 5.0 aspires to create a society centered around humanity with advanced intelligence, ensuring a high-quality lifestyle with contentment and vigor. This is achieved by providing necessary goods and services to individuals at the required level when needed, achieved through the integration of cyberspace and tangible verse with technologies such as 5G, Big Data, artificial intelligence, and more.

In the course of human history, society has undergone four distinct transformations: the hunter-gatherer society (Society 1.0), agricultural society (Society 2.0), industrial society (Society 3.0), and information society (Society 4.0). Presently, we are advancing towards a super-smart and human-centered society (Society 5.0), illustrated in the upper portion of Figure 1. The evolution of industry has mirrored these societal shifts, commencing with the industrial society and progressing through four revolutions in a relatively brief span, driven by advancements in technology. Currently, the industrial landscape is in the process of transitioning to the next phase, namely Industry 5.0.

Distinctions between Industry 5.0 and Society 5.0

By examining the definitions of both Industry 5.0 and Society 5.0, a methodical contrast is conducted to enhance comprehension of their association and interrelation illustrated in Figure 2 The comparative diagram provides a visual representation of the similarities and distinctions between Industry 5.0 and Society 5.0 across four dimensions: goal, value, organization, and technology.

Objective Aspect: A perspective with humanity's betterment holds significant importance in both Industry 5.0 and Society 5.0. Industry 5.0 strives to unleash human ingenuity within the industrial landscape, steering it towards a human-centric, resilient, and sustainably prosperous future. This approach aims to address issues inherent in the present degree of industrial development and quality of life. Simultaneously, Society 5.0 sets its goal on constructing a human-centered, super-smart, and efficient society, nurturing a collective, cozy, and sustainable future for all. In the future of industry and society, the vitality and individual needs of each person are projected to be the foremost considerations.

Example: Within the framework of Industry 5.0, manufacturing and productivity will be tailored to incorporate the unique elements, such as wisdom, skills, and expertise, of each employee. This customization aims to enhance human abilities by leveraging cutting-edge technologies. For instance, robots and co-bots are designed to adjust their engagement approaches based on the presence of different workers in the collaborative production environment. Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) can deliver personalized training content for engineers and the workforce. Additionally, Industry 5.0 emphasizes human-centric products and services, involving humans in the complete process of launching a product—starting from conceptualization and customization to ongoing service acquisition throughout the product's lifecycle. In Society 5.0, human-centric services are anticipated to extend to all members of society, profoundly influencing their daily lives. For instance, individuals can conveniently purchase custom-tailored food, clothing, and other items. Innovative commuting methods can offer personalized services for each driver based on factors such as age, occupation, and destination. Smart grids will optimize energy provision by considering individuals' energy usage habits, affordability, and other factors, potentially increasing energy efficiency and reducing operational costs collectively.

Dimension of Value: In the context of Industry 5.0, the value chain encompasses the entire product lifecycle, incorporating innovative Research and Development (R&D), highly efficient production, personalized services, recycling, and more. There is a growing trend of designing value creation processes downstream in the product lifecycle. On the other hand, Society 5.0, as a combination of individual systems, generates value through individualized service systems, smart transportation systems, intelligent manufacturing systems, and other interconnected components (Atsushi Deguchi, 2020).

Organizational Aspect: The organizational framework of the industry comprises manufacturing cells, factories, supply chains, and similar entities. Industry 5.0 places a significant emphasis on enhancing the resilience of industrial organizations, particularly in addressing challenges posed by uncertainties, such as the Covid-19 pandemic. On the other hand, Society 5.0 aims to seamlessly integrate cyberspace and physical space, precisely catering to individual demands, fostering tight connectivity within modern cities, and efficiently resolving societal issues in a super-smart manner. Within the organizational dimension, the industry plays a pivotal and dynamic role in society. This dynamic interaction explains the accelerated pace of societal transformation following the first industrial revolution. Technology Dimension: The influence of emerging technologies, including next-generation wireless networks, big data, artificial intelligence (AI), digital twin, and others, profoundly shapes both Industry 5.0 and Society 5.0.

The evolution of a particular industry, and in some cases the entire society, is increasingly dependent on the ongoing trends of digitization and intellectualization propelled by these innovative technologies. Each component within the system, whether it be Industry 5.0 or Society 5.0, stands to gain from and contribute to the advancement of technology. ***Example:*** Digital twin facilitates the connectivity between both, cyber and physical realms, and ushering in various new technologies, such as big data. In the context of Industry 5.0, digital twin remains integral in enhancing the efficacy and proficiency of a product through out its lifecycle. For instance, the extensive data collected from digital twin applications can contribute to refining product design and optimizing manufacturing processes. Data mining techniques can unveil implicit faults and intricate causality, leading to improved maintenance outcomes. The precise virtual representation within the digital twin model allows interactive simulation of the manufacturing process, enhancing user experience through personalized services and expedited training.

Similarly, in the context of Society 5.0, digital twin applications can elevate the operational effectiveness of smart homes, smart cities, and even smart societies, providing real-time states to support operational optimization. Real-time monitoring and analysis of potential societal problems enable the implementation of effective prevention measures, averting severe societal transformations.

While Industry 5.0 and Society 5.0 may have unique conceptual foundations and diverse approaches to achieving value within distinct organizational frameworks, they share a common goal of prioritizing human-centric principles. This involves finding a harmonious equilibrium between economic advancement and societal well-being. An illustrative example in the upcoming industrial landscape is the implementation of human-centric assembly processes, leveraging both physical and intellectual enhancements through technologies like brain robotics. Additionally, the vision of a human-centric society foresees a future where individuals can generate value unrestricted by time and location, within a secure space, and in synergy with the natural environment, unbounded by constraints.

Common principle between Industry 5.0 and Society 5.0

Industry constitutes a fundamental element of society, influencing and driving societal development. Likewise, societal transformations play a pivotal role in fostering subsequent industrial revolutions. Common difficulties and possibilities are discernible in both Industry 5.0 and Society 5.0.

Human-Cyber-Physical Systems (HCPS) (Dimitris Mourtzis, 2022): Whether in Industry 5.0 or Society 5.0, the integration of virtual realm and tangible environment stands out as a critical enabling technology. Given that humans are highly innovative, adaptable and most creative, flexible, and active components within the system, be it industry or society, their close involvement in the cyber-physical interaction loop and decision-making processes (T. Yang, 2021) gives rise to Human-Cyber-Physical Systems (HCPS). In technical terms, HCPS can manifest as expansive systems with significant potential to tackle shortcomings in the future of industry and society.

Human Digital Twin (HDT): Within Human-Cyber-Physical Systems (HCPS), digital twin technology serves as a pivotal enabler. In human-centric industries or societies, the exploration of human digital twin (HDT) and human society becomes crucial and timely. This includes areas such as HDT modeling, HDT simulation, HDT theory, and related research efforts.

Green Intelligent Manufacturing (GIM): The vision for both industry and society is geared towards enhanced intelligence and sustainability. Using manufacturing, a shared component of Industry 5.0 and Society 5.0, as an illustration, the integration of Artificial Intelligence (AI) for green manufacturing presents numerous opportunities and challenges, shaping what is known as Green Intelligent Manufacturing (GIM). GIM offers a promising paradigm for manufacturing, addressing future challenges in both industry and society (Figure 2).

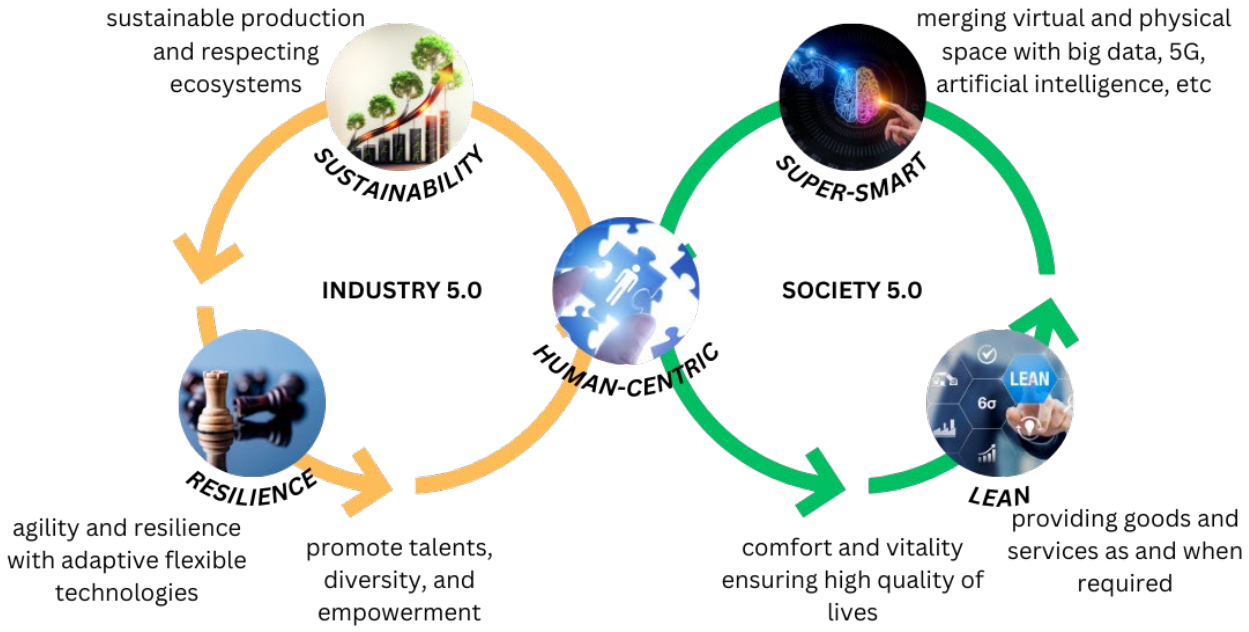

Figure 2. Correlations between Industry 5.0 and Society 5.0

Human-Robot Collaboration (HRC) (Rane, 2023)**:** With the rapid development of robotics technology in Industry 4.0, Diverse usage scenarios have been investigated to improve efficiency in production and elevate the quality of services. Human-Robot Collaboration (HRC) emerges as one of the research domains with considerable potential and complexity for achieving human-centricity in manufacturing systems. HRC involves the integration and complementation of human and machine intelligence, unleashing a continuous innovation capability, eliminating the necessity for large sensory networks, extensive data storage, and computational requirements (Sihan Huang, 2022).
Future Employment and Workforce: As a consequence of the ongoing revolutions in industry and society, an increasing number of physical or repetitive tasks will be automated, leading to the elimination of many existing jobs and giving rise to unemployment issues and a range of significant social challenges. However, this process is also characterized by a positive trajectory, generating numerous new jobs that require a workforce adept in emerging technologies. Examples of these new roles include data analysts, automated guided vehicle (AGV) coordinators, augmented operators, and more. All stakeholders involved in this shift should be mindful of the unchangeable patterns of development, recognizing the need to efficiently adapt to the latest circumstances within a critical time window.
Furthermore, to anticipate, react to, and recover from disruptions, a smart and resilient manufacturing (Jiewu Leng, 2022) system is defined as an agile, flexible, and reconfigurable system. Such a system leverages real-time operational and environmental data through intelligent sensor systems, employing explanatory, anticipatory, and guiding analytics methodologies.

Conclusion

In summary, the exploration of Industry 5.0 and Society 5.0 underscores their shared focus on a human-centric future. Industry 5.0 envisions a resilient manufacturing system, while Society 5.0 aspires to create an intelligent and efficient community. Both concepts, though hypothetical (Marco Dautaj, 2022), converge on human centricity, aiming to balance economic development with societal well-being.

A key concern is the impact on the workforce, particularly the potential loss of employment due to automation in Industry 5.0. The transition, though offering new opportunities in emerging technologies, requires careful consideration of disruptions. Human-Robot Collaboration (HRC) emerges as a promising area, demanding a skilled workforce adept in working with intelligent machines.

Shared fundamentals, like Human-Cyber-Physical Systems (HCPS) and Green Intelligent Manufacturing (GIM), provide collaborative avenues for addressing challenges. As these concepts remain theoretical, stakeholders must navigate uncertainties and contribute collectively to ensure a prosperous future that prioritizes technological advancements alongside workforce welfare.

Disclaimer

This research paper on Industry 5.0 and Society 5.0 is intended for academic purposes only. The information presented herein has been compiled from various online resources, scholarly articles, and theoretical frameworks. The purpose of this paper is to explore and analyze the conceptual foundations of Industry 5.0 and Society 5.0. It is crucial to note that the content presented in this research paper relies heavily on existing literature and speculative ideas related to Industry 5.0 and Society 5.0. As of the completion of this paper, the practical implementation and real-world viability of these concepts remain uncertain and largely theoretical.

The reproduction of information from different sources is meant to provide a comprehensive understanding of the subject matter and does not imply endorsement or confirmation of the ideas presented. The author acknowledges the intellectual contributions of various scholars and researchers in the field. Readers are encouraged to approach the content critically and consider the evolving nature of Industry 5.0 and Society 5.0, recognizing that advancements in technology, economic structures, and societal paradigms may impact the feasibility of the proposed concepts. This paper does not make definitive claims about the practical implementation or future developments in these areas.

Furthermore, the author accepts no responsibility for any inaccuracies or omissions that may be present in the text. Readers are urged to consult primary sources and conduct further research to validate and expand upon the concepts discussed in this paper. In conclusion, this research paper serves as a scholarly exploration of Industry 5.0 and Society 5.0, based on the available literature and theoretical frameworks. It is not intended to provide conclusive answers but rather to stimulate discussion, critical thinking, and further research on these emerging concepts.

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Biographies

Semail Ülgen is an Associate Professor and Chair of Industrial Engineering Department at Antalya Bilim University, Antalya, Turkey. She earned B.S. in Mathematics from Bilkent University of Faculty of Science, Turkey, Masters and PhD in Mathematics from Purdue University, West Lafayette, IN, USA. She has published journal and conference papers. She had worked as a professor at the University of Mississippi, Oxford, MS, USA, at Grand Valley State University, Allendale, MI, USA, at Northwestern University, IL, USA and at Indiana University, Bloomington, IN, USA. Dr. Ülgen was a recipient of the Young Scientist Award for Turkish American Scientists and Scholars Association (USA) in 2006. Her research interests include Finsler Geometry; Applications to Mathematical Physics, Stochastic Processes and its Applications. She is member of IEOM, AMS, Turkish Mathematical Society. She owns a research and trade company (INNOSU) on water efficiency in agriculture and industry.

Mohammad Muneeb is a final year Industrial Engineering student at Antalya Bilim University. He is really keen about the intersection of science, technology and collaboration. With strong belief in crucial role of diversity, he envisions a future where human-machine collaboration is central of progress. Passion for aviation industry lend him a presitgious internship which helped in gaining insights about the dynamic world of aviation technology. He conducted analytical research based on forecasting methods for a packaging and cardboard manufacturing firm in Turkey. Currently, he is volunteering in medical industry to streamline processes through business automation. Although still learning, he is commited to applying technology to real-world challenges and firmly believes that machines potentially make lives easier, it is upto human how to utilize one.