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Review

The Future of the Human–Machine Interface (HMI) in Society 5.0

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Abstract: The blending of human and mechanical capabilities has become a reality in the realm of Industry 4.0. Enterprises are encouraged to design frameworks capable of harnessing the power of human and technological resources to enhance the era of Artificial Intelligence (AI). Over the past decade, AI technologies have transformed the competitive landscape, particularly during the pandemic. Consequently, the job market, at an international level, is transforming towards the integration of suitably skilled people in cutting edge technologies, emphasizing the need to focus on the upcoming super-smart society known as Society 5.0. The concept of a Humachine builds on the notion that humans and machines have a common future that capitalizes on the strengths of both humans and machines. Therefore, the aim of this paper is to identify the capabilities and distinguishing characteristics of both humans and machines, laying the groundwork for improving human–machine interaction (HMI).

Keywords: human–machine interface; HMI; Society 5.0; Industry 5.0; Artificial Intelligence (AI)

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Citation: Mourtzis, D.; Angelopoulos, J.; Panopoulos, N. The Future of the Human–Machine Interface (HMI) in Society 5.0. *Future Internet* **2023**, *15*, 162. https://doi.org/10.3390/fi15050162

Academic Editor: Iwona Grobelna

Received: 31 March 2023
Revised: 21 April 2023
Accepted: 25 April 2023
Published: 27 April 2023

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1. Introduction

Industry 5.0 (I5.0) [1] is a subset of the larger concept of Society 5.0 (S5.0) [2], which envisions a super-smart and intelligent human-centered society that leverages advanced technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), robotics, and eXtended Reality (XR) for addressing a plethora of societal problems. Industry 5.0 specifically focuses on the application of these technologies in manufacturing and production systems to enable more efficient human–robot collaboration (HRC) [3]. More specifically, I5.0 is an upcoming manufacturing concept that aims to improve collaboration between humans and robots by promoting the use of human–machine interfaces (HMI) in manufacturing systems and production networks [4]. This involves utilizing advanced technologies such as cloud computing, 5G networks, Artificial Intelligence (AI), and digital twins (DTs) for the design of more robust decision making frameworks for engineers. Automation and robotics are key areas of focus in the development of smart factories, which are enabled by various information and communication technologies (ICTs), infrastructure, and control systems such as smart machinery, cyber-physical machine tools (CPMTs), robotics, and processes in factories [5]. The concept of a Humachine, as has been mentioned, emphasizes the integration of humans and machines, leveraging the strengths of both to enhance their overall capabilities. To improve human–machine interaction (HMI), it is essential to understand the distinct characteristics and capabilities of each. Humans possess certain abilities that machines do not, such as creativity, intuition, empathy, and common sense. Humans can understand complex situations and respond to them appropriately, whereas machines can only respond based on pre-programmed instructions. Humans can also learn and adapt to new situations quickly, while machines require training and reprogramming. On the other hand, machines have some advantages over humans, such as processing speed, accuracy, and consistency. Machines can handle vast amounts of data and perform complex calculations much faster than humans. They are also not subject to human limitations such as fatigue, boredom, and emotional bias. Therefore, in order to address these challenges and improve HMI, new ways to combine the strengths of humans and machines have to be found. For example, machines can assist humans in performing repetitive and time-consuming tasks, freeing up time for humans to focus on more creative and strategic work. Machines can also analyze and process data, presenting it to humans in a way that is easy to understand and use [6]. To achieve this, the development of more advanced Machine Learning algorithms and Artificial Intelligence (AI) technologies that can mimic human decision-making processes is necessary. Further to that, it is important to improve the design of HMIs, making them more intuitive, user-friendly, and able to provide real-time feedback and guidance. To that end, this paper deals with the Humachine concept and emphasizes the integration of humans and machines, combining their strengths to improve the overall performance of manufacturing processes and systems.

1.1. Societal and Industrial Transformation in the Form of Revolutions

In the available literature, there have been several discussions on industrial revolutions that extend to several associated aspects and discretize key milestones and innovations in chronological order. However, there is little, to our best of our knowledge, discussion on the correlation to societal evolution. Correspondingly, regarding society, five key eras can be distinguished, which are the key topic of the following paragraphs. Society 1.0 was characterized by our earliest ancestors living in small, nomadic groups and relying on hunting and gathering for their sustenance. As humanity progressed, Society 2.0 emerged with the development of agriculture, which allowed for larger settlements and more complex social structures. Society 3.0 marked the beginning of the industrial era, with mass production and urbanization leading to significant societal changes. Society 4.0, also known as the digital era, is characterized by the widespread use of computers, the Internet, and other digital technologies [7].

Industry 4.0 and Industry 5.0 are indeed two different terms that are used in order to describe different stages of the industrial revolution timeline. To compare the two, Industry 5.0 is an evolution of Industry 4.0 that emphasizes the integration of humans and machines towards the creation of a more human-centered and sustainable manufacturing landscape. Industry 4.0 refers to the fourth industrial revolution, which is characterized by the integration of digital technologies, such as the Internet of Things, Artificial Intelligence, and Big Data, into the manufacturing process. In reality, Industry 4.0 represents a series of technologies and techniques that are focused on the complete digitization and digitalization of manufacturing systems and networks. On the other hand, Industry 5.0 is a subset of a greater initiative that has been given the name Society 5.0 by the Japanese government. Industry 5.0 seeks to integrate humans and machines in a way that maintains and elevates the virtues of both. Rather than replacing human workers with machines, Industry 5.0 aims to create a more human-centered and sustainable manufacturing process by utilizing the creativity, problem solving skills, and emotional intelligence of human workers in conjunction with the precision and efficiency of machines. Specifically, this initiative targets the utilization and expansion of the current technological advances in order to create a super-smart and intelligent society, thus focusing on the human aspect of technologies. Consequently, it would be wise to state that Society 5.0 is characterized by three keywords, namely, (i) human-centric, (ii) sustainable, and (iii) resilient. Following the same convention, Industry 4.0 can also be considered as a subset of the current societal status, which has also been defined in several research works as Society 4.0.

The fundamental characteristics of Society 5.0, which differ from Society 4.0 in terms of value creation, diversity, decentralization, resilience, sustainability, and environmental harmony, are illustrated. Society 5.0 is considered to be a human-centered Industry 4.0 environment and is defined by the Cabinet Office of Japan as a society that integrates cyberspace and physical space to achieve a balance between economic progress and social problem solving [8]. Society 5.0 aims to use digital technologies and data to create a diverse society where people can pursue happiness in their own unique ways. In Society 5.0, individuals will have the freedom to pursue diverse lifestyles and values without constraints. The focus will shift from efficiency to problem solving, value creation, and meeting individual needs. Society 5.0 aims to eliminate suppressive influences on individuality, such as gender, race, and nationality, as well as wealth and information concentration disparities. Additionally, Society 5.0 aims to establish safety nets for unemployment and poverty to create a society in which anyone can create value, in safety and harmony with nature and free from existing constraints. Society 5.0 seeks to achieve a world where people can live in peace without fear of terrorism, natural disasters, or cyberattacks [9].

1.2. Vision and Pillars of Industry 5.0 and Society 5.0

Industry 5.0 is a term used to describe the next phase of industrial development, which is characterized by the integration of advanced technologies such as Artificial Intelligence, the Internet of Things, and robotics with human labor to create more efficient and productive manufacturing processes. The vision of Industry 5.0 is to create a manufacturing environment that is both highly efficient and sustainable while also promoting social and economic benefits for workers and communities. The technological pillars of Industry 5.0 include, among others, the following [10]:

- Cyber-physical systems (CPS): this refers to the integration of physical and digital systems, allowing for real-time monitoring and control of manufacturing processes [11].
- Artificial Intelligence (AI) and Machine Learning: AI algorithms can be used to analyze vast amounts of data to identify patterns and optimize manufacturing processes, improving productivity and reducing waste [12].
- The Internet of Things (IoT): The IoT connects devices and sensors throughout the manufacturing process, providing real-time data on the status of equipment and materials [13].
- Additive Manufacturing (AM): AM technologies such as 3D printing allow for the creation of complex and customized parts, reducing waste and increasing efficiency [14].
- eXtended Reality (XR): XR technologies can be used to train workers and provide real-time information on the manufacturing process, improving safety and productivity [15].

As such, the vision of Industry 5.0 is to create a manufacturing environment that is highly efficient, sustainable, and socially responsible, promoting the well-being of both workers and communities while driving economic growth (Figure 1).

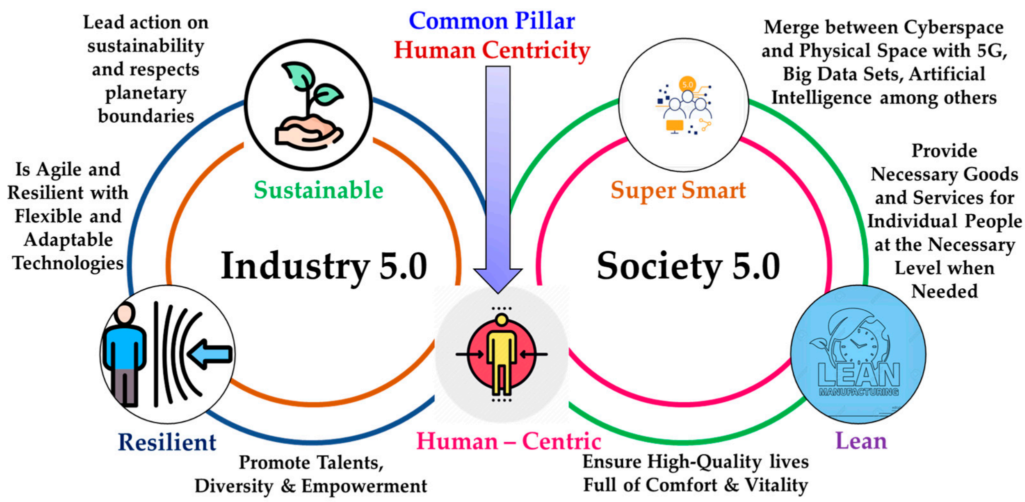

Figure 1. Vision of Industry 5.0 and Society 5.0 (Adapted from [2]).

1.3. Building Society 5.0: Challenges and Opportunities

Society 5.0 is based on the idea of a human-centered society where technology is used to solve social problems and promote the well-being of individuals and communities.

While there are numerous opportunities presented by Society 5.0, there are also several challenges that must be addressed to achieve its goals.

Challenges:

Inequality: The integration of technology into society has the potential to exacerbate existing social inequalities, such as access to healthcare, education, and employment opportunities. It is important to ensure that these technologies are accessible to all, regardless of socioeconomic status [16].

Privacy and Security: The increasing use of advanced technologies has raised concerns about data privacy and security. It is essential to establish regulations and protocols to protect sensitive data and prevent misuse of technology [17].

Digital Divide: The digital divide refers to the gap between those who have access to technology and those who do not. It is important to ensure that everyone has access to technology to prevent exclusion and promote equality [18].

Ethical considerations: The use of advanced technologies raises ethical questions about their impact on society and the potential for unintended consequences. It is important to establish ethical guidelines and principles to ensure that these technologies are used in a responsible and ethical manner [19].

Opportunities:

Improved healthcare: Society 5.0 can facilitate the development of personalized healthcare solutions, leveraging AI and the IoT to monitor and diagnose health issues in real time [20].

Sustainable living: Society 5.0 can help reduce the environmental impact of human activities through the development of smart cities, green energy solutions, and sustainable transportation systems [21].

Digital transformation: Society 5.0 can help businesses and organizations become more efficient and productive using advanced technologies such as robotics, automation, and AI [22].

Economic growth: Society 5.0 can create new industries and job opportunities, promoting economic growth and development [23].

The green and digital transitions of Industry 5.0 and Society 5.0 aim to promote intentional and creative living. Universities and businesses have a crucial role to play in achieving this goal. Along with the development of Information Technology (IT), efforts must also be made to enhance industrial innovation and improve the information literacy of every citizen to create a people-centric way of life [24]. As we move towards Society 5.0, universities must not only advance technology but also foster information literacy through personalized education. Industry 5.0 and Society 5.0 are interconnected, and the fifth industrial revolution will accelerate social progress, aided by society's transformation. In Table 1, the similarities and opportunities presented by these two revolutions are summarized.

Table 1. Similarities between Industry 5.0 and Society 5.0.

Similarities between Industry 5.0 and Society 5.0	
Challenges	**Opportunities**
1. Aging population	1. Human–cyber-physical systems (HCPS)
2. Resource shortages	2. Green intelligent manufacturing (GIM)
3. Environmental pollution	3. Human–robot collaboration (HRC)
4. Complex international situations	4. Future jobs and operators 5.0
	5. Human digital twins (HDTs)

1.4. Humachine Definition

According to [6], a Humachine is defined as a hybrid that expresses the combination of human qualities, including creativity, intuition, judgement among others, with the inherent mechanical advantages of machines (Table 2).

Table 2. Key definition for the Humachine term [25,26].

Human: "Relating to or characteristic of humankind. . . . Of or characteristic of people as opposed to God or animals or machines, especially in being susceptible to weaknesses. . . . Showing the better qualities of humankind, such as kindness."	Humachine The combination of the better qualities of humankind—creativity, intuition, compassion, and judgment—with the mechanical efficiency of a machine—economies of scale, Big Data processing capabilities—augmented by Artificial Intelligence, in such a way as to shed the limitations and vices of both humans and machines while maintaining the virtues of both
Machine: "An apparatus using mechanical power and having several parts, each with a definite function and together performing a particular task. . . . Any device that transmits a force or directs its application. . . . An efficient and well-organized group of powerful people. . . . A person who acts with the mechanical efficiency of a machine."	

Definition: *the word "Humachine" first appeared on the cover of a 1999 MIT Technology Review Special Edition and coined to describe "the symbiosis that is currently developing between human beings and machines–Humachines"*. [25,26]

Essentially, the term Humachine is used to describe the process and the result of merging humans with machines, combining the most important qualities of each party but simultaneously maintaining their identity. Taking into consideration the main theme of Society 5.0, which is human-centricity, and its extension to the investigation of the human aspect of technologies, the term "humachine" acts in favor of this initiative since humankind is on the verge of harnessing the power (i.e., mechanical and computational advantages) of machines in order to amplify the capabilities of humankind.

1.5. Humachine Modus Operandi

The essential parts of a Humachine intelligent system can be summarized as the following three: (i) sensing, (ii) thinking, and (iii) execution. It is stressed that in such systems, it is not necessary for the observer to know which system influences the result as long as the system operates well, and human operators are not in danger. In this context, three scenarios for implementing Humachines can be identified. In the first scenario, which is illustrated in Figure 2i, machine intelligence can be added to the system in order to augment human intelligence and reduce labor intensity. In this scenario, the human is considered the "master", and, accordingly, the machine is the "slave". With this configuration, human operators complete the tasks; however, information from the sensing devices is only processed by the machine. Therefore, the machine can play the following roles in the master/slave configuration presented above:

(1) Generate accurate quantitative information based on sensor signal processing that exceeds the range of human feeling;
(2) Supervision of human actions and provision of advice/warnings to human operators in the event of identification of a possible danger/human error.

Intelligent systems can automatically control certain well-structured systems that exhibit good linearity. Under these cases, system performance can be improved based on the principle of machines being the "master", and humans being the "slave", which is illustrated in Figure 2ii. In this Humachine configuration, the machine generates the information automatically and makes decisions based on the system's knowledge base so that the machine can automatically proceed with the execution of tasks. Consequently, in this configuration, the human roles can be summarized as the following:

(1) Help the machine in the generation of qualitative information that the machine sensing devices cannot interpret;
(2) Supervise the tasks executed by the machines and intervene whenever appropriate.

However, a third alternative scenario is also presented that facilitates the solution of problems that cannot be solved solely by a human operator or a machine. Instead, a cooperative configuration is structured, as illustrated in Figure 2iii. In this configuration, the cooperation between the two can be executed in two modes: (i) the system acts only after man–machine consultation or (ii) the system acts as a result of digital experimentation. In Figure 2iii, a collaborative decision-making framework is presented where both humans and machines sense the situation and propose their own decisions, after which they consult with each other to reach a final decision that controls the system.

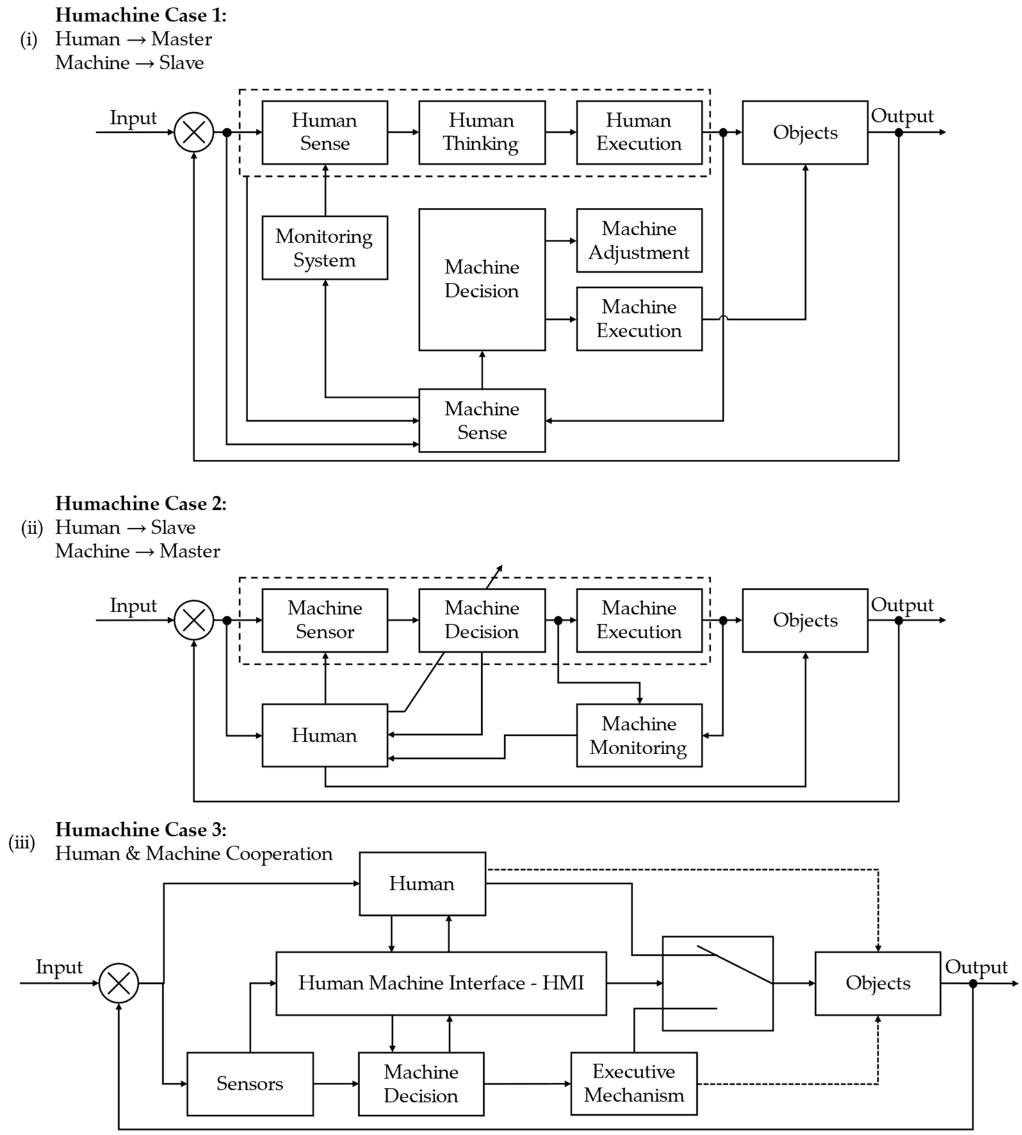

Figure 2. Humachine operational frameworks; (**i**) Human master and Machine slave; (**ii**) Human slave and Machine master; (**iii**) human and machine cooperation.

1.6. Paper Organization

The structure of the rest of the paper is as follows. In Section 2, the literature review methodology is presented and discussed. Then, in Sections 3–5, the concepts of human–computer interaction (HCI), human–machine interaction (HMI), and human-centric manufacturing (HCM), respectively, are investigated. Further, in Section 6, a discussion is conducted, and a conceptual framework is proposed. Finally, the manuscript is concluded in Section 7 and points for future elaboration are presented.

2. Literature Review Methodology

To ensure inclusion of peer-reviewed articles, the search query was applied to retrieve publications from Scopus, which was used as the primary database to obtain articles for bibliometric analysis. The review methodology was adapted from the paper [27].

Search Query:

"(TITLE-ABS-KEY (industry 5.0) OR TITLE-ABS-KEY (society 5.0) AND TITLE-ABS-KEY (human AND machine AND interface) OR TITLE-ABS-KEY (humachine) OR TITLE-ABS-KEY (human AND machine AND interaction))".

The literature was searched specifically for journals, conference proceedings, title words, and years. The initial search returned a total of 70 scientific literary articles (Figure 3i). Among them, 32 journal articles, 20 conference papers, 2 books, 2 book chapters, 12 review papers, 1 conference review, and 1 editorial were identified. In addition, regarding topic, the majority of the publications fell under the topics of computer science and engineering as presented in Figure 3ii.

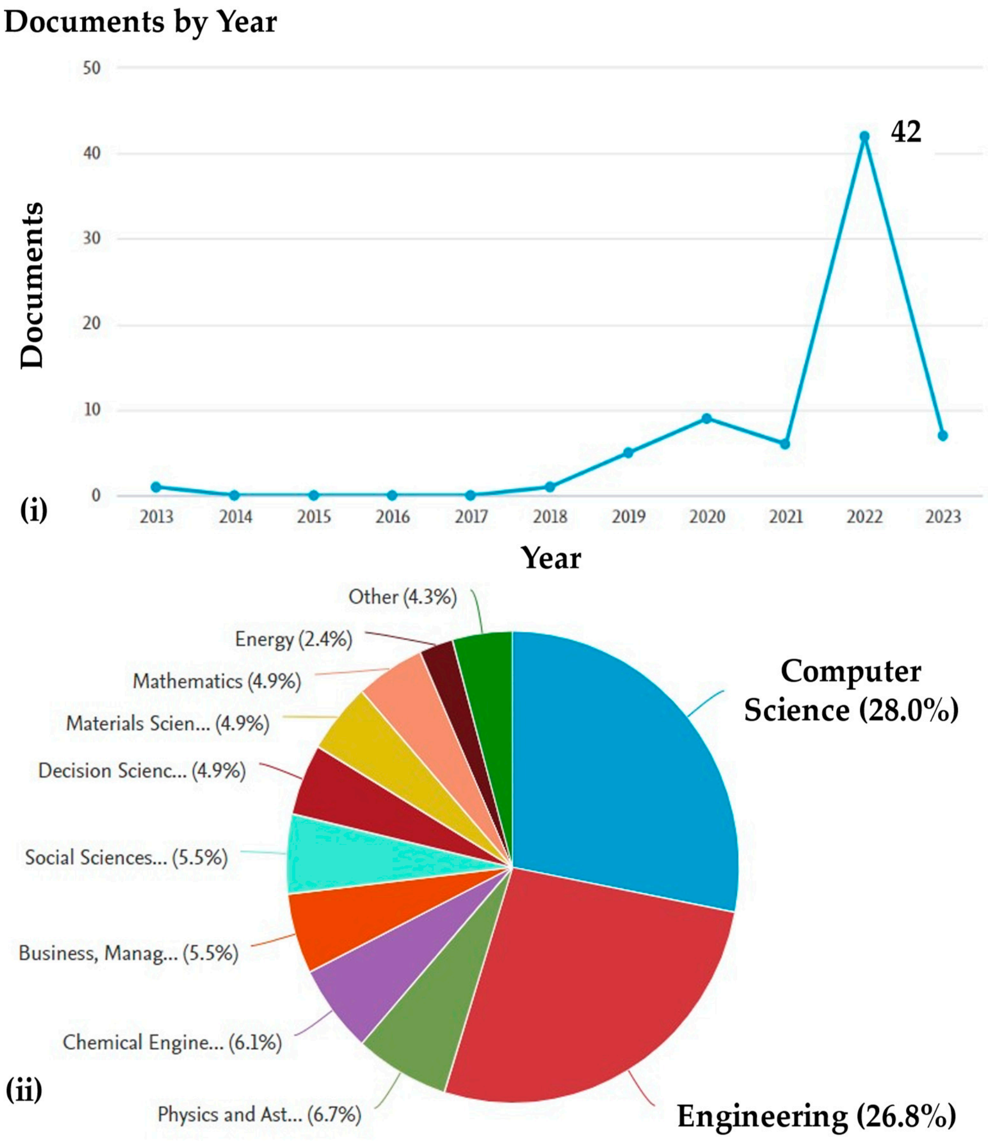

Figure 3. (**i**) Documents by year; (**ii**) documents by subject area.

The results dataset was transformed into CSV format for further processing, and VOSviewer software was utilized to visualize and analyze the bibliometric form of the results [28] (Figure 4). VOSviewer provides a variety of functions such as creating keyword maps based on shared networks and producing maps with multiple items, publication maps, country maps, journal maps based on co-citation networks, and maps with multiple publications. Users can modify the number of keywords used and eliminate less significant ones.

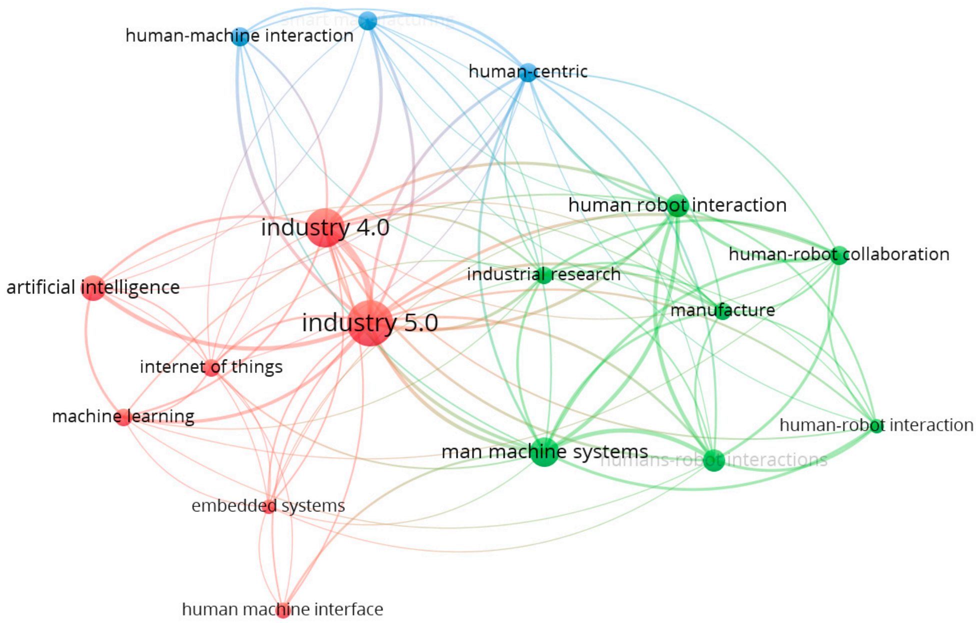

Figure 4. Results of bibliometric analysis.

In a VOS diagram, each object or entity is represented by a point, and the similarities between them are represented by the distance between these points. Objects that are closer together are more similar than those that are farther apart (e.g., Industry 5.0 in Figure 4). VOS diagrams are useful for identifying clusters or groups of similar objects or entities, which can help identify research topics or fields that are related to each other. They can also be used to identify outliers or anomalies that may warrant further investigation. More specifically, three (3) clusters were identified in this literature investigation, as summarized in Table 3.

Table 3. Clusters as constructed using VOSviewer Software.

Cluster 1 (7 Items)	Cluster 2 (7 Items)	Cluster 3 (3 Items)
Artificial Intelligence	Human–robot interaction	
Embedded systems	Human–robot collaboration	
Human–machine interface	Human–robot interaction	Human-centric
Industry 4.0	Human–robot interactions	Human-centric interaction
Industry 5.0	Industrial research	Smart manufacturing
Internet of Things	Man–machine systems	
Machine Learning	Manufacture	

3. Human–Computer Interaction (HCI)

3.1. Key Milestones

Human–computer interaction (HCI) is the field of study that focuses on optimizing how users and computers interact by designing interactive computer interfaces that satisfy users' needs. It is a multidisciplinary subject covering computer science, behavioral sciences, cognitive science, ergonomics, psychology, and design principles. The evolution of HCI can be traced back to the early days of computing when computers were large, complex machines that required specialized knowledge to operate. As computing technology became more advanced and accessible, HCI evolved to become more intuitive and user-friendly. A timeline of human–computer interaction (HCI) is illustrated in Figure 5, along with some of the key milestones in the evolution of HCI, which are listed below [29]:

- Command-line interface (CLI): The earliest HCI was based on the command-line interface (CLI), which required users to enter text commands to interact with the computer. This type of interface was difficult to use for non-experts and required extensive knowledge of computer commands.

- Graphical user interface (GUI): In the 1980s, the graphical user interface (GUI) was developed, which used icons, menus, and windows to make computing more intuitive and user-friendly. The GUI made it easier for users to navigate and interact with the computer and is still used widely today.
- Touchscreens: The introduction of touchscreen technology in the 1990s and early 2000s revolutionized HCI by allowing users to interact directly with graphical elements on the screen. This technology made computing even more intuitive and accessible and paved the way for the development of mobile devices.
- Natural language processing (NLP): In recent years, natural language processing (NLP) has become a major area of research in HCI. NLP allows users to interact with computers using spoken or written language rather than commands or mouse clicks. This technology is still in its early stages but has the potential to make computing even more natural and intuitive.
- Virtual Reality (VR) and Augmented Reality (AR): With the advent of VR and AR technologies, HCI is moving beyond the traditional screen-based interface. These technologies allow users to interact with digital content in a more immersive and natural way and have the potential to revolutionize HCI in areas such as gaming, education, and healthcare.
- Metaverse: The metaverse is a virtual world where users can interact in a 3D space using avatars. Human–computer interaction in the metaverse involves natural language processing, haptic feedback, and Virtual Reality to create a more immersive and natural experience. It has the potential to revolutionize the way we interact with digital content and with each other.

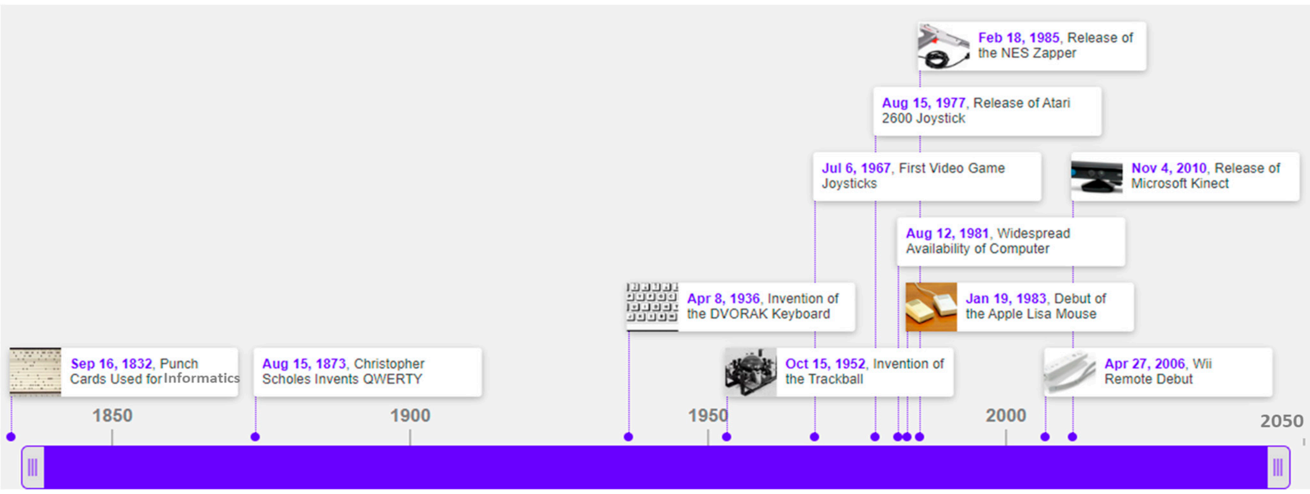

Figure 5. Timeline of human–computer interaction (HCI).

3.2. From HCI to Human Perception

Human perception is a field of study that focuses on understanding how people perceive and interpret sensory information from the environment. It is closely related to human–computer interaction (HCI) because both fields are concerned with how people interact with technology. However, while HCI focuses on designing technology that is easy to use and understand, human perception seeks to understand the underlying cognitive processes that shape our perception of the world. By studying human perception, we can gain insights into how to design technology that is more intuitive and user-friendly. For example, understanding how people perceive color can help designers create interfaces that are easy on the eyes and improve readability. Figure 6 portrays an individual decision making approach where humans and machines make decisions based on their own perceptions and evaluations and a synthesis evaluator selects the better decision to control the system. If the machine's decision is better, it will give humans signs or warnings and take control of the system. Conversely, if the human's decision is better, they will control the system, and the machine's knowledge base will be improved through an emulation algorithm. Ultimately, these approaches aim to facilitate mutual learning and collaboration between humans and machines [30]:

1. User interface: traditional human–machine interaction only incorporates human perception from system output;
2. Physiology: improved models include personal capabilities, individuality, and actual conditions;
3. Interpersonally: with regard to physiological processes involved in interpersonal communication.

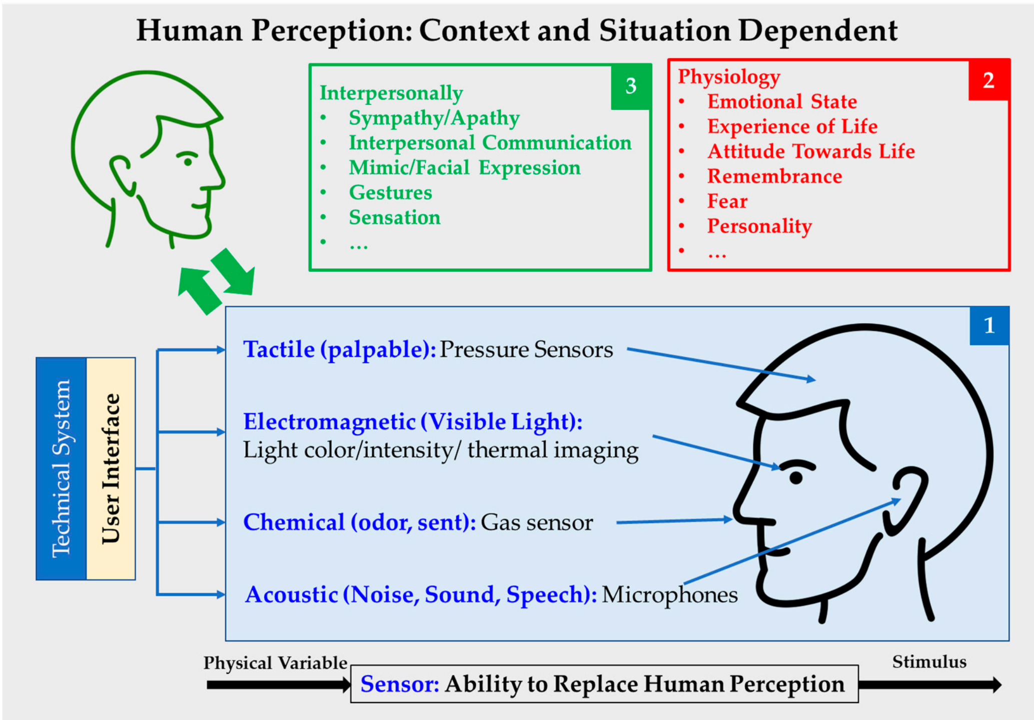

Figure 6. Human perception: context- and situationally dependent (adapted from [31]).

4. Human–Machine Interaction (HMI)

Human–machine interaction (HMI) is a field of study that focuses on the design, development, and evaluation of interfaces between humans and machines. It is closely related to human–computer interaction (HCI) but includes interactions with a broader range of machines such as robots, autonomous vehicles, and smart home devices. HMI seeks to create interfaces that are intuitive, efficient, and enjoyable for users to interact with. This involves understanding user needs and preferences as well as the capabilities and limitations of machines. The goal of HMI is to create a seamless and natural interaction between humans and machines, improving the efficiency and effectiveness of the interaction. Human–computer interaction is of critical importance because it makes products more usable, safe, helpful, and functional. It creates a seamless and enjoyable user experience, rather than leaving the user frustrated as they try to figure out why the system is not working as they expect it to work and doing what they want it to do. It makes systems more intuitive, intelligible, and useful [31].

4.1. Key Enabling Technologies and Goals of HMI

Key enabling technologies of human–machine interaction (HMI) include [32,33]:

Artificial Intelligence (AI) and Machine Learning (ML): these technologies enable machines to learn from data and adapt to user behavior, making interactions more personalized and efficient;

Natural language processing (NLP): NLP enables machines to understand and respond to human language, making interactions more natural and intuitive;

Robotics: robotics technology involves the design, construction, and operation of robots to perform tasks in a wide range of settings;

Computer vision: computer vision allows machines to perceive and interpret visual information, enabling them to recognize objects and understand gestures;

Haptic technology: haptic technology provides tactile feedback to users, enhancing the sensory experience of interacting with machines;

Augmented Reality (AR) and Virtual Reality (VR): AR and VR technologies enable users to interact with virtual objects and environments in real time;

Internet of Things (IoT): IoT technology involves connecting physical devices to the Internet, enabling them to exchange data and interact with each other.

The goals of HMI include:

Improve efficiency: the goal of HMI is to improve efficiency and productivity by automating routine tasks and augmenting human capabilities;

Improve user experience: HMI aims to create intuitive and user-friendly interfaces that make it easy for people to interact with machines;

Increase safety: HMI strives to improve safety by reducing the risk of accidents and errors in high-risk industries such as aviation, transportation, and healthcare;

Enable personalization: HMI enables machines to adapt to individual preferences and behavior, providing a personalized experience for each user;

Foster collaboration: HMI aims to foster collaboration between humans and machines, enabling them to work together to achieve common goals.

Additionally, in the Industry 4.0 era, we encountered a wide variety of human–technology interactions (HTIs); any time a human uses technology, there is some type of hardware and/or software involved that enables and supports interaction. HTI concentrates on the aspects in which technologies facilitate the interaction between the human and the environment. An important goal of HTI is to develop principles and algorithms for autonomous systems to enable safe, direct, effective, and trustworthy interaction with humans [34]. Figure 7 depicts the comparison between HCI, HMI and HTI whereby the current new technologies and trends not only are assisting in the human–machine interface, but also have moved towards interaction and interfacing technology between humans and autonomous systems.

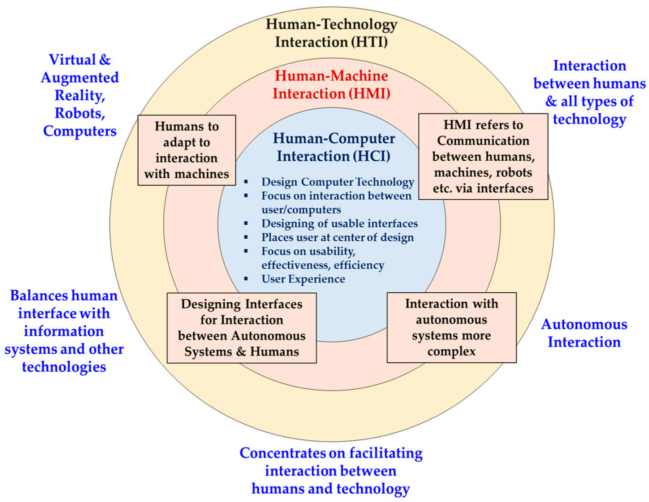

Figure 7. Comparison between HCI, HMI, and HTI (adapted from [35]).

4.2. Augmented Intelligence

Augmented intelligence, also known as intelligence amplification, refers to the use of Machine Learning, Artificial Intelligence (AI), and other technologies to enhance human decision making and problem solving abilities. Augmented intelligence differs from Artificial Intelligence in that it seeks to augment, rather than replace, human intelligence. Natural language processing (NLP): NLP is a type of AI that enables computers to understand and respond to human language. NLP can be used to analyze large volumes of text data, such as customer feedback, and extract meaningful insights to help humans make better decisions. Predictive analytics: Predictive analytics uses Machine Learning algorithms to analyze data and predict future outcomes [36]. For example, a retailer might use predictive analytics to forecast sales based on historical data and current trends. Virtual assistants: Virtual assistants, such as Siri or Alexa, use natural language processing and Machine Learning algorithms to help humans perform tasks more efficiently. For example, a virtual assistant might help a person schedule appointments, order groceries, or control smart home devices. Decision support systems: Decision support systems are computer programs that use data and algorithms to help humans make better decisions. For example, a healthcare provider might use a decision support system to help diagnose a patient's condition based on symptoms and medical history. The goal of augmented intelligence is to help humans make better-informed decisions by providing them with relevant information, insights, and recommendations. By augmenting human intelligence with Machine Learning and AI technologies, humans can perform tasks more efficiently, accurately, and with greater insights, leading to better outcomes [37].

Prescriptive analytics and augmented intelligence are related concepts that both use Machine Learning and Artificial Intelligence (AI) to provide humans with insights and recommendations for decision making. Prescriptive analytics refers to the use of data, statistical algorithms, and Machine Learning techniques to identify the best course of action for a given situation. It involves analyzing data and identifying patterns to make predictions about future outcomes, then recommending a course of action based on those predictions. Augmented intelligence, on the other hand, refers to the use of AI and other technologies to enhance human decision making and problem-solving abilities. It seeks to augment, rather than replace, human intelligence by providing humans with relevant information, insights, and recommendations to help them make better-informed decisions. Prescriptive analytics is a type of augmented intelligence because it provides humans with specific recommendations for actions to take based on data and analysis. For example, a healthcare provider might use prescriptive analytics to recommend a treatment plan for a patient based on their medical history and current condition. The provider can then use their own judgment and expertise to make a final decision about the course of treatment [38]. In summary, prescriptive analytics and augmented intelligence are both forms of Artificial Intelligence that aim to provide humans with insights and recommendations to improve decision making. Prescriptive analytics specifically provides specific recommendations based on data analysis, while augmented intelligence seeks to enhance human intelligence more broadly by providing relevant information and insights.

4.3. Brain Computer Interface (BCI)

A brain-computer interface (BCI) can be realized as a form of the so-called Humachine by enabling direct communication of the human brain and computer systems [39]. BCIs hold a lot of promise for enabling individuals to control devices and communicate directly with computers using their thoughts. Several approaches have been presented in the literature, with the most commonly applied framework being electroencephalography (EEG) [40]. It is often, however, that these technologies are coupled with other Industry 4.0 technologies, such as eXtended Reality (XR), in order to improve human perception. For example, in [41], a Mixed Reality (MR) framework is proposed in order to facilitate remote user control of robotic arms. However, there are several challenges that need to be overcome to make BCIs more effective and reliable. Some of these challenges include:

1. Signal quality: One of the key challenges in the development of BCIs is obtaining high-quality signals from the human brain. By default, brain signals are weak and can be easily contaminated by noise and interference from other sources, such as muscles and other electronic devices. Therefore, accurate detection and interpretation of brain activity is a challenging task [42];
2. Invasive vs. non-invasive BCIs: The current implementations of BCIs can be divided into two major categories: i) invasive and ii) non-invasive. Invasive BCIs require the implantation of electrodes directly into the brain, while non-invasive BCIs use external sensors to detect brain activity. Despite the fact that invasive BCIs can provide higher-quality signals, they are also riskier and more expensive. On the contrary, non-invasive BCIs are safer for humans and more accessible, at the expense of lower-quality signals [43];
3. Training and calibration: BCIs require substantial effort in terms of training and calibration in order to work effectively. Furthermore, it is imperative for users to learn how to control their brain activity in such a way that can be detected and interpreted by the BCI. As a result, this can be a time-consuming and frustrating process for some users, causing discomfort [44];
4. Limited bandwidth: BCIs often have limited bandwidth, thus allowing only a limited range of brain activity to be detected and interpreted. Therefore, the types of actions that can be controlled using a BCI are still limited [45];
5. Ethical and privacy concerns: Indeed, BCIs have been evidenced to be really useful for the future of human–computer interfaces. However, there are certain ethical and privacy concerns. For example, data ownership legislation needs to be established. Furthermore, issues regarding data misuse and the development of suitable mechanisms to counteract such issues need to be explored [46].

5. Human–Centric Manufacturing (HCM)

Human–centric manufacturing (HCM) is an approach to manufacturing that places the human operator at the center of the manufacturing process. It aims to create a work environment that is safe, healthy, and comfortable for workers, while also optimizing manufacturing efficiency and productivity. Human–machine interaction (HMI) is a key component of HCM, as it is essential for creating interfaces between humans and machines that are intuitive and easy to use. HMI plays a critical role in HCM by enabling workers to interact with machines in a way that is natural and efficient. This involves designing interfaces that are intuitive and user-friendly while also providing feedback to the user to help them understand the status of the machine and the manufacturing process. Collaborative intelligence is enabled by empathic understanding between humans and machines [47,48]. In traditional system-centric manufacturing control strategies, humans are viewed the same as any other manufacturing resources, prioritizing system productivity and reliability over the human factor, which is insufficient for future manufacturing. Concerns have been raised that AI advancements could lead to job loss on the shop floor [49]. However, research shows that better system performance is achieved when humans and AI systems collaborate to form a partnership, creating collaborative intelligence [50]. Interactive collaboration between humans and empathic machines can determine the most effective collaboration mechanisms and action plans in a dynamic setting. Consequently, manufacturing control must evolve to incorporate learning, reasoning, and control mechanisms. The goal of HCM is to create a manufacturing environment that is optimized for human workers, rather than simply automating tasks and replacing human labor with machines. This requires a deep understanding of the needs and capabilities of human workers, as well as the capabilities and limitations of machines. HMI is an essential component of this understanding, as it enables designers to create interfaces that are tailored to the needs of human workers. In summary, HCM and HMI are closely intertwined, as they both seek to optimize the relationship between humans and machines in the manufacturing environment. By creating interfaces that are intuitive and user-friendly, HMI can help create a manufacturing environment that is safe, healthy, and comfortable for workers, while also optimizing manufacturing efficiency and productivity (Figure 8).

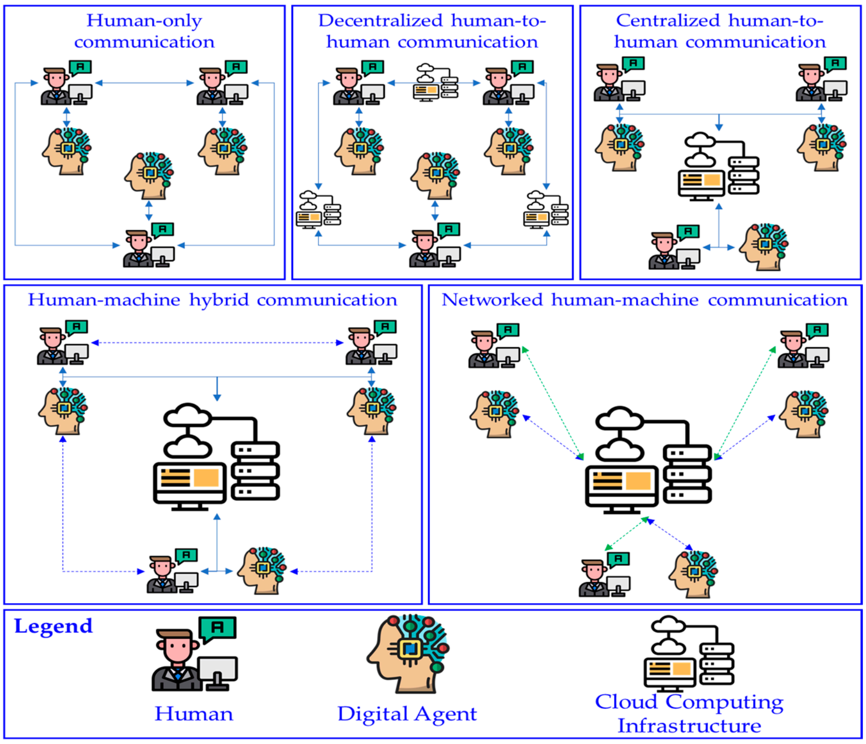

Figure 8. Types of HCPS communications.

5.1. Importance of Human-Centric Smart Manufacturing

Human-centric smart manufacturing is a manufacturing approach that places human beings at the center of the manufacturing process. It involves the use of advanced technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and robotics to enhance manufacturing processes while focusing on the needs of workers. The importance of human-centric smart manufacturing can be seen in the following ways [33]:

Improved safety: Human-centric smart manufacturing systems are designed to prioritize worker safety. By automating dangerous and repetitive tasks, they reduce the risk of accidents and injuries in the workplace;

Increased efficiency: Smart manufacturing systems can analyze data in real time, enabling workers to identify and resolve issues quickly. This results in improved productivity, reduced downtime, and increased profitability;

Enhanced worker experience: Human-centric smart manufacturing can improve the work environment, reduce physical strain, and enhance job satisfaction. By automating mundane tasks, workers can focus on more engaging and challenging work, leading to higher levels of job satisfaction;

Flexibility: Smart manufacturing systems can adapt to changing production needs quickly. This means that workers can adjust to changes in demand, resulting in more efficient use of resources and reduced waste;

Improved quality: Smart manufacturing systems can help reduce errors and defects in products. By monitoring the production process, they can identify issues early, enabling workers to make necessary adjustments to maintain quality.

As a result, human-centric smart manufacturing is essential for creating safer, more efficient, and more satisfying work environments. By prioritizing worker needs and leveraging advanced technologies, smart manufacturing can help manufacturers achieve better outcomes while also benefiting their employees.

5.2. Parallelism of Biological Vision System with Cyber-Physical Vision System

The biological vision system and the cyber-physical vision system share some similarities in terms of their parallelism. Here are a few ways in which they are similar [51]:

Neural networks: Both biological and cyber-physical vision systems rely on neural networks to process visual information. In the biological vision system, the brain's neural networks process and interpret visual signals from the eyes. In the cyber-physical vision system, artificial neural networks are used to process and interpret visual data captured by cameras and sensors;

Parallel processing: Both vision systems use parallel processing to process visual information quickly. In the biological vision system, multiple regions of the brain process visual information in parallel. In the cyber-physical vision system, multiple processors or cores can be used to process visual data in parallel;

Hierarchical processing: Both vision systems use hierarchical processing to analyze visual information. In the biological vision system, the brain processes visual information in multiple stages, with each stage processing increasingly complex features. In the cyber-physical vision system, algorithms are used to process visual information in a hierarchical manner, starting with basic features and progressing to more complex features;

Adaptability: Both vision systems are adaptable and can learn from experience. In the biological vision system, the brain can adapt to changes in the environment, such as changes in lighting or the presence of obstacles. In the cyber-physical vision system, Machine Learning algorithms can be used to improve the system's ability to recognize and classify visual information.

To sum up, the parallelism of the biological vision system and the cyber-physical vision system highlights the potential of Artificial Intelligence to replicate and even improve upon the natural abilities of the human visual system. By leveraging the strengths of both systems, researchers can create more efficient and effective vision systems that have a wide range of applications in fields such as robotics, autonomous vehicles, and surveillance. Further to that, computer vision is best suited for simple mechanical tasks or periodic tasks, such as defect detection in objects, pattern recognition, fraud detection. However, human vision outperforms machine vision in tasks requiring perception of objects and context understanding. A comparison is presented in Figure 9.

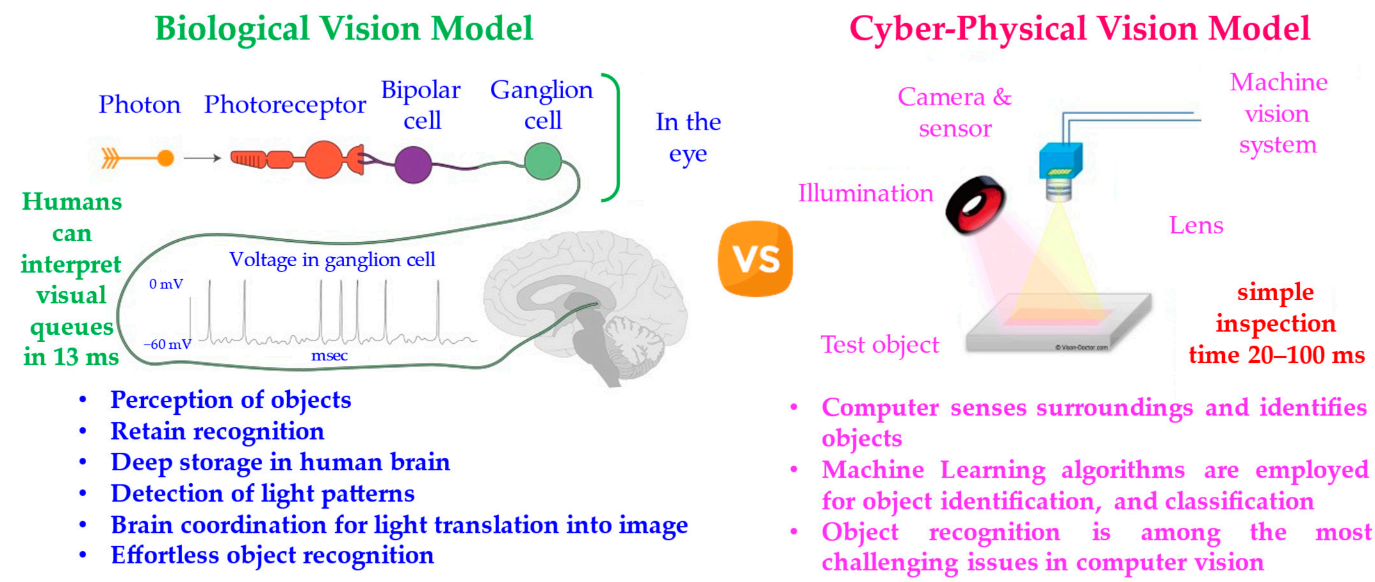

Figure 9. Comparison between biological vision system and cyber-physical vision system.

5.3. Human Digital Twins

A human digital twin is a virtual representation of a real human being that is created using digital data. It is a model that replicates the physiological, biological, and behavioral characteristics of an individual, allowing for simulations and predictions of their responses to different stimuli, situations, or environments. Here are some of the key characteristics of a human digital twin:

Real-time data: A human digital twin relies on real-time data from sensors, wearable devices, and other sources to accurately represent the current state of the individual. This data can include physiological measures such as heart rate, blood pressure, and temperature, as well as behavioral measures such as movement, speech patterns, and facial expressions [52];

Multi-dimensional representation: a human digital twin represents a person in a multi-dimensional manner, incorporating aspects such as their physical attributes, cognitive processes, emotions, and social behaviors [53];

Personalization: A human digital twin is personalized to the individual it represents, capturing their unique physical and behavioral characteristics. This allows for more accurate simulations and predictions of their responses to different stimuli and situations [25];

Machine Learning and AI: A human digital twin is often developed using Machine Learning and Artificial Intelligence algorithms that can learn from the data collected from the individual over time. This allows the twin to adapt and evolve as the individual's characteristics change [54];

Simulation and prediction: A human digital twin can be used to simulate and predict the individual's response to different stimuli and situations, such as exposure to a new drug or a change in environment. This can be used to optimize treatments or interventions, as well as improve the individual's overall health and wellbeing [27].

Digital twins that reproduce not only the outer aspects of a human being, such as physical and physiological characteristics, but also inner qualities such as personality, sensibilities, thoughts, and skills pave the way for the reproduction of social aspects in digital space, such as human behavior and communication. Thus, a human digital twin is a powerful tool for understanding and predicting human behavior and responses and has a wide range of applications in fields such as healthcare, sports science, and social science research (Figure 10).

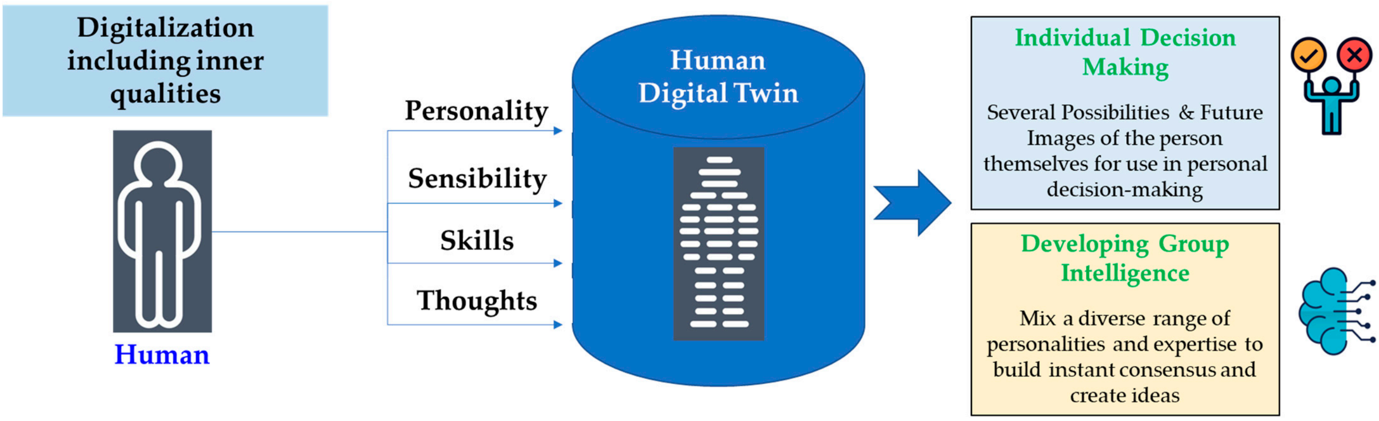

Figure 10. Human digital twins.

5.4. Contribution of Human Digital Twins

Human digital twins have the potential to revolutionize the way we understand and manage human health, wellbeing, and performance. Here are some of the potential applications and benefits of human digital twins [55]:

- Proxy (virtual agent) meetings between digital twins: digital twins with the personality and characteristics of individual people can react as if they were the real people in response to approaches from others in cyberspace [56];
- Creating a personal/virtual agent to work on your behalf: you can extend the range of human activity from the real world to cyber space using digital twin computing [57];

- Enabling dialogue that would be impossible in the real world: digital twins can also be used to communicate with people who do not currently exist, such as the deceased, to gain knowledge and experience [58];
- Using digital twins as an interface: creation of a derivative of your own digital twin endowed with abilities you do not possess [15];
- Enabling dialogue: language skills can be fabricated by exchanging or merging the abilities of your own Digital Twin with someone else's [15];
- Personalized healthcare: Human digital twins can be used to develop personalized treatment plans based on an individual's unique characteristics and responses to different stimuli. By simulating and predicting how an individual will respond to different medications or therapies, healthcare providers can optimize treatments and improve outcomes [25];
- Disease prevention: Human digital twins can be used to monitor an individual's health and detect early signs of disease or illness. By analyzing data from wearable devices and other sources, the twin can identify patterns and anomalies that may indicate a potential health problem [59];
- Sports performance optimization: Human digital twins can be used to optimize sports performance by simulating and predicting how an individual will respond to different training regimens and environmental conditions. This can help athletes and coaches develop more effective training plans and prevent injuries [60];
- Workplace safety: Human digital twins can be used to improve workplace safety by simulating and predicting how an individual will respond to different work environments and hazards. This can help to identify and mitigate potential risks before they occur [61];
- Social science research: Human digital twins can be used to study human behavior and social dynamics in a controlled environment. By simulating and predicting how individuals will interact with each other under different conditions, researchers can gain insights into complex social phenomena [62].

In summary, human digital twins have the potential to revolutionize our understanding of human health, wellbeing, and performance, and to improve outcomes in a wide range of domains.

5.5. Use Cases of Human DTC

5.5.1. Collective Consensus Building

Collective consensus building for human digital twins refers to the process of developing a shared understanding and agreement among stakeholders regarding the use, development, and management of human digital twins. It involves bringing together various groups, including researchers, developers, policymakers, and users, to collaboratively define the scope and objectives of human digital twins, establish ethical and legal guidelines, and ensure that the technology is used in a responsible and beneficial manner. Here are some of the key considerations in collective consensus building for human digital twins [63]:

Privacy and data protection: Human digital twins rely on collecting and analyzing large amounts of personal data. It is essential to establish clear guidelines for how this data will be collected, stored, and used and ensure that users have control over their data and are informed about how it is being used;

Ethics and social considerations: Human digital twins raise a range of ethical and social issues, including concerns around autonomy, informed consent, and potential biases in the algorithms used to develop and manage the twins. It is essential to establish ethical guidelines for the use of human digital twins and ensure that these guidelines are continuously reviewed and updated as the technology evolves;

Interoperability and standards: Human digital twins may be developed by different organizations using different technologies and standards. It is essential to establish interoperability standards to enable different human digital twins to work together seamlessly and ensure that the technology is developed in an open and collaborative manner;

User engagement: Human digital twins must be developed in collaboration with end users, including patients, athletes, and workers, to ensure that the technology meets their needs and is aligned with their values and preferences;

Governance and regulation: Human digital twins may require new governance structures and regulations to ensure that they are developed and used in a responsible and transparent manner. This may involve developing new regulatory frameworks that are specific to human digital twins or adapting existing frameworks to accommodate this emerging technology.

Thus, collective consensus building for human digital twins is critical for ensuring that this technology is developed and used in a responsible and beneficial manner. By bringing together diverse stakeholders, we can establish a shared vision for the future of human digital twins and develop guidelines and standards that promote ethical and responsible use of this emerging technology.

- A human digital twin has a memory of personal knowledge, experience, etc., so it can think and judge while having the same personality and sense of values as the real-life person and engage in various tasks;
- A digital twin replicates communication that takes place in the real world, so it can engage in advanced tasks that require communication with multiple people;
- A typical example is consensus building during a meeting.

5.5.2. Towards Personalized Healthcare with Augmented Reality and Digital Twins

Digital technology has the potential to transform medicine and the healthcare industry in a sustainable way. At the same time, digital technology could equalize the relationship between medical professionals and patients. Many techniques and technologies have been proposed over the years for the diagnosis and treatment of diseases such as cancer. To add to these, technological breakthroughs in the fields of information and communication technologies (ICT), Augmented Reality (AR), and Artificial Intelligence (AI) might be of aid throughout the diagnosis and prediction process. Using AI algorithms and AR as technological pillars, the authors in [52] propose a conceptual framework for the display of magnetic resonance imaging (MRI) scans, data acquisition, and analysis from patients. Additionally, preliminary development is given, and future advancements are explored in light of the implications encountered. The graphical user interfaces (GUIs) (Figure 11a,b) and an information and communication technology (ICT) flowchart are presented in Figure 11c.

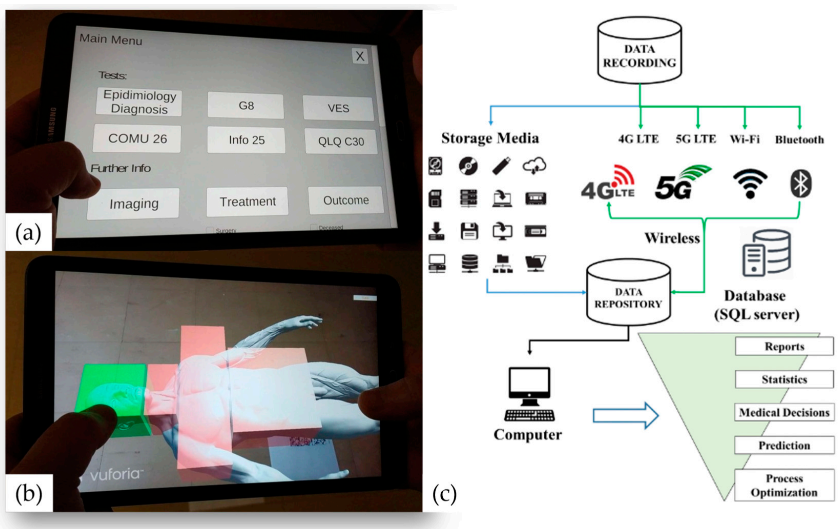

Figure 11. (**a**,**b**) Graphical user interface for human digital twin application; (**c**) information and communication technology (ICT) flowchart [52].

5.5.3. Future Prediction and Growth Support

Human digital twins are digital replicas of real-life human beings that can be used to simulate and analyze different scenarios and outcomes. They are created by collecting data from various sources such as wearable devices, medical records, and genetic information and using Artificial Intelligence and Machine Learning algorithms to build a virtual model of a person. The potential for human digital twins is vast, and it is predicted that they will play a significant role in various industries such as healthcare, education, entertainment, and even space exploration. Here are some future predictions and growth support measures for human digital twins [64]:

Healthcare: Human digital twins can be used to create personalized treatment plans for patients based on their individual genetic makeup and medical history. This can lead to more effective treatments and better outcomes for patients;

Education: Human digital twins can be used to create virtual simulations of real-life scenarios that students can learn from. This can provide a more immersive and engaging learning experience;

Entertainment: Human digital twins can be used to create virtual avatars that can interact with real people in virtual environments. This can lead to more personalized and engaging entertainment experiences;

Space exploration: Human digital twins can be used to simulate the effects of long-term space travel on the human body. This can help researchers develop better ways to keep astronauts healthy during extended space missions.

As the technology for creating human digital twins continues to advance, we can expect to see more applications for this technology in various industries. However, there are also potential ethical and privacy concerns that need to be addressed to ensure that human digital twins are used responsibly and for the benefit of society.

6. Discussion

6.1. Humachine Framework

Humachines are necessary for the future because they can bring significant benefits and opportunities in various domains, including:

- Enhanced productivity and efficiency: humachines can augment human capabilities with the speed, accuracy, and consistency of machines, leading to higher productivity and efficiency in many industries;
- Improved decision making: combining human reasoning and intuition with Machine Learning algorithms can lead to better decision making, reducing errors and improving outcomes;
- Advanced healthcare: Humachines can help healthcare professionals in diagnoses, treatment planning, and monitoring, leading to more accurate and personalized healthcare;
- Innovation and creativity: by collaborating with machines, humans can access vast amounts of data, tools, and insights that can fuel innovation and creativity in various fields;
- Automation of mundane tasks: automation of repetitive and mundane tasks can free up human time and energy to focus on more meaningful and creative tasks, leading to higher job satisfaction and engagement.

In summary, the Humachine concept provides a vision of a future where machines and humans collaborate to solve complex problems and create new opportunities. This partnership between humans and machines can create a world where we work smarter, not harder, where we can achieve more together than we can alone. A conceptual framework highlighting the necessity of Humachines is presented in Figure 12.

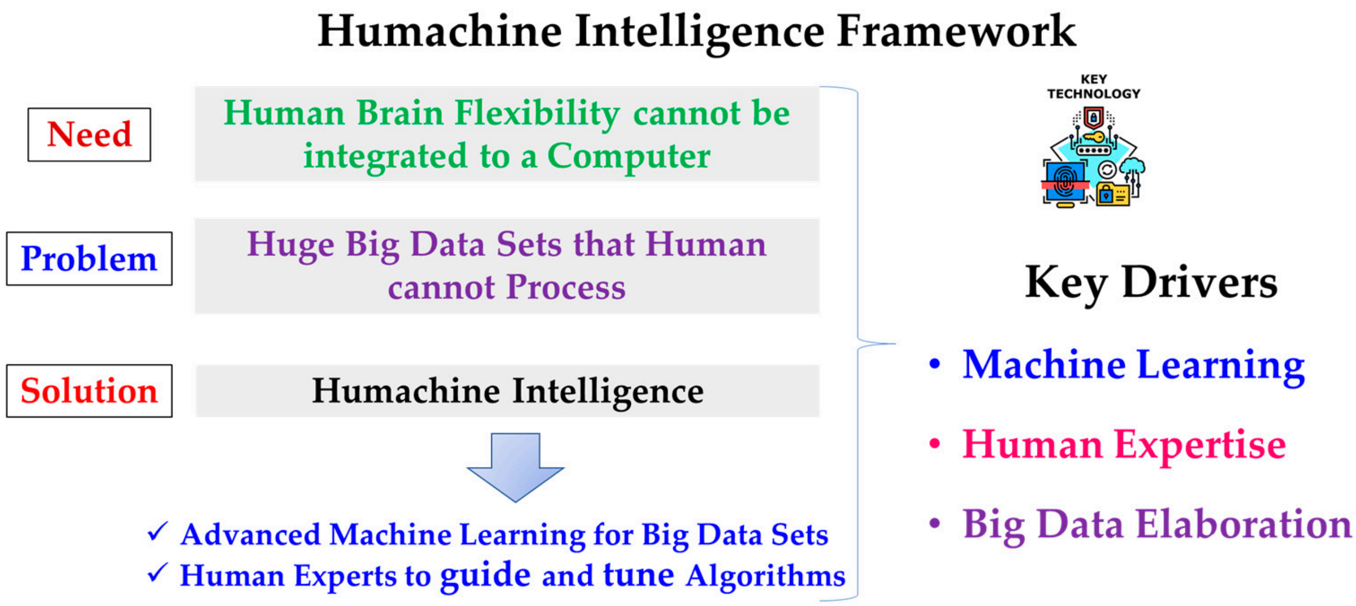

Figure 12. Humachine intelligence conceptual framework.

More specifically, a Humachine conceptual framework can be viewed as a combination of human and machine intelligence, where both work together to achieve a common goal. The key components towards the development of a Humachine framework are:

Purpose: The purpose of a Humachine system is to leverage the strengths of both human and machine intelligence to achieve a common goal. The goal can be anything from solving a complex problem to improving productivity;

Roles: The Humachine framework defines specific roles for both humans and machines. Humans are responsible for tasks that require creativity, critical thinking, and empathy, while machines are responsible for tasks that require speed, accuracy, and scalability;

Collaboration: Collaboration is key in a Humachine system. Humans and machines must work together seamlessly to achieve the desired outcome. This requires effective communication, trust, and respect between the two;

Data: Data is the lifeblood of a Humachine system. Machines require large amounts of high-quality data to perform effectively, while humans provide context and meaning to the data;

Feedback: Feedback is crucial in a Humachine system. Humans provide feedback to machines to improve their performance, while machines provide feedback to humans to help them make better decisions;

Ethics: Ethics must be at the forefront of a Humachine system. Humans must ensure that machines are not making decisions that are harmful to society, while machines must be programmed to adhere to ethical guidelines;

Continuous learning: A Humachine system must be constantly learning and improving. Humans and machines must be willing to adapt and evolve as new information and technology become available.

6.2. Latest Advances in AI

In the last five (5) years, the American Artificial Intelligence organization OpenAI made public a new initiative known as ChatGPT. It is a large language model dedicated to advancing Artificial Intelligence in a safe and beneficial way for humanity. More specifically, ChatGPT is based on the (generative pre-trained transformer) GPT-3.5 architecture. Most recently, ChatGPT was made available to a limited number of researchers and developers in June 2020, and by October 2020, a commercial API (application programming interface) version was made publicly available.

Generative pre-trained transformers form the basis for advanced AI tools such as the above-mentioned ChatGPT, Chatsonic, and Bloom. More specifically, for the development of such applications, a relatively new field of AI models, known as "foundation models", have been implemented [65]. Briefly, these models are used for the training of self-supervised neural networks based on the utilization of vast unlabeled data, and the resulting models can be used for a plethora of applications. For the sake of completeness of the presented research work, in the following table (i.e., Table 4), versions of foundation models are presented along with their key characteristics.

Table 4. GPT foundation model versions.

Model	No of Parameters	Training Dataset	Max Sequence Length	Release Date
GPT 1	0.12×10^9	Common Crawl, BookCorpus	1024	2018
GPT 2	1.5×10^9	Common Crawl, BookCorpus, Web Text	2048	2019
GPT 3	175×10^9	Common Crawl, BookCorpus, Wikipedia, Books, Articles, etc.	4096	2020
GPT 3.5	355×10^9	Common Crawl, BookCorpus, Wikipedia, Books, Articles, etc.	4096	2022
GPT 4	1×10^{12}	Common Crawl, BookCorpus, Wikipedia, Books, Articles, etc.	8192	2023

Despite the advances displayed above regarding GPT models, there is still room for further development. More specifically, the founders (i.e., OpenAI) recently published a research work [66] in which the experiments indicate that the upcoming version of GPT, GPT 4.0, has many more features than its predecessor and outperforms GPT 3.5 in almost all tests. The key takeaway is that AI is slowly but steadily gaining ground and soon will be a very powerful tool available to humankind. In an attempt to support the previous statement, the authors in [67] conducted an experiment in which ChatGPT is used in order to assist academic authors in the writing of an academic manuscript. The outcome of this experiment indicates that such AI models can assist academics and by extension humankind to process and extend current/existing knowledge. However, the critical aspect of ethics remains among the top issues to be resolved [68].

6.3. Limitations and Risks of AI Adoption

The adoption of Artificial Intelligence (AI) technology has the potential to revolutionize many industries and improve the efficiency of various processes. However, there are also limitations and risks associated with AI adoption that need to be considered. One limitation is the lack of transparency in some AI systems, which can make it difficult to understand how decisions are being made. This can lead to biases and errors in decision-making. Additionally, there is the risk of job displacement as AI systems are able to automate many tasks that were previously performed by humans. There is also the risk of cybersecurity threats as AI systems can be vulnerable to hacking and malicious attacks. It is important for organizations to carefully consider these limitations and risks when adopting AI technology and implement appropriate safeguards to minimize these risks. This includes ensuring transparency in AI systems, investing in upskilling and reskilling programs for employees, and implementing robust cybersecurity measures (Table 5).

Table 5. Limitations and risks of AI adoption [6].

Risk	Description
Control problem	AI becomes a singularity with a decisive strategic advantage and goals that are orthogonal to human interests
Accountability gap	Those most affected by AI have no ownership or control over its development and deployment
Affect recognition	Unethical applications of facial recognition technology to judge interior mental states
Surveillance	Intrusive gathering of civilian data that undermines privacy and creates security risks from data breaches
Built-in bias	When AI is fed data that contains historical prejudices, resulting in bias in, bias out
Weaponization	Using bots to negatively impact the public through social media or cyberattacks
Deepfakes	Creating lifelike video fakery to sabotage the subject of the video and undermine public trust
Wild AI	Unleashing AI applications in public settings without oversight

7. Conclusions and Outlook

Human–machine interaction (HMI) is a crucial aspect of Society 5.0, in which technology is leveraged for solving social challenges and improving quality of life. The key objective of HMI is to create a harmonious relationship between humans and machines where they work together towards a common goal. This is achieved by focusing on the strengths of each component, with machines handling tasks that require speed and accuracy while humans focus on tasks that require creativity, critical thinking, and empathy. One of the primary challenges in achieving effective HMI is ensuring that machines are designed to be user-friendly, transparent, and accessible. To achieve this, designers must take into account the diverse needs of users, including those with disabilities and elderly populations. Additionally, ethical considerations, such as privacy protection, must be taken into account. Another critical aspect of HMI in Society 5.0 is the development of human digital twins, which are virtual representations of humans that can be used for simulations and predictive analysis. Human digital twins have the potential to revolutionize healthcare, education, and other fields by enabling more accurate and personalized interventions. To fully realize the potential of HMI in Society 5.0, collaboration and cooperation across multiple fields, including technology, social sciences, and humanities, is required. This will require a multidisciplinary approach that prioritizes diversity and inclusivity. In conclusion, HMI is a vital component of Society 5.0, enabling technology to be harnessed for social good. While challenges remain, including ethical considerations and the development of accessible and user-friendly interfaces, the potential benefits of HMI are vast, and a collaborative approach is key to realizing them.

The key takeaway from the presented research work is to raise awareness on the integration of machines with humans in order to realize what has been defined as the Humachine. It has to be stressed that machines should be not treated as threats or competitors to humankind. On the contrary, it is suggested to treat them as a set of useful tools in order to vastly expand our capabilities and mitigate the limitations of humankind as we know them. Undeniably, in the long term, the replacement of human operators and workers might be more financially profitable. However, it is more ethical for society to provide certain tools to augment professionals rather than replacing them. The misuse of Artificial Intelligence methods is capable of and has already caused major problems. Decisions that may affect people should be made by people.

Author Contributions: Conceptualization and methodology, D.M., J.A. and N.P.; investigation, N.P.; writing—original draft preparation, J.A.; supervision, D.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

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

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