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Prospects of Computational Intelligence in Society: Human-Centric Solutions, Challenges, and Research Areas

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Abstract: The future of society could be shaped by artificial intelligence (AI), which is a part of soft computing that deals with probabilistic reasoning, neural networks, fuzzy logic, and evolutionary algorithms. This paper focuses on issues that are faced by soft computing as it moves towards human-centric solutions, outlines the challenges for soft computing, and provides possible research directions for development. Currently, there is an increasing emphasis on human-centered solutions in various fields, such as the healthcare industry, transportation sector, financial institutions, and education systems in the world today. Using soft computing techniques in this way comes with its own advantages, especially when managing unclearness or ambiguity or unsureness existing within humans' decision-making processes. Soft computing based on using neural networks may help to develop computer systems capable of faking human behavior and preferences as they evolve over time by using fuzzy logic and evolutionary algorithms. This human-centric approach helps improve the user experience while creating more symbiotic ties between technology and society, leading to examples such as personalized medicine treatment plans, among others. Soft computing's future in society will be, to a large extent, determined by the provision of human-friendly AI while addressing the ethical, legal, and social challenges of its applications. Rights on AI represent humanity and shall be accountable. Collaborating with interdisciplinary scientists and carrying out frontier studies on developing human-friendly AI systems from ethical, legal, and social perspectives and welfare has the potential to have an influence on community and policy-maker decisions, facilitate a suitable climate for soft computing and AI in society, leverage it for empowering individuals, communities, and societies, and to improve the quality of human life while respecting human values and dignity. It also paves the way for society to be more inclusive and equitable.

Keywords: soft computing, human-centric solutions, challenges, artificial intelligence, fuzzy logic

1. Introduction

In the 18th century, there was a big change caused by Industry 1.0, which was when products started being made using new methods and processes that were able to be generated by machines [1]. By the completion of the 1700s, this had made its way from England and reached the United States, where it had started around 1760. Industry 1.0 marked the shift from a manual to a machine-based economy and affected a number of industries, including acrylic, fabric extraction, mining, and the farming sector in terms of manufacturing [2]. Moreover, a second industrial transformation, famously between 1871 and 1914, Industry 2.0 emerged, allowing for a faster convergence of creative ideas and human movement. Increased automation within production facilities that characterized this era triggered growth in the employment rate via higher labor productivity, thus diluting social cohesion as the unemployment rate increased even faster.

The introduction of memory-programmable controllers and automated computers in the 1970s led to the era called the "digital revolution". The focus was on producing as many computational chips as possible using integrated circuits to enable mass production for cheaper costs, hence the increased use of digital phones, personal computers, and email services around that time [3, 4].

The advent concerning Industry 4.0 has increased flexibility within enterprises, enabling them to depend on decisions driven by data. The next technological revolution to come thereafter is termed Industrialization Version 5.0, with a focus on creating intelligent machines [5]. An excellent balance between human judgment and modern technology defines Industry 5.0 in manufacturing. This new industrial revolution highly draws from the digital Industry 4.0, where increasing human significance is found amidst extremely automated environments involving robots as well as (completely) automated production lines. The Industrial 5.0 transformative phase is defined as the merger of humanity with machines, which increases overall efficiency in manufacturing processes. The manufacturing sector is benefiting from increased productivity thanks to human labor and universal robotics [6].

The characteristic feature of Industry 5.0 is an emphasis on using AI for the good of everyone. But ever since AI began to spread across manufacturing, several problems have arisen, such as lack of employment, secrecy, and algorithmic prejudices. That's why, attributable to this Industry 5.0 would focus on the construction and deployment of AI that is accountable, see-through, and morally

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right. Also, at the heart of Industry 5.0, there is a determination to be sustainable and responsible with regard to the environment. There has been a time when it was necessary to have sustainable manufacturing practices due to the immediate issues of resource depletion together with climate change. At the Industry 5.0 level, production should be energy-efficient as well as minimize pollution and advance the ideas of circular economy principles. The objective of Industrial Revolution 5.0 is to set up an Industry that is more eco-friendly and sustainable by using renewable energy sources in order to adopt green production methods wherever applicable.

Moreover, Industry 5.0 places great focus on humans working with machines, ethics in AI integration, and great importance on diversity and inclusivity in the workforce. Through this, Industry 5.0 hopes to promote actions that ensure everyone can get involved and succeed in manufacturing by enabling individuals to have a say in creating options for themselves and others. Industry 5.0 is dedicated to constructing a future for the industry that is more inclusive and egalitarian, from programs promoting underrepresented groups to gender equality measures.

The work of obtaining electronic processes is controlled by changing input from one form to another. One of the key differences between soft computing and conventional computers lies in their flexibility regarding environmental changes. Soft computing deals with problem-solving approaches where the results may not be clear-cut. Several effective industrial uses of various soft computing techniques are presented, including fuzzy logic-based automated operating discipline, neural network-based empirical emulators of basic models, genetic programming-based rapid new product development, and swarm intelligence-based advanced process optimization [7].

Soft computing is an alternative computing sense in which there are solutions for complex issues with vague or approximate output results. These attributes comprise a subdomain within computer science named "soft computing" that employs inexact, ambiguous, and approximate reasoning for dealing with difficult problems. It differs from traditional computing techniques seeking mathematical models and precise algorithms to address hard tasks. Soft Computing techniques cater to uncertainty and imprecision that are present in data and decision-making processes found in the actual world.

The critical elements of soft computing are as follows: Industry 5.0 applications of intelligent technologies can accelerate innovation. It offers an innovative approach to business by leveraging innovative tools and an intelligent manufacturing method to create products made of intelligent materials [8].

Fuzzy logic suggests methods for dealing with uncertainty through an imprecise interpretation from a measurement perspective, in which computers can opt for "vague" as opposed to clear-cut choices during decision-making.

Neural networks: Pattern recognition, class differentiation, and prediction—for instance, pattern recognition, and outcome prediction—are functions performed by neurons located in the human brain, linked together and shaped into layers, making neural networks because these networks have undergone extensive training based on data that enable them to recognize patterns and anticipate outcomes.

Evolutionary computation: Most computational methods, including genetic algorithms (GA) and evolutionary strategies (ES), derive from genetic theories of evolutionary genetics and natural selection in computers. The processes involve selection, crossover operations, and mutation used in optimization solutions where iterative improvements take place.

Probabilistic reasoning: Probabilistic reasoning deals with exercising one's intelligence under several uncertain circumstances, finite models, or otherwise. It is usually used where the lack of finality in its output makes it desirable, like risk analysis, prognosis, or decision support system. The following are some domains where soft computing approaches are heavily utilized:

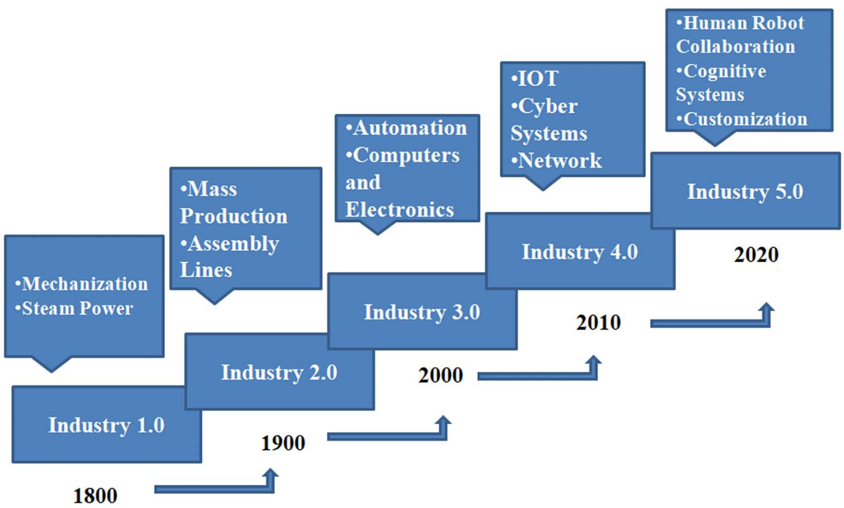
Creation: In the field of production, soft computing has been applied to increase product quality assurance, manage production tasks, foresee repair needs, and enhance processes.

Funds: In the financial area, soft computing helps people evaluate risk, foresee changes in the stock market, and invest in portfolios most efficiently while also identifying fraudulent acts.

Medical AI can help investigate drugs, monitor patients, define diagnoses, and customize treatments accordingly. Movement: The path optimization for vehicles without drivers is done using the same techniques employed by logistics planning and traffic control systems.

Figure 1 depicts the evolution of the industrial era from 1.0 to 5.0 and shows how each revolution has affected the growth of

Figure 1
Industrial revolution



manufacturing and the economy over time. The aim of Industry 5.0 is to take Industry 4.0 to another level [9]. The primary task of this paper is to explain How approaches to soft computing have changed from Industry 1.0 to Industry 5.0 all through the course of several revolutions [8]. In addition, it aims at making clear essential elements to distinguish between quite different soft computing approaches as well as approaches of soft computing, the functions played by soft computing within industries, and the use of such techniques throughout every stage in the mass production revolution.

The remaining sections of the paper are arranged as follows: Section 2 discusses similar interconnected work, Section 3 discusses the role that soft computing plays in Industry 5.0, Section 4 discusses methods and concepts of soft computing in Industry 5.0, Section 5 discusses the progress of soft computing in Industry 5.0, Section 6 discusses soft computing in society, Section 7 discusses the case study, and Section 8 concludes with references.

2. Related Work

Society relies heavily on computational intelligence, particularly in the context of human-centered solutions. This comes with both challenges and research opportunities. By integrating artificial intelligence (AI) into various sectors such as the industry, smart homes, and healthcare, humans are made better. Also, there have been concerns about the ethical considerations, security problems, and privacy violations related to the application of AI technologies. In light of these challenges, there is an increasing demand for human-centered, ethical, and fair AI technologies that have been designed responsibly. Some of the emerging research areas include Deep Graph Learning (DGL) for Social Good aimed at addressing social issues and improving people's lives using advanced AI methods. Furthermore, Computational intelligence can create a more equitable, sustainable society through human-centered techniques, multi-disciplinary teamwork, and responsible design of AI systems.

The paper discusses six important issues in the design of human-centered artificial intelligence (HCAI) technologies that are able to prioritize ethics and fairness and enhance human welfare [10]. A challenge faced is that HCAI systems need to have meaningful metrics defined so as to align with the user's and developers' objectives rather than relying on easily computable ones, which may not truly reflect how the system affects people. Therefore, it has been found by Zhang [11] that the performance of machine learning (ML) and artificial intelligence (AI) has been exceptionally good in a number of disciplines, including computer vision, natural language processing, and knowledge discovery. This research specifically looks into using Deep Graph Learning (DGL) approaches to address pressing social issues and using them for social good applications, under its name DGL for Social Good (DGL4SG).

Computational Intelligence offers human-centric solutions in diverse fields like medicine, finance, and education, which help solve social problems through data analysis, process optimization, and system improvement. The research by Caraffini et al. [12] employs evolutionary computation, neural networks, Fuzzy logic, and modern EC optimizers. According to Fernandes and Graglia [13], the paper has focused on ethical AI development, calling for a collaborative dimension towards different perspectives as well as continuous upgrading and human supervision to avoid biases while finding solutions that are more transparent and equal, thereby benefitting society. According to this multidimensional approach that is used to solve algorithmic biases. There is consistency in training and human management so that everything remains clear and fair.

3. Role of Soft Computing in Industry 5.0

To make sure that Industry 5.0 can be achieved, this paper reviews in-depth soft computing techniques that foster harmony between people and machines by expounding on manufacturing process optimization and decision-making in dynamic industrial settings where computers have complicated roles. This research demonstrates that soft computing will facilitate the creation of intelligent factories that are flexible enough to focus not only on output but also on employees' comfort.

Table 1 compares different soft computing techniques and outlines their descriptions, benefits, drawbacks, and applications regarding the requirements and restrictions of the individual problem. Thus, it enables the selection of the best-suited one for coming up with ideal solutions under Industry 5.0 as well as other areas.

Soft computing deals with a variety of real-world and complicated problems characterized by uncertainty, imprecision, and incomplete information. It has been suggested that soft computing be used to solve nonlinear and mathematically un-modeled systems (tractability) and to build new generation artificial intelligence [14]. It helps machines perform similarly to how individuals reason out things or select the best alternatives, thereby creating superior and more flexible solutions. After Industry 4.0, they called the following stage "Industry 5.0", which involves increased human-computer cooperation, focusing mainly on going green. Soft computing has a key part in making Industry 5.0 by offering solutions to difficult problems that can be changed and adapted. Here are some of the major roles of soft computing when it comes to Industry 5.0:

Making decisions and optimizing: Soft computing methods, comprising genetic algorithms, fuzzy logic, and neural networks, enable smarter selections in rapidly changing uncertain environments, ensuring that firms' production or distribution systems are very effective in terms of resource use at the lowest possible expense.

Predictive maintenance: By applying soft computing techniques, extensive sensor databases can be studied to predict machinery failures or maintenance within industrial premises. Thus, this method would make Industry 5.0 even better because fewer times would be lost with machines working efficiently throughout while the cost of any necessary repairs decreases.

Adaptive control systems: Using soft computing, an adaptive control system can be developed that allows modifying the production parameters according to changing process conditions or customer quality requirements, thus enhancing process efficiency, product quality, and adaptability.

Human-machine collaboration: Soft computing facilitates cooperation between human beings and computers. As a result, communications between robots and humans engaging in automation are improved in terms of safety and effectiveness.

Customized manufacturing: In terms of Industry 5.0, companies can assess data and make personalized products through the application of soft computing techniques in order to manufacture them on a large scale. This implies that in such a way, the firms would always be able to supply their customers with goods customized for them by looking into their individual preferences, analyzing marketing trends as well as estimating production capability levels, hence enhancing market efficiency and creating brand loyalty.

Table 1
Contrasting the silent features of various soft computing techniques

S. No	Technique	Description	Advantages	Disadvantages	Applications
1	Fuzzy logic	It works on the uncertainty via linguistic variables and fuzzy rules.	Imprecise and vague data are handled.	May not be able to define fuzzy rules without expert knowledge.	Decision support systems, quality control, and control systems.
2	Neural networks	Computational models inspired by the human brain, which contain layers of interconnected nodes/neurons.	Able to learn complex patterns from data. Appropriate for nonlinear relationships.	Training requires vast amounts of data, which, at times, makes it prone to overfitting.	Pattern recognition, classifying, predicting, optimizing.
3	Genetic algorithms	Optimization algorithms are inspired by natural selection and genetics. They can iteratively optimize problems like maxima or minima to make the best solution possible.	Useful in dealing with complicated, multimodal issues in optimization. Works for variables that are either discrete or continuous types.	It costs a lot in terms of math for big problems, and the optimal solution cannot be said to have been arrived at.	Optimizing, designing, scheduling, and tuning parameters
4	Evolutionary strategies	Optimization techniques based on evolutionary principles. Employ mutation, recombination, and selection to search for optimal solutions.	Suitable for continuous optimization problems. Can handle noisy and uncertain environments.	May require careful parameter tuning. Convergence speed can be slower than other methods.	Optimization, design, control, autonomous systems.
5	Swarm intelligence	Algorithms are modeled on collective behaviors of self-organized and decentralized systems (for example, bees, ants, and so on).	It is robust against isolated failures. It scales up to the size of giant problems.	May arrive at solutions that are less than optimal. Dependent on the settings of the parameters.	Optimization of routing, task allocation, network design, and sensor networks.

Energy management and sustainability: In this case, the use of soft computing by Industry 5.0 would minimize energy consumption and pollution controls and improve overall environmental quality. In this context, some examples include evolutionary algorithms and neural networks, which, among other processes, seek to reduce power consumption during energy-consuming activities, identify where electricity savings can be made, and provide backup for the introduction of renewable sources into production processes.

Supply chain optimization: Soft computing approaches enhance supplier chain operations by managing stock levels, forecasting demand, and optimizing transportation routes. As a result, goods and materials are delivered on schedule, stockholding expenses are decreased, and the supply chain operates more efficiently overall.

SC is a blend of fuzzy, neural, and evolutionary computing [15]. Production systems that are intelligent, flexible, and focused on people are built on the foundation of soft computing, which enables sustainability advancement, productivity increase, and creativity guarantee for many other dimensions under Industry 5.0 guidelines.

So as to enhance different aspects of them, Table 2 here explains the ways in which various Manufacturing & Production processes have adopted and utilized key enabling technologies for soft Computing in each of the Industrial Revolutions.

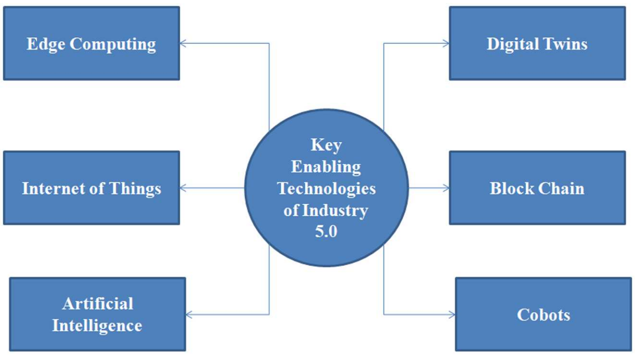
As shown in Figure 2, together, the enabling technologies propel production in the direction of Industry 5.0 and promote sustainability, effectiveness, and innovation in the digital era. Industry 5.0 is based on various technologies that are geared toward allowing human-robot collaboration, customized manufacturing, and environmentally friendly modes of production [16]. Most of these key technologies will almost always bring about shifts in innovation for many sectors. Cobots, short for collaborative robots, are used in tasks that require precision and could share workspaces with their human counterparts by taking on tasks that involve strength, speed, or accuracy.

These machines boost efficiency and productivity in manufacturing processes, resulting in a seamless connection between humans and robots [17]. An IoT technology bridges the periphery between physical devices, sensors, or any kind of equipment, and the internet monitors or even controls industrial processes from a distance. This allows us to predict a failure in a machine ahead of time through the analysis of its efficiency in production or predictive maintenance for the health of any asset through the valuable insights provided by IoT devices. Artificial intelligence and cognitive activities can be

Table 2
Revolution in the soft computing sector

S. No	Industrial revolution	Soft computing instance	Application instance
1	1.0 - Mechanization	Fuzzy Logic in Steam Engines	Fuzzy logic is used to regulate temperature and pressure in steam engines to ensure optimal performance.
2	2.0 - Large-scale manufacturing	Algorithms Generated in Assembly Lines	Using evolutionary algorithms to maximize productivity and minimize constituent travel distance when optimizing assembly line layout.
3	3.0 - Automation	In Engine Control Measures, Fuzzy Logic	I am using fuzzy logic in engine control devices (oecus) to modify air-fuel ratios and fuel injection timing in cars based on sensor inputs.
4	4.0 - Digitalization	Predictive maintenance using neural networks	Analyzing sensor data from equipment and predicting sustaining requirements in manufacturing facilities using neural networks to avoid unplanned downtime.
5	5.0 - Human-Machine Collaboration	Cooperative Robotics with Reinforcement Learning	Collaborative robotics leverages reinforcement learning to let robots benefit from human demonstrations and adapt accordingly, improving performance on tasks like assembly.

Figure 2
Essential Industry 5.0 supporting technologies



performed by machines through various approaches like deep learning, natural language processing, machine learning, and others. Large datasets are analyzed, patterns are extracted, and predictions are made using AI algorithms to improve decision-making, personalize products, and streamline production processes.

Large volumes of information generated by sensors, Internet of Things devices, and additional resources can be processed and cross-checked using big data analytics platforms to gain actionable insights, spot patterns, and inform decisions. With the help of an analytical tool, manufacturers can perform demand forecasting, quality control, and predictive maintenance, as well as optimize their supply chains, thus increasing productivity and flexibility. By utilizing blockchain technology, it is easy to develop secure, transparent, and distributed.

Industry 5.0 utilizes blockchain to build supply chains' traceability, accountability, and trust and authenticate products, hence facilitating smart contracts for the automation of transactions and agreements, among others. Edge computing, on the other hand, reduces latency, bandwidth consumption, and reliance on central cloud infrastructure as it moves data processing closer to where it is generated. Edge Computing is making real-time decisions, and launching self-contained systems. It powers low-latency apps within IoT-based production settings.

As shown in Table 3, technologies that facilitate have a critical part in a number of Industry 5.0 uses that promote creativity, effectiveness, and sustainability for contemporary manufacturing and production processes.

4. Practices and Concepts of Soft Computing in Industry 5.0

The application of soft computing principles in the 5.0 Industry allows for human-machine collaboration and aids in personalized manufacturing and sustainable production. Conversely, Industry 4.0 does not put emphasis on humans at all. Therefore, it is crucial to take into account aspects such as work-life balance, socio-technical approaches, and operator assistance technologies or human-machine cooperation [18]. This is where the Soft computing theory and practices are widely used in business.

4.1. Human-machine collaboration

Theory: SC theory emphasizes the progress of intelligent, adaptable systems that can interact with humans naturally and learn from data.

Practice: Personalized Manufacturing involves creating collaborative robots (cobots) that work next to human beings in shared spaces using SC methods like fuzzy logic, neural networks, or reinforcement learning. These types of robots can learn quickly and decide even faster, guiding safety by assisting humans with their tasks based on how people behave.

Theory: Soft computing provides opportunities for customization in production processes based on individual customers' preferences and requirements regarding manufacturing activities.

Trainings: The application of soft computing approaches like neural networks, genetic algorithms, and machine learning encompasses production line layout configuration, real-time product customization based on customer response to changes in demand, and optimization of production scheduling.

Table 3
Significance of technologies that facilitate the Industry 5.0 applications

	Enabling technologies					
Industry 5.0 Uses	Cobots	Edge computing	Digital twins	Big data	AI	Blockchain
Intelligent healthcare	Low	High	Medium	High	High	High
Cloud manufacturing	High	High	High	High	High	High
Manufacturing	High	High	High	High	High	High
Education	Low	High	Medium	Medium	Medium	Medium
Human–cyber–physical systems	High	High	High	High	High	High
Disaster management	Medium	High	Medium	High	High	Medium

4.2. Sustainable production

Theory: Soft computing helps enterprises achieve efficient resource utilization, waste reduction, and pollution abatement.

Practice: In manufacturing processes, fuzzy logic controllers, genetic algorithms, or optimization algorithms can be implemented as part of soft computing for waste, energy, and emissions management. This will lead to optimal resource utilization with respect to the ease of switching to renewable sources of energy, hence complying with the principles of circular finance.

4.3. Ethical AI and conscientious automation

Theory: According to soft computing concepts, it is important to respect ethical values when using artificial intelligence and automation technologies responsibly.

Practice: To ensure that all decisions are Clear, fairness-aware machine learning, and understandable artificial intelligence are examples of soft computing techniques used to ensure that artificial intelligence networks and automated processes are transparent, accountable, and consistent with ethical standards and societal norms. This entails addressing prejudice, bias, and unforeseen repercussions in decision-making processes and AI systems.

4.4. Flexible and adaptive manufacturing

Theory: The theory of Soft Computing emphasizes the importance of manufacturing systems' agility, adaptability, and flexibility in promptly adjusting to shifts in market demands and technological advancements.

Practice: Techniques like neural networks, fuzzy logic control, and evolutionary algorithms have made it possible to create adaptive manufacturing systems. These systems can modify production schedules, rearrange production lines, and allocate resources optimally in response to priorities or conditions that change in real time.

In Industry 5.0, critical aspects of soft computing practice and theory are aimed at creating smart adaptable human-centric fabrication systems whose efficiency, customizations sustainability, and ethics are prioritized, leading towards not only collaboration between men but robots too for purposes of innovation and economic growth.

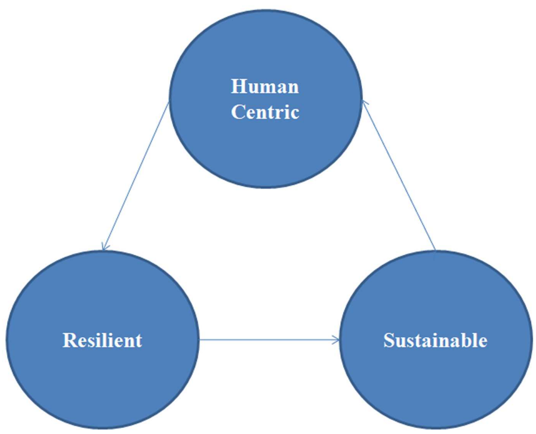
5. Advancements of Soft Computing in the Industry 5.0

Within the field of information technology, soft computing has been the subject of substantial progress, which has led to transformational changes in production and even ensured mutual work of people and machines. In Industry 5.0 applications, soft computing methods comprise the fundamental elements because they offer the ability to handle complex systems which are sometimes unclear and incomplete. It is in Industry 5.0 where we can find three basic but interconnected values: "human-centric", "sustainable", and "resilience".

Industry 5.0 has a higher priority on empowering humans by using technology to augment rather than replace human talents, as shown in Figure 3. The framework for the human-machine symbiosis is one in which humans and robots team up to create intelligent teams that can feel, think, and act as a unit in response to incoming tasks and circumstances in production [19].

It seeks to provide chances for people to make significant contributions to society and the workforce. To optimize their professionalism and work-life balance, industrial workers need to continuously improve their skills and stay in the workforce [20]. Industry 5.0 acknowledges the benefits of resilience in the face of COVID-19 outbreaks, economic downturns, and climate change. In addition, it spurs the creation of systems that are highly flexible and easily adjustable; these will be able to endure unexpected disasters at any point in time. This imminence of calamity demands the adjustment of industrial processes towards being resistant against any disturbance ensuring the provision and maintenance of vital infrastructure in moments of crisis; this sets "resilience" apart.

Figure 3
Core values of Industry 5.0



Natural catastrophes and modifications to the geopolitical landscape [20] require future companies to react swiftly. Industry 5.0 considers sustainable development to be an essential value in promoting environmentally friendly technologies and methods aimed at minimizing the environmental effects of industrialization. Sustainability is a need for the sector to honor natural limits. Reusing, recycling, and repurposing natural resources in a circular manner is necessary to reduce waste and its harmful effects on the surroundings. This will eventually lead to a circular finance that makes better and more efficient use of resources. "Resilience" refers to the requirement for industrial output to improve in order to withstand disruptions and guarantee that vital infrastructure can be supplied and maintained during emergencies. Future businesses must possess the flexibility to respond quickly to both natural calamities and shifts in the geopolitical landscape [20].

This is an in-depth analysis of how the soft computing is progressing in Industry 5.0:

In Industry 5.0, soft computing methods like swarm intelligence, fuzzy logic, neural networks, and evolutionary algorithms have been widely used to address the many problems that plague contemporary production. The incorporation of these methods into cooperative robotic systems, or cobots, is one of the major developments. These Cobots are built to work along with humans in shared workspaces, performing tasks that need adaptability, dexterity, and flexibility. Cobots can perceive human gestures, comprehend commands in a common language, and modify their behavior in response to changing environmental conditions thanks to soft computing techniques, which guarantee effective and safe human-machine cooperation.

Enhancing sustainability through product customization in Industry 5.0, besides cobots, and soft computing is vital for optimizing production processes. To maintain optimal performance, parameters including temperature, pressure, and speed are regulated with the help of fuzzy logic controllers, while other new technologies may have something different. Neural networks utilize vast quantities of sensor data so as to forecast equipment crashes, avoid downtime, and enhance maintaining schedules, which culminates in high efficiency and reduced costs. Genetic algorithms serve to fine-tune the production schedules and management of supplies supply chain logistics alongside strategic relationship management in power generation aimed at ensuring that the achievable results are optimal, even when dealing with conflicting objectives and limitations. Other key developments of soft computing in Industry 5.0 lie within the concept of customized manufacturing. Through machine learning approaches and data analysis, the manufacturer is capable of collecting all the data about customer preference, market trends, and production data in order to produce products to order. Adaptive producing systems, which may constantly modify production processes, set up production lines, and optimize resource allocation to satisfy specific client needs, are made possible by soft computing approaches. Upgrading to this extinct level of customization doesn't just make clients happier; it also saves on the expenses involved in holding inventory stocks while at the same time cutting on wastage. Consequently, it promotes eco-friendlier ways of producing goods that are more effective.

Furthermore, the ethically sound and practical application of Mechanization and artificial intelligence technologies in Industry 5.0 is facilitated by soft computing. The use of explainable AI techniques is crucial in enabling AI systems to be transparent, responsible, and reliable by exposing their decision-making processes. Selecting a process outcome is the first step in the intelligent best practices analysis [21]. Machine Learning algorithms are aware of fairness and mitigate bias and discrimination in AI models, resulting in fair results and preventing any negative repercussions. These are promoted by such steps towards ethical AIs and responsible automation, therefore creating trustful relations between machines and their human creators as well as ensuring that technologies are designed for the human good within the considerations of ethics and moral conduct.

Particularly, such development in Industry 5.0 has led to a change in the producing landscapes with soft computing, resulting in production systems that are human-centered, adaptive, and agile. Some of the areas experiencing innovations through soft computing in the Industrial Revolution 4.0 and beyond are Personalized manufacturing, cooperative robots, and moral AI [22]. The future of manufacturing with the advancement of Industry 5.0 will be led by soft computing, redefining the relationship between humans and machines in the digital age.

As shown in Table 4, in the previous industrial revolution, Industry 4.0 was able to make a background for smart production and optimization by adopting artificial intelligence-like functions, enabling soft computing technologies, while Industry 5.0 is differentiated by their high-level development that makes possible more complex man-machine interaction by application of various techniques and tools, such as personalized manufacturing or sustainable production [23] practices that embrace ethics. It is soft computing that continues to shape the industrial sector's future in the digital age, vital to modern manufacturing's sustainability, efficiency, and creativity.

6. Soft Computing in Society

Soft computing is transforming society through its ability to offer flexible and intelligent solutions to address different types of problems. For example, it is used in diagnosing diseases and planning how they should be treated when it comes to healthcare; enhancing prediction methods coupled with managing risks within the finance sector; optimizing movement of cars by way of traffic management systems and unmanned vehicles in case transport sector: promoting effectiveness and environmental friendliness of various energy sources provided especially by those renewable ones alongside this it advocates for efficiency as far as production is concerned where both cost control measures require tailor-made approaches on how best they can get their products through. Often referred to as ethical AI, Soft Computing establishes such humane characteristics as honesty and openness. In addition, it permits individual learning in school settings and is essential in surveillance of the habitat. In summary, it is a revolution in our daily lives that is realized through new creations, better understanding when compared to other forms of artificial intelligence, and scoping for societal challenges which may lack permanent solutions if the initial system does not adapt continuously.

6.1. Future of soft computing in Industry 5.0

Recent studies suggest that process control systems based on swarm intelligence, models or regulations having intricate structures, networks of systems with smart agents playing wide roles, perception-based simulation, and composite systems may well be key directions of future developments in soft computing technology [7]. With its innovative approach, Industry 5.0 will contribute to the resolution of the manufacturing-social need mismatch issue

Table 4
The progress of soft computing in Industry 4.0 vs Industry 5.0

Progress	Industry 4.0	Industry 5.0
Collaborative robotics	Collaborative robots (Collaborative robots) have begun to emerge, but the human-robot corporation is still in the beginning stages.	Advanced soft computing methods facilitate interaction between people and collaborative robots, which are sophisticated today and can change their behavior slowly while remaining safe.
Production process optimization	Fuzzy logic, neural networks, and genetic algorithms are soft computing techniques used to optimize production processes.	There are soft computing algorithms that Permit optimization and adaptation in real-time of production processes to ensure efficiency and quality in dynamic manufacturing environments.
Predictive maintenance	Analyzing sensor data and predicting equipment failures, soft computing enables predictive maintenance.	With the aid of soft computing methods such as reinforcement learning and profound learning, predictive maintenance becomes not just proactive and precise but also achieves improved reliability with increased levels of accuracy in the prediction mechanism.
Customized manufacturing	Soft computing allows for customized manufacturing by using adaptive manufacturing systems and personalization algorithms.	Soft computing technology is enabling massive product customizations in the production of goods, allowing real-time customization and self-product manufacturing.
Ethical and responsible AI	Contribute to ethical AI by making explainable Artificial Intelligence (AI) and fairness-alert machine learning algorithms the issue of soft computing.	AI is made ethical, and automation is made responsible; therefore, there should be transparency, accountability, and fairness in AI decision-making systems and machines.
Sustainability and resource optimization	Soft computing furthers sustainability by enhancing energy management while curbing wastage and reducing emissions.	Even further initiatives in sustainability may be taken using soft computational resources and video monitoring systems in combination with high optimization levels.
Real-time decision-making	Soft computing assists in making real-time decisions by analyzing and processing data from multiple resources.	In rapid manufacturing ecosystems, fuzzy logic approaches influence instantaneous judgment adaptability and responsiveness through an understanding of manufacturing process interfaces, supply network dynamics as well as buyer predilections.
Human-centric design	Soft computing facilitates better human-machine interaction as well as cooperation, which improves human-centric design.	In Industry 5.0, soft computing has been used to allow for natural language processing, which has enabled augmented reality or virtual reality that enhances human collaboration with machines while enabling workers to be empowered through this collaboration approach as a result of being designed based on human-centricity.

[24]. Models based on the principles of manufacturing planning could be replaced by more general logistic models that would define interrelations between logistical and other processes from supply chain management through production to product delivery.

As shown in Figure 4, the technology of quantum computing uses quantum states together for computing, for example, interference. Entanglement and with quantum computers, we execute quantum calculations. It performs calculations that rely on the potential state of the Instance before measurement. This is referred to as human-machine interaction, where machineries interact with humans through a user interface. Gesture-based natural user interfaces are used to catch the attention of people because they allow human beings to make utilize of machines based on natural and instinctive behaviors. It is the direction that Industry 5.0 is expected to take because it will still be human beings at its core as a system, and this allows for the introduction of new technologies even further than what we already have. The interface itself may provide further insights into why individuals behave as they do.

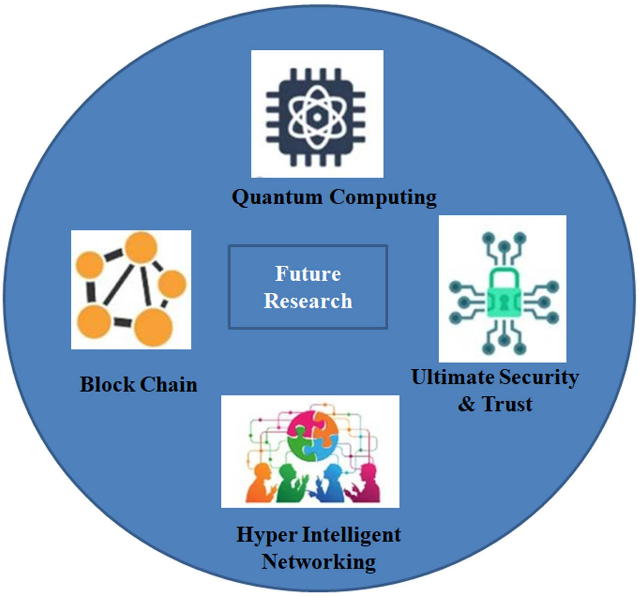
6.1.1. Human-centric solutions

The Industry 5.0 human-oriented solutions humanize workers and prioritize their well-being, safety, and empowerment while at the same time utilizing sophisticated technologies for productivity, efficiency, and innovation improvements. Industry 5.0 is the new approach of approaching industrial production with profitable, economic, and financial impacts, not just a trend [25]. In Industry 5.0, some examples of human-focused solutions are presented in this:

Collaborative Robotics (COBOTS): Industry 5.0 puts back built-in human and robots' cooperation where COBOTS collaborate with human workers in the same workspace. COBOTS have been installed with sensors and soft computing techniques, enabling safe and intuitive human interaction. They facilitate repetitive or dangerous tasks, serving as an advantage to the employees because they increase productivity and reduce ergonomic pressure.

Personalized work environments: Industry 5.0 makes custom-made workplaces that meet each person's lifestyle and requirements through using IOT sensors and soft computing algorithms. Workers feeling good while working has led to increased productivity. Some like natural light, while others may opt for something dimmer than the traditional LED lights. Add Transient pleasure-seeking urge shall never be satisfied by such means because this pursues pleasure contradictorily as it combines something deadly serious

Figure 4
Prospective studies on Industry 5.0



with irresponsibility and self-indulgence, otherwise known as man's delusion. Comfortable offices make employees more productive.

Safety and preventative maintenance: In Industry 5.0, safety management and predictive maintenance are handled through the application of soft computing-based techniques like machine learning and predictive analytics. Failure forecasting systems based on these solutions analyze equipment sensor data and indicate potential failures before they start, minimizing equipment downtimes and enhancing worker safety.

Augmented Reality (AR) for Training and Assistance: For example, staff now depend extensively on AR technologies in Industry 5.0, where head-mounted displays enable them to see digital information, instructions, or annotations that speed up the learning period, producing more productive outcomes with instant support during complex processes.

Natural language interfaces: Interfaces like Interfaces for Natural Processing (NLP) and Industry 5.0 make it possible for humans to communicate with systems and machines in the best possible natural way. Alternative soft computational methods, chatbots (rule-based bots or artificial intelligence that results in talking like humans) and voice-activated controls can provide staff-free ways of interacting with digital assistants so as to enhance performance in terms of information searching, incident reporting, or seeking help when required during emergencies thereby promoting higher working efficiency complemented by safety.

Here's how Industry 5.0 explains these aspects: AI ethics and decision-making. Soft computing techniques help make AI systems explicit, accountable, and fair so that employees can do it. There are times when they need to challenge them due to job security or potential loss of it. Empowering to significant effect on decision-making through employee feedback and participation

The advent of the Industry 5.0 platform allows workers to express their thoughts and take part in the decision-making process. Through the application of Soft Computing mechanisms, we are able to get information about what is taking place at ground level and analyze it in a similar manner; therefore, workers offer suggestions and identify issues that are part of ongoing improvement projects, leading to cooperative work environments and encouragement.

The human-centered remedies in Industry 5.0 demonstrate the shift towards a more worker-centric, worker-encouraging, and inclusive method of technology adoption that uses cutting-edge technologies to ensure safety and well-being, augment human skills, and guarantee safety. This indicates that Industry 5.0, which blends more broadly with Industry 4.0, represents a very different kind of viewpoint. This shows how important research and innovation are to maintaining an industry's extended services. It provides regenerative goals and direction for the technological advancement of industrial output while taking humanity and people-planet prosperity into consideration.

The human-centric technique [26] replaces technical advancement-driven manufacturing using a method that is both society- and human-centric, placing fundamental human goals and aspirations at its center. Employees in the sector will subsequently be expected to assume new roles as a consequence of the shift in value from viewing personnel as a "cost" to an "investment". Industrial technology should be adaptable and capable of meeting the diverse demands and needs of its workforce since technology is meant to serve society and its members. It is vital to provide a safe, friendly work environment that prioritizes the physical, mental, and overall wellness of employees in addition to their fundamental rights to privacy, independence, and human dignity. For industrial workers to have a better chance of landing a good job and keeping a work-life balance, they must constantly retrain and enhance their skills. The following are some advantages of human-centric solutions in Industry 5.0:

More productivity: The collaboration between humans and intelligent systems results in enhanced efficiency, which is a powerful tool for boosting productivity. Fewer downtimes, fewer mistakes, etc., make it all seamless. Also, better workflows and task management systems make processes easier, leading to more productivity and general performance improvement.

Improved safety: The application of advanced safety standards and monitoring systems is vital in accident prevention efforts. Therefore, collaborative robots and automated processes significantly remove risks from working sites. Moreover, real-time hazard detection and warning systems further improve workplace safety by providing timely notifications or alerts that help combat possible threats.

Better Satisfaction of Users In adaptive AI technologies that consider unique tastes/preferences/personalized services are delivered to each person. A user-friendly interface, therefore, increases the chances of a better experience from their usage while Human-Computer Interfaces remain active in delivering high-quality experiences worth sharing about technology with humans therein plus its relation with customer service operations across different domains today enabled by artificial intelligence (AI).

Adaptable and flexible: This allows them to produce more individualized products in quicker times due to their ability to rapidly switch from one type of production requirement to another. Besides, this flexibility also means that such producers can effectively meet the demands of the consumers while keeping their clients satisfied, which include fastener manufacturing companies currently prevailing within the market trends.

More informed decisions: Predictive analysis and data-driven insights significantly improve decision-making. Informed problem-solving is achieved by using real-time data collection and feedback loops, which facilitate the organization of problems as they emerge and the identification of solutions at that specific time. When we proactively manage this flow, we are able to make higher-quality decisions based on current and pertinent information.

Lower operating costs: Better resource allocation by various business units results in lower operating costs. Energy-efficient machines use less energy and produce less trash because they operate with less power consumption, promoting sustainable development.

Table 5
Industry 5.0's impact level and advantages of human-centered solutions

Benefits	Percentage of impact level
Higher flexibility and adaptability	60%
Reduced operational costs	65%
Improved user satisfaction	70%
Better decision-making	75%
Enhanced safety	80%
Increased productivity	90%

The above Table 5 provides a concise overview of the benefits and uses of human-centric solution in Industry 5.0 [27].

Above is Figure 5 which illustrates the various advantages of human-centric remedies in Industry 5.0.

6.1.2. Challenges

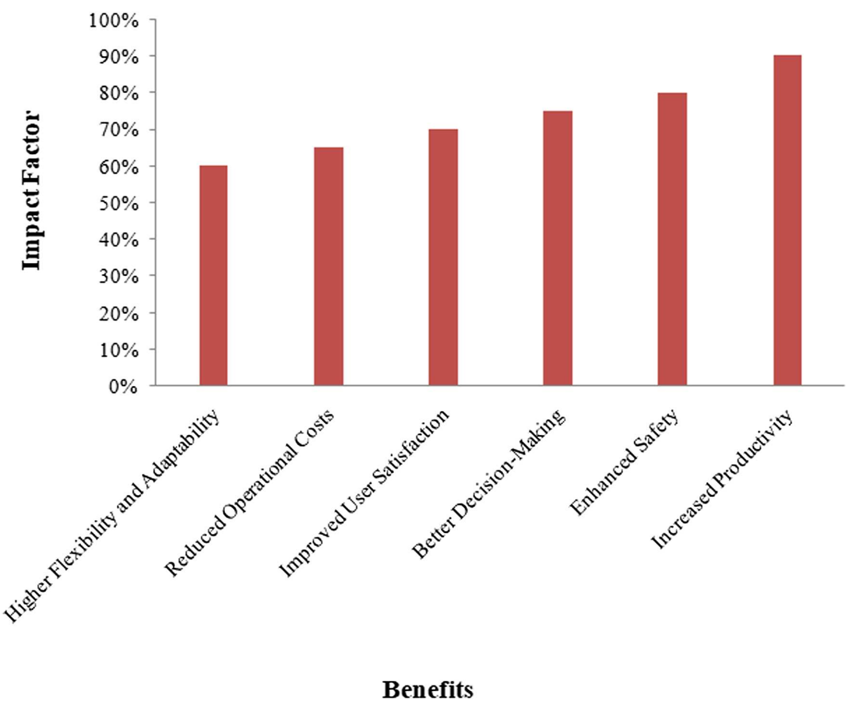
Among the concerns not previously seen in Industry 5.0 are social diversity, the evaluation of how ecological and social values are developing, how SMEs and customers are integrated across whole value chains, and how complex systems are. A summary of Industry 5.0's goals is provided in Sharma et al. [26], which addresses a number of research issues. Furthermore, the interdisciplinary nature of research disciplines necessitates flexible, outcome-driven innovation policies that are ecosystem-focused and demand large investments in addition to productivity. The technical and industrial world is full of difficulties that call for stability, adaptation, and readiness [28]. Here are some particular problems with Industry 5.0, along with examples:

Technology interoperability: Because these are hard problems with different standards, integrating various modern approaches like robotics, AI, and the Internet of Things into the current systems can be difficult. For example, connecting IOT sensors from many vendors may be difficult for a manufacturing facility, leading to data silos and inefficiencies in data exchange and analysis.

Security and confidentiality of data: Through networked devices and sensors, the fifth industry generates massive volumes of data, causing issues as regards security and confidentiality thereof. For example, a smart plant that integrates prognostic maintenance through sensor inputs should take all necessary measures to prevent Cyber Attacks on sensitive operational details meant for proper functioning from getting into unauthorized hands.

Workforce skills gap: Although companies are able to see the benefits they would gain in their quest for a high-quality workforce with digital skills, enabling their employees to acquire these advanced skills remains an uphill task. An example of how difficult it can be for a company to upgrade its staff is a car assembly factory that wants to integrate some aspects of Industry 5.0 such as robotics and automation, into its operation system yet at the same time find it hard

Figure 5
Benefits of human-centric solutions in Industry 5.0



to allow those who would be working on these machines learn how they work including basic programming and machine maintenance skills.

Use of AI ethically: In Industry 5.0, organizations face moral issues such as algorithmic bias, fairness, and accountability when implementing AI. An online shopping platform that has to exercise utmost care in making sure that its AI system, which proposes products, does not lead to any type of discrimination or violate the privacy rights of its clients.

Change management: Employees and other interested parties resist traditional manufacturing companies when they change their strategies to improve performance and become more advanced versions of themselves. For example, a classic manufacturing company looking to transform from a conventional model into an intelligent factory might find it hard to convince its workforce to adopt new technologies and processes.

Infrastructure investment: For example, a logistics company deploying real-time tracking and optimization systems might need to expand its IT infrastructure to handle the increased demands for data processing and storage. Industry 5.0 will necessitate investments in digital infrastructure, including cloud computing, Internet of Things networks, and data analysis platforms.

Environmental sustainability: Although Industry 5.0 offers to increase efficiency and optimize resources, its impact on the environment is causing concern [29]. It is always important to take into account the effects that a 3D printing capability that converts to technology for additive manufacturing would have on the environment in terms of waste generated and resources consumed during production.

To overcome these challenges, organizations need to combine technical innovation, cooperation, regulatory compliance, and change management in businesses with stakeholders. When we overcome these challenges, it becomes possible for businesses to achieve the full potential of Industry 5.0 by enhancing environmental friendliness, increasing output, and coming up with new ideas in the production area.

To thrive, Industry 4.0 and Industry 5.0 will need a large amount of support from government agencies. Whatever course the industry takes, the guiding concepts of sector 5.0—Resilience, sustainable development, and human-centric have become important drivers of societal advancement rather than outcomes of GDP-driven economic expansion. The Quality of Life of the Next Generation Act, the Paris Agreement, the Sustainable Development Goals of the United Nations (SDGs), the Actual Progress Indicator 2.0, The Economy of Wellness, the National Performance Structure, and the OECD Better Life Index are a few examples of recent government initiatives to incorporate them into national policies.

6.1.3. Prospective research areas

Because they must be addressed, investigating Industry 5.0 is crucial for dealing with recent challenges in the sector and gaining the most from the latest production technologies and human-centered designs. It has been found that industries give priority to economic rather than social or environmental sustainability, as indicated by a study conducted in some manufacturing companies; hence, it is essential to implement the technology of Industry 5.0 [30]. Below are some of the prospective fields of study in the Industry 5.0:

Human-machine interaction: We will explore how Industry 5.0 can benefit from the application of virtual reality, augmented reality (VR), and natural language processing (NLP) to enhance user experience, collaboration, and usability by linking people with machines in new ways. This will lead to predictive maintenance and reliability improvements using machine learning data analysis and IOT sensors, which will lead to more efficient asset management.

Ethical AI and responsible automation: Automated systems should incorporate trust, responsibility, and ethical decision-making into their designs. The research question being addressed here is what different approaches may be employed in constructing ethical artificial intelligence (AI) frameworks, fairness-based algorithms, and transparency solutions.

Sustainability and circular economy: In Industry 5.0, the focus is on sustainable manufacturing practices, techniques for optimizing resource utilization, and the concepts of the circular economy to lessen waste production, protect the environment, and increase the rate of resource utilization.

Cyber-physical security: This is achieved through cyber-physical systems (CPSs), which are used in market chains, commercial systems, and smart manufacturing plants to reduce hazards and protect essential infrastructures against cyber threats.

Advanced materials and additive manufacturing: Industry 5.0 uses include manufacturing by additives (3D printing), fast prototyping, on-demand production, and customization. These are assessed by investigating new materials, techniques, and design methods.

The growth of Industry 5.0 has been significant in the application of the digital twin technology for enabling production processes, instruments, and end products to be modeled, virtually simulated, and optimized, thus improving productivity, quality, and innovation. Supply Chain Optimization: This study describes how Industry 5.0's AI, blockchain, and Internet of Things (IoT) devices boost and improve supply chain visibility, prevent disruptions, and coordinate them more effectively through resilience, agility, and optimization. Human-Centered Design and Ergonomics: We investigate worker-centric technologies, occupational safety regulations, and ergonomic design principles to maximize employee comfort, health, and productivity in different sectors or industries like Industry 5.0.

Regulatory compliance and standards: In Industry 5.0 deployments, it is crucial to study how industries meet laws through compliance standards and quality certification processes.

Decision Support Systems and Data Analytics Industry 5.0 environments use platforms for real-time data analysis decision support systems and improved data analytics methodologies to extract essential features, optimize operations, and make decisions based on data.

Smart cities and urban manufacturing: The goal of this research is to establish a connection between Industry 5.0 technologies and smart city projects to aid in the development of the urban manufacturing industry, ecologically sustainable development, and future urban survival structures.

To name a few industry-enabling technologies, some researchers have integrated the most recent developments in a variety of fields, including bionic devices, artificial biotechnology, genetic engineering, quantum computation, nanotechnology, smart regeneration materials, and brain-computer interfaces. 5.0 [31–34].

7. Case Study

Case study: House automation using gentle computing applications

Company: Honeywell International Inc.

Honeywell, a world leader in home automation and control systems, employs soft computing applications to improve its smart home solutions. Using fuzzy logic, neuro networks, and machine learning technologies, Honeywell has created advanced systems that manage residential environments more efficiently and intuitively.

7.1. Objectives

1) Optimizing energy consumption while increasing comfort levels in households
2) Improving accuracy and adaptability in home automation systems
3) Creating an easy-to-use interface that is also appealing to homeowners

7.2. Technologies used

Fuzzy logic: For running away from imprecise inputs and making more humanity-like decisions.

Artificial Neural Networks (ANNs): For remembering things and forecasting future actions.

Machine learning (ML): For forever-enhancing and tailoring system reactions.

Internet of Things (IoT): For linking and taking charge of assorted smart home gadgets.

7.3. Implementation

7.3.1. Smart thermostat control

Learning algorithms: Honeywell smart thermostats learn their users' daily routines and temperature preferences through ANNs. Consequently, the system alters the heating and cooling patterns over time according to those users' choices, thus enhancing effective energy consumption.

Fuzzy logic control: The thermostat employs fuzzy logic to manage temperature settings more accurately. It takes into account things like external temperature, time of day, and who is at home or not, making subtle adjustments that traditional thermostats cannot make.

Remote access and automation: Users can control their thermostats from a distance using the Honeywell application. In addition to setting up schedules by hand, the thermostat will also automate itself through geofencing, switching on energy-saving modes when no one is inside the house.

7.3.2. Home security and surveillance

Adaptive security systems have been integrated into Honeywell devices, which utilize machine learning to separate what's normal from abnormal, such as distinguishing between a pet and a burglar. For instance, it can ignore the movements of pets while alerting the owner immediately when there is danger.

Other devices: This security system is compatible with other smart home appliances, such as door locks and lighting. For example, if there is any strange activity within the vicinity of the house, all the lights can be switched on automatically, and even all doors can be locked.

Real-time monitoring and alerts: Users can receive real-time alerts through the Honeywell app to monitor their home's security. Image recognition based on ANNs reduces the chances of false alarms.

7.3.3. Energy administration

It provides sophisticated systems that employ smart meters and monitors to measure the usage of energy in real time for things like gas, water, and electricity. This framework employs machine learning techniques for analyzing utilization trends with the aim of giving recommendations for reducing energy consumption. Automatic Energy Saving: The system is actually capable of switching off the non-essential machines when they are not in use, e.g., lights in empty spaces or HVAC equipment when they are opened. Consumption Reports and Insights: The Honeywell app provides users with detailed information about their energy consumption, enabling them to recognize areas requiring improvement as well as to know their usage patterns.

7.4. Benefits

Reduced energy costs: Honeywell's smart home system reduces energy usage by adjusting heating, cooling, and appliance operation according to user habits and ambient situations.

Increased comfort and convenience: Soft computing techniques allow homeowners to control home settings better, increasing their general comfort level.

Enhanced protection against burglars: An effective home burglar alarm system that detects movement inside the house increases home safety by sending accurate alerts to the homeowners promptly, decreasing cases of false alarms in the process.

Easy for everyone to use: With little human involvement in operation, this system learns something new every day about its owner hence able to adjust itself to their taste or preference.

8. Conclusion

In conclusion, human potential and the course of civilization or community is to develop solutions for people's problems and/or consider future areas of study are likely key aims of advancing soft computing within it. For instance, these include Artificial intelligence (AI), machine learning (ML), and natural language processing (NLP). AI-based technologies such as sentiment analysis or collaborative robots have been identified as potential game changers in facilitating faster decision-making when addressing issues affecting humans without putting them at risk of harm from other people or even themselves. The inculcation of soft computing into society is seemingly intuitive, yet it also presents quite a few problems that need to be urgently addressed. These are problems we have termed challenges; this is in regard to problems of security, privacy, and workforce competencies deficits, ethical issues involved in the deployment of AI, Infrastructure investment, sustainability in the environment, and change management in organizational contexts. It is necessary to overcome those obstacles in such a way that we all act together, with politicians taking part among many others working together, such as industry captains and experts, etc. The general population, too, needs to be involved if we want to incorporate soft computing technologies responsibly and fairly into our everyday lives as stakeholders as a whole. There are many possible fields of future exploration into this field, like human-practical relations between men and machines, forecasted maintenance's regularity, supply chain improvement, advanced materials, and additive manufacturing, digital twin technology, sustainability, and circular economy, human-centered design and ergonomics, ethical AI and responsible automation, cyber-physical security, and data analytics and decision support systems. Developing novel solutions, fostering a more inclusive, long-lasting, and resilient community, and reacting to changes that affect society may be possible if experts concentrate on specified research fields. In a nutshell, it is envisaged that human-centered solutions will characterize the future of soft computing in communities, with problems to be dealt with and exciting research areas to be ventured into. By working together, being creative, innovative, and using soft computing technologies responsibly, we have the ability to transform lives, give people more power, and influence the world for the better.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Author Contribution Statement

Kishor Kumar Reddy Chinthala: Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing, Visualization. **Monika Singh Thakur:** Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing, Visualization. **Mohammed Shuaib:** Software, Validation, Formal analysis, Resources, Writing – review & editing, Visualization, Supervision, Project administration. **Shadab Alam:** Software, Validation, Formal analysis, Resources, Writing – review & editing, Visualization, Supervision, Project administration.

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