INDUSTRY 5.0:

Bridging Humanity and Technology for a Sustainable Future

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Industry 5.0: Bridging Humanity and Technology for a Sustainable Future

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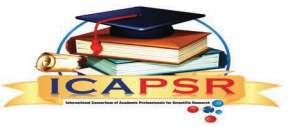

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Foreword

We stand at the threshold of a transformative era, an industrial revolution unlike any before. **Industry 5.0: Bridging Humanity and Technology for a Sustainable Future** is not just about technological progress; it is about placing humanity at the heart of innovation. It is our opportunity to reclaim what we missed during past revolutions and leap into a future where artificial intelligence, the metaverse, and quantum computing harmonize with human creativity, ethics, and sustainability.

The book, captures this pivotal moment with remarkable insight. It reminds us that, as Prime Minister Shri Narendra Modiji declared, "Yahi samay hai, sahi samay hai" - this is our moment, the right moment. With India's youthful energy and vast demographic dividend, we are uniquely poised to lead this shift, blending ancient wisdom with cutting-edge innovation.

Throughout history, the concept of *panch tatva* (the five elements) has symbolized balance and interconnectedness. Today, Industry 5.0 mirrors this philosophy, integrating technology, sustainability, human values, policy, and resilience, much like the *panch pyaare* embodying service and unity. The chapters in this book explore how collaborative robots (cobots), digital twins, and intelligent supply chains can coexist with environmental consciousness and ethical governance.

I believe Uttarakhand, with its rich cultural heritage, spiritual depth, and vibrant youth, can be a guiding force of this new era. Our state, nestled in the lap of the Himalayas, embodies the cosmic dance of tradition and progress - a perfect testament to the confluence of heritage and innovation.

I commend the authors for crafting a work that not only explains technological advancements but also envisions a future where industries empower people, bring forth sustainable development, and elevate societal well-being. My compliments to Uttaranchal University for capturing the moment and bringing this to fruition. Amidst discussions over 12 intense meetings with me, this book is a guiding light for policymakers, industry leaders, and young innovators alike, illustrating how we can achieve global leadership through Industry 5.0.

Let us embrace the cosmos of possibilities, ensuring that technological evolution uplifts humanity and preserves the planet for generations to come.

Industry 5.0 will play an integral role in India's vision of Viksit Bharat @2047. It is a culmination of dep rooted commitment, that has risen strategically from lab to land, and will be beneficial in providing valuable insights into our country's growth story. It is an honour to introduce this visionary work to the world.

Jai Hind.

Lt Gen Gurmit Singh

Preface

The inspiration for this book **"Industry 5.0: Bridging Humanity and Technology for a Sustainable Future"** came from the Hon'ble Governor of Uttarakhand **Lt Gen Gurmit Singh, PVSM, UYSM, AVSM, VSM (Retd).** He is committed to promote research, innovation, and knowledge exchange that can further contribute to the development of the state and nation. His "One University One Research" initiative is an innovative step for enabling Universities to conduct important research that not only enhances academics but also directly benefits society.

Under the program, Uttaranchal University took this opportunity to move forward with "Industry 4.0 and Sustainable Development". During various meetings, Hon'ble Governor encouraged us to take the outcomes to the next level by sharing the facts with community of academics, policy makers, economists, political leaders, technocrats etc and make them aware about futuristic technological advancements.

With this motivation the authors decided to write a book on Industry 5.0, to promote economic expansion, improve technological advancements and solve ethical issues. We are certain that initiatives will help to build a more promising and sustainable future for our country.

The world stands at the precipice of a new industrial revolution. We are entering Industry 5.0, a new era that builds on the foundations established by its predecessors but places a greater emphasis on the integration of human intelligence, sustainability, and collaboration. Examining how innovative technologies like the Industrial Internet of Things (IIoT), Artificial Intelligence (AI), Extended Reality (XR), and Quantum Computing are revolutionising industries globally, "The Evolution Continues" dives into this shift.

This book offers a vision for the future, one in which Industry changes to become more responsive, networked, and environmentally sensitive. The synergy between human knowledge and machine capabilities is at the core of Industry 5.0, promoting a degree of cooperation that guarantees improved results, increased production, and the development of environmentally friendly, sustainable solutions.

This book also discusses some of the most important issues and prospects that may arise in the future, such as cybersecurity, cobots' role in human-machine collaboration, and the critical role that edge computing and 5G will play in guaranteeing instantaneous connectivity throughout industrial ecosystems.

It integrates the technological, strategic, and human aspects of this revolution as it examines areas with an eye towards the future. It is an exhortation to innovators, educators, technologists, and leaders in the industry to seize the opportunities.

Industry 5.0 will be influencing the future with cybersecurity and the Industrial Internet of Things (IIoT), digital twins, metaverse, quantum computing, and sustainable manufacturing, each chapter explores a crucial facet of this shift.

Industry 5.0's effects extend beyond the manufacturing floor. It permeates supply chains, education, defence, and even human augmentation, promoting an industrial environment that is

human-centric, where employees are empowered, decision-making is improved, and sustainability is taken on the top priority.

This book seeks to promote inventions and provide tactical frameworks for integrating technology and humans in a way that benefits organisations, communities, and the environment. Let's welcome technology as we enter this new industrial era, not as a disruptive force but as a means of empowerment, sustainability, and collective advancement.

Prof. (Dr.) Dharam Buddhi
Prof. (Dr.) Rajesh Singh
Prof. (Dr.) Anita Gehlot

Acknowledgment

The book "Industry 5.0: Bridging Humanity and Technology for a Sustainable Future" explores the emerging technologies and combines the strategic, technological, and human facets of the Industrial Revolution.

Firstly, we are deeply grateful to God for His blessings and showing the pathway for providing the insights. A special thanks to Hon'ble Governor of Uttarakhand Lt Gen Gurmit Singh, PVSM, UYSM, AVSM, VSM (Retd), whose expert guidance, and constructive feedback turned this manuscript into something much stronger and more meaningful.

The book is an exhortation to action for industry leaders, educators, technologists, and innovators to take advantage of the potential. With cybersecurity, the Industrial Internet of Things (IIoT), digital twins, the metaverse, quantum computing, and sustainable manufacturing, Industry 5.0 will have a significant impact on the future. Each chapter examines a key aspect of this change.

We would like to extend our heartfelt gratitude to all the individuals who have supported us throughout the journey of writing this book. Without their encouragement, insight, and love, this book would not have come to fruition.

We are thankful to President - Uttaranchal University Sh. Jitendra Joshi ji, Vice President- Ms. Ankita Joshi and Executive Director- Students Affairs & IT - Dr. Abhishek Joshi for their support and motivation to complete the book.

We extend our thanks to publisher "Wisdom Leaf Press" for the support and publication assistance.

To our family, friends and colleagues who offered their thoughts, suggestions, and encouragement, we thank you for your time and your unwavering belief in us. Your perspectives enriched this work in ways we could never have imagined. Without the assistance of numerous resources, this book would not have been able to complete.

Finally, to our readers—thank you for choosing to spend your time with this book.

Prof. (Dr.) Dharam Buddhi
Prof. (Dr.) Rajesh Singh
Prof. (Dr.) Anita Gehlot

Industry 5.0: Bridging Humanity and Technology for a Sustainable Future

Contents

Chapter 1

THE EVOLUTION CONTINUES: TRANSITIONING TO INDUSTRY 5.0

The transition to Industry 5.0 embodies a massive leap in the evolution of industries, shifting focus from automation and digitization to a more human-centered, sustainable, and resilient framework in manufacturing. Artificial Intelligence (AI), the Internet of Things (IoT), big data analytics, and cyber-physical systems integrated into traditional modes of production during Industry 4.0 and revolutionized it. However, it focused on achieving efficiency and automation, often reducing the role of a human being in the industry.

Industry 5.0 serves as a counterbalance to these shortcomings by re-injecting human creativity, well-being, and ecological restoration as important constituents of industrial development. It promotes the partnership between a human being and smart technologies, incorporating robotics, AI, and quantum computing working unitedly with the human mind in the form of flexible and adaptive manufacturing systems. Industry 5.0 serves to not only enhance operational efficacy, but also emphasize ethical AI, sustainable production, and welfare of society.

The shift from Industry 1.0 to 5.0, capturing critical technological and philosophical changes. It also focuses on risks associated with this change such as cybersecurity, integration, and ethical issues. Furthermore, it analyses how Industry 5.0 using quantum computing and AI automation enables innovation across different industries like healthcare, manufacturing, logistics, and smart cities.

Now, as industries prepare for the epic scale-up of Industry 5.0, firms need to focus on how to optimize human and machine inputs. The interdisciplinary collaboration among scientists, industries, and regulators to achieve a sustainable and smart industrial ecosystem. By promoting human and machine integration in Industry 5.0, technology can be fully utilized while addressing ethical, environmental, and social concerns.

1.1 Industrial Evolution

There have been multiple changes in the industrial world that have altered business operations, product manufacturing, and distribution. These changes stem from the advancement of technology, the adoption of intelligent systems, and the changing nature of work. The most recent industrial paradigm, Industry 4.0, introduced the use of automation, data transfer, cyber-physical systems, and artificial intelligence (AI) which drastically improved productivity. Industry 4.0 improved manufacturing and logistics, but the approach was very mechanized and digitized, which sidelined people and sustainability. People losing their jobs, ethical AI decision-making, and the damage high-energy industrial activities cause the environment are some concerns that resulted due to this method.

With the integration of human creativity, adaptability, and advanced technology, the next phase of evolution, revolution 5.0, aims to be sustainable and human-centric. Industry 5.0 is focused on creating resilient industrial ecosystems where humans and intelligent systems synergistically work

together unlike its predecessor. This transition is driven by the increasing obligation for ethical AI, sustainable production processes, and efficiency oriented personalized manufacturing that is socially and environmentally responsible.

The focus on the collaborative effort between humans and machinery is a distinctive feature of industry 5.0. Rather than focusing on replacing human workers with automated systems, revolution 5.0 in turn seeks to augment human abilities by embedding robotics, AI, and even quantum computing into industrial processes. Businesses are now able to capitalize on advanced computational power while retaining human innovative decision making and problem solving at the heart of the operations. Harnessing technologies such as collaborative robots, digital twins, and quantum computing boosted AI models will dramatically increase the adaptability and intelligence of industrial environments.

In addition, Industry 5.0 makes sure everything is aligned to the key concepts of sustainability and resilience. There is greater emphasis on environmental protection and energy conservation, prompting industries to use better technologies, manage resources more efficiently, and lower carbon emissions. Most have started adopting Circular economy practices that ensure low waste and high efficiency in material recovery during the manufacturing processes. This is fundamentally different from the Industry 4.0 attitude, which sought maximum efficiency and profit at the expense of environmentally sustainable practices.

The progress from Industry 4.0 to Industry 5.0 poses issues as well as advantages. Innovations such as AI and machine learning come at the cost of requiring greater investments. Companies will also need to be willing to put in the effort to rethink their business processes for a smoother integration of humans and machines. On the other hand, industries would benefit from improved technological innovation, increased employee engagement, and heightened operational agility. Of equal significance, cybersecurity is a multifaceted issue that must be addressed due to the implication of AI and IOT in data privacy and protection within Industry 5.0. Cybersecurity uses quantum computing to provide new solutions for safeguarding sensitive industrial information, using drastic new encryption techniques which are effective. It analyzes how quantum computing, AI, and IoT can be incorporated to build socially responsible and safe industrial systems, as well as the practical barriers that must be addressed for smooth implementation. Through the application of human-machine collaboration, Industry 5.0 will be able to achieve a world of technological growth, that is ethical, environmentally conscious, and socially responsible.

1.2 Key Differences between Industry 4.0 and Industry 5.0

The move from Industry 4.0 to Industry 5.0 is a remarkable change in the industrial landscape with a new definition of automation, Artificial Intelligence (AI) and Human-Machine Interface (HMI) collaboration. While Industry 4.0 was concerned with automation, remote decision making, and the interconnection of industries through the IoT, Industry 5.0 reconditions human-centric approaches by ensuring a proper synergy between intelligent systems and human imagination. This transition is brought about by the increasing understanding that although automation is effective, it is far from being adaptable, ethical and creative as human beings.

One of the key differences between the two paradigms lies in the contributions of human employees. Industry 4.0 sought to reduce the level of human participation by introducing smart machines, robots, and AI-based decision systems that worked independently. Factories and supply chains became more efficient and cost-effective as a result of predictive maintenance, real-time data analytics, and robotic automation. But there were also concerns around the loss of

employment, ethical concerns regarding AI-based decision making, and the systems inability to adapt to complicated and omnidirectional scenarios. These issues are mitigated in Industry 5.0 by guaranteeing that automation complements human capabilities rather than supplants them. Cobots and AI assistants are built to engage with human operators, which permits greater personalization, agility, and creativity in the production processes.

A further crucial difference lies in sustainable focus and ethically-friendly manufacturing. Industry 4.0 placed emphasis on efficiency, productivity, and profitability, often to the detriment of environmental concerns. These practices, along with their high energy consumption, resource depletion, and industrial waste, became demanding global issues that pushed the world to adopt greener industrial practices. Transitioning to Industry 5.0, the model becomes more sustainable by incorporating circular economy principles, alternative energy sources, and green production methods. AI-powered resource management systems reduce energy consumption, while digital twins allow the environmental consequences of a process to be monitored in real time to ensure responsible production.

Ethical aspects and social values are just as important in Industry 5.0. While Technology proved to be the pillar of support for Industry 4.0, its 5 counterpart makes sure that technological progress is in sync with societal progress. This encompasses the area of AI systems which need human supervision in deep and sensitive areas of decision making whereby humans need to trust the system. Ethical AI approaches are adopted to protect biases in the decision making process; to ensure that workers and consumers are treated fairly. Moreover, human wellbeing is advanced through safer, more flexible working conditions and lower levels of stress and higher levels of job satisfaction.

The distinct features of Industry 5.0 emerges and sets it apart from its predecessor through customization & personalization. Industry 4.0 aimed to achieve efficiency through mass production and other standardized means. Unfortunately, modern society shifted its focus towards highly customized and tailored products and offerings. Industries can now use AI, IoT, and quantum computing to implement the features of mass personalization, where efficiency does not have to be sacrificed. Manufacturing order driven smart factories have the ability to change the configuration of production lines in real-time according to the wishes of consumers. The result is effortless flexibility and responsiveness to demand.

In short, as Industry 4.0 revolved around the areas of automation, efficiency and connectivity, Industry 5.0 shifts focus to a more human-centered, ethical and sustainable industrial moral ecosystem. It guarantees that technology assists humanity instead of taking its place, shaping a world where advanced systems and human creativity coexist. This shift facilitates the creation of industries that are more streamlined while also being more flexible, responsible, and resilient to global challenges. Figure 1.1 Shows details for Industrial Revolution.

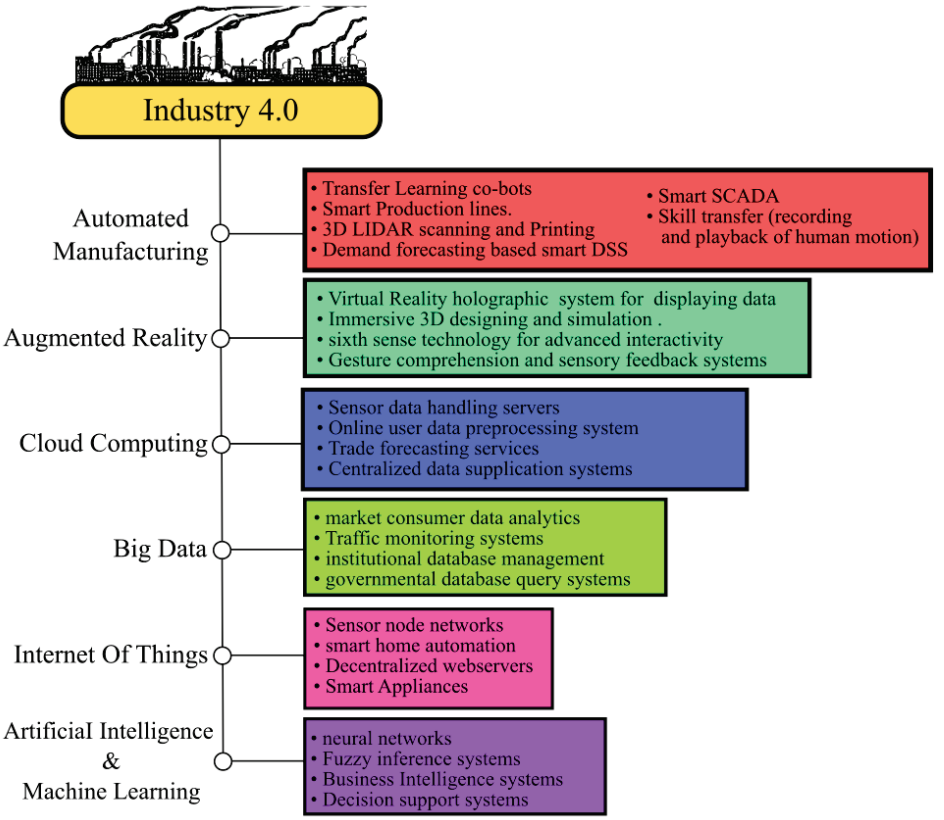

Figure 1.1: Components of Industrial Revolution 4.0

1.3 Role of Advanced Technologies in Industry 5.0

Industry 5.0 is shifting the business environment by promoting collaboration, sustainability, and smart automation, and it marks a significant shift. Compared to Industry 4.0 which relied on AI technology and IoT for efficiency, Industry 5.0 focuses on advancing technology more. Combining human creativity with machine intelligence allows more functions to be automated. This change guarantees environmentally friendly, adjustable, and custom-made industrial processes which work to the advantage of the industry, employees, and the ecology.
Several key technologies play a pivotal role in enabling this transition:

Collaborative Robots (Cobots) In contrast to traditional industrial robots, Cobots are built to assist human operators rather than solely function independently. These intelligent robotic systems are crafted to serve as an aid rather than replacement to the worker, which enhances efficiency, productivity, and safety. Equipped with AI and Machine Learning algorithms coupled with sensory capabilities, Cobots are programmable to identify human gestures, adapt to an ever changing environment, and perform intricate work that requires human supervision.

Quantum Computing for Advanced Decision-Making

Quantum computing transforms industrial activities through optimization, prediction, analytics, and problem-solving capabilities. Conventional AI and machine learning approaches depend on classical computing, which when faced with huge volumes of data is impractical. Quantum computers, aided by superposition and entanglement, can handle more intricate industrial situations at a rate that is significantly greater than classical computers. In the scope of Industry 5.0, quantum computing is important for:

- Supply chain optimization – Predicting disruptions and improving logistics.
- AI-powered manufacturing – Enabling real-time adaptation of production processes.
- Material discovery – Simulating molecular structures for advanced materials and eco-friendly solutions.

Edge Computing for Real-Time Processing

Industry 5.0 looks for rapid processing efforts and quite literally zero latency responses, especially in robotic automation, smart factories, and predictive maintenance. Edge computing means bringing data processing closer to the source which reduces dependency on the cloud, decreases response time, and improves data security.

In manufacturing, edge computing allows for:

- Quicker AI decision making without the need to transfer data to central cloud servers.
- Reduction of downtime and enhancement of operational productivity through IoT-enabled predictive maintenance.
- Increased cybersecurity by minimizing the risk of centralized data breaches.

Digital Twins- The Future of Virtual Industrial Operations

A digital twin is a virtual copy of a physical object, system, or process that exists in real time. It offers an interactive simulated environment that is used by industries for monitoring, testing, and optimization. Industry 5.0 uses digital twins for:

- Enhance predictive maintenance – Reducing machine failures through AI-driven insights.
- Optimize energy consumption – Simulating energy-efficient processes before implementation.
- Personalize production – Allowing manufacturers to prototype custom products virtually before mass production.

Sustainable Manufacturing for a Greener Future

Industry 5.0 focuses on the eco-friendly aspect of production, which is a stark contrast to past industrial revolutions. Companies are adopting sustainable technologies, such as:

- Circular economy models, which recycle and reuse materials.
- AI-driven energy efficiency solutions to reduce waste.
- Smart grids for renewable energy integration in industrial settings.

Industry 5.0 integrates advanced technology and the industrial ecosystem by improving the effectiveness of human interaction as well as protecting the environment. This blend between intelligent automation and human creativity guarantees a future that is industrially sophisticated, resilient, and ethically responsible. Figure 1.2 shows Components of Industry 5.0.

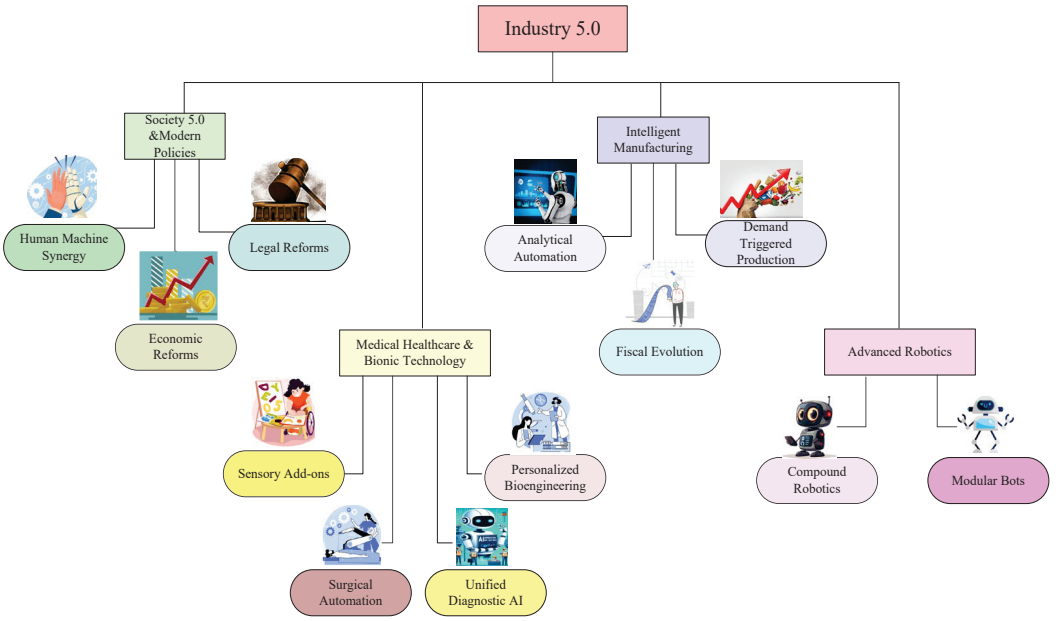

Figure 1.2: Components of Industry 5.0

1.4 Human-Centric Approach and Workforce Implications

A key aspect of Industry 5.0 is the reintroduction of human's intelligence, creativity and adaptivity within industrial processes. Instead of focusing solely on efficiency, automation, and machine intelligence as was the focus with Industry 4.0, Industry 5.0 aims to integrate human abilities with technology instead of substituting them entirely. This shift in focus emphasizes the importance of human-machine interaction, moral AI, and sustainability, all of which help foster processes that are industrially progressive while promoting the health and productivity of the workforce.

The changes that are brought about by Industry 5.0 are extremely powerful in relation to the workforce as it calls for a change in attitude towards work, learning of new skills, and most importantly, innovation.

Reskilling and Upskilling

As AI, IoT, quantum computing, and robotics converge, the adoption of new technologies will require workers to manage, operate, and collaborate with sophisticated systems. The workforce of the future must learn to excel at:

- AI and Machine Learning – Understanding how AI-driven systems function and optimizing their applications in production environments.
- Human-Robot Interaction – Working with cobots (collaborative robots) to enhance efficiency and safety in industrial tasks.
- Cybersecurity Awareness – Managing secure interactions with smart devices and ensuring data integrity in interconnected systems.
- Digital Literacy & Programming – Navigating cloud computing, digital twins, and edge computing platforms for real-time decision-making.

Organizations must prioritize training programs and certifications to ensure that workers remain relevant and can transition into new roles seamlessly.

Job Evolution

Conventional factory work will give rise to new skill-based occupations that emphasize problem solving, critical thinking, and flexibility over monotonous tasks. With machines taking care of their repetitive duties, people will:

- Focus on strategic planning, creative problem-solving, and AI oversight.
- Take up roles as technology supervisors, data analysts, AI trainers, and sustainability officers.
- Collaborate with intelligent machines in real-time decision-making rather than being mere machine operators.

As cognitive skills and problem solving become ever more crucial, workers will spend their time on more creative and productive tasks which helps to boost overall job satisfaction and career duration.

Enhanced Workplace with Human-Technology Collaboration

Industry 5.0 prioritizes creating a safe, efficient, and employee-friendly workplace by incorporating:

- AI-powered safety monitoring to reduce workplace accidents.
- Wearable IoT devices for real-time health monitoring, fatigue detection, and improved ergonomics.
- Adaptive work environments where AI dynamically adjusts conditions such as lighting, temperature, and workload to optimize human performance.

Bionic Enhancements

A crucial aspect of Industry 5.0 is the incorporation of bionic technologies, where wearable and implantable systems enhance human capabilities. These innovations include:

- Exoskeletons – AI-powered robotic suits that reduce physical strain on workers, minimizing workplace injuries and increasing productivity.
- Bionic Prosthetics – Advanced prosthetic limbs controlled by neural signals, enabling individuals with disabilities to perform industrial tasks.
- Brain-Machine Interfaces (BMIs) – Direct communication pathways between the human brain and computers, allowing workers to control machines using thought-based commands.

Bionic enhancements will enable workers to push beyond physical and cognitive limitations, enhancing productivity while ensuring worker health and safety.

1.5 Challenges and Opportunities in Transition

Shifting from Industry 4.0 to Industry 5.0 is a difficult journey to navigate, but it is transformative as well. As a business, as an industry, and as a society, this transition brings unique challenges, but it also open new doors. While Industry 4.0 has already brought in automation, AI enable manufacturing, IoT integration, or the use of AI in business functions, Industry 5.0 goes one step further by reintroducing human interaction, green AI, and human capital into the industrial processes.

1.5.1 Challenges in Transitioning to Industry 5.0

Integration Costs and Infrastructure Overhaul

There are a lot of sectors that are still using legacy systems designed for Industry 4.0 automation. These systems need a cobot, AI-powered decision making, and quantum computing which require a lot of financial investment to upgrade. Small and medium enterprises (SMEs) may not be able to afford the new digital infrastructure, resulting in adopting processes which would be heavily inefficient.

Cybersecurity and Data Protection

As the world becomes more interconnected, the threat of cyberattacks, information security breaches, and even Artificial intelligence vulnerabilities escalate. Safeguarding intelligent systems, cloud data storage, and IoT devices increases the demand for robust cybersecurity frameworks. The challenge and solution lie in quantum computing. While it can discontinue conventional methods of security encryption, it can also offer proactive strategies to solve these concerns, such as quantum cryptography.

Regulatory and Ethical Considerations

The implementation of AI in decision making processes is a cause of concern in issues such as bias, fairness, and accountability. There should be regulations put in place by governments and institutions concerning the application of AI ethically and safeguarding the rights of employees. It is also important to avoid discrimination and excessive use of automation by being transparent in the ways AI systems make decisions.

1.5.2 Opportunities in the Transition to Industry 5.0

Enhanced Innovation and Human-Centered AI

Industry 5.0 merges human intellect and AI's accuracy to tackle problems and create solutions more effectively. In addition to increased productivity, the use of BMIs and cobots enhances employee interaction with intelligent machines. Automation improves innovation by optimizing decisions made in product design, quality assurance, and the management of the supply chain.

Sustainability and Green Manufacturing

Industry 5.0 encourages environmentally sustainable measures in industrial activities by decreasing carbon emissions, waste, and energy use. Circular economy models focuses on reuse, repurposing, and resource optimizing, helping to limit negative environmental footprint. Sustainability-oriented AI applications in quantum computing cost-effectively support industries in achieving energy efficiency objectives.

Competitive Advantage and Market Leadership

Companies moving towards the Industry 5.0 technologies will gain an advantage over their competitors, greatly enhancing their operational responsiveness and effectiveness. Personalized manufacturing, where AI facilitates new products to be built and tailored to consumer's needs, will open new markets and improve the customer experience. Companies shifting to human-centred smart manufacturing will spearhead the new strategies for future workforce development improving employee engagement and job satisfaction. The shift between Industry 4.0 and 5.0 has financial, security and regulatory issues, but it also promises transformation in neo innovation, sustainability, and human-AI integration. Companies willing to embrace the challenges while taking advantage of the opportunities will be forerunners in this new industrial revolution.

1.6 Indian Perspective

Industry 5.0: India's Position and the Path Forward

Beyond the automation and connection of Industry 4.0, Industry 5.0 places an emphasis on responsible AI, sustainable growth, and human-machine collaboration. To improve productivity and decision-making, it combines artificial intelligence (AI), robotics, quantum computing, digital twins, and IoT-driven edge technology. Cobots with AI capabilities will help employees, and cybersecurity with AI and quantum analytics will improve decision-making. Manufacturing will accelerate thanks to real-time data analysis made possible by edge computing and the Internet of Things. Digital twins will aid in maintenance and production optimisation.

India's Strength: A Young, Tech-Savvy Workforce

In 2023, 808 million people were youth in India. India boasts a large pool of Industry 5.0 talent with more than 4.5 million STEM graduates each year. In order to prepare youth for AI-driven enterprises, government has initiated programs like "Skill India" and "Digital India" seek to improve technical education and digital literacy. The necessity for comprehensive reskilling and upskilling programs is highlighted by the fact that just 48.7% of Indian graduates are employable in the digital economy.

The Path Forward: Sustainability & Workforce Development

Industry 5.0 encourages blockchain-based transparent supply chains, AI-assisted waste reduction, and low-carbon solutions. To be competitive, India needs to make investments in R&D, digital infrastructure, and workforce development. India has the potential to become a worldwide leader because to its robust IT sector, thriving startup ecosystem, and ambitious industrial projects. But it's imperative to handle cybersecurity threats, moral dilemmas, and legal loopholes. India has the potential to leverage Industry 5.0 to promote job creation, economic expansion, and environmental sustainability by combining ethical AI with sustainable industrial practices.

Professor Dharam Buddhi, Vice Chancellor, Uttaranchal University Dehradun, India is an Academic, Administrative and Innovative leader. He is an alumnus of IIT Delhi and Ex-Professor, School of Energy and Environmental Studies, Devi Ahilya University, Indore. He was an international consultant to Asian Development Bank during 2016-2018 for Green Power project in Sri Lanka. Presently, he is an Indian Project Coordinator of Indo-Australia collaboration Project on "Thermal Energy Storage for Food/Grain Drying with CST/RE to Lower Pollution".

Prof. Buddhi got Lifetime Achievement Award 2023 for outstanding contribution in Academics and Research. He is globally Ranked in the top 2% researchers worldwide in the field of energy in the year 2021, 2022, 2023 by Stanford University/Elsevier.

His areas of research are Clean and Renewable Energy, Energy Conservation, Green Building and Energy storage. He guided 20 research scholars leading to Ph.D. degree and has published 250+ research papers and reviews. Further, 150+ patents to his credit out of which a few has been granted. Dr Buddhi has very high citations of the order of 17000+ of his publications.

Professor Rajesh Singh, Director (Research & Innovation), Uttaranchal University, Dehradun, India has more than twenty two years of experience in academics & research. He has completed his Post Doctorate from Universidad Internacional Iberoamericana, Mexico. His area of expertise includes embedded systems, robotics, wireless sensor networks, Internet of Things and Machine Learning. He has filed 500+ IPR, including 100+ Indian & International patent grants, 5 PCT and published 500+ research articles in SCI/Scopus journals. He has been featured among top ten inventors for ten years 2010-2020, by Clarivate Analytics. He is mentor to seven Startups and ten scholars have completed their PhD under his supervision.

He is listed among top 2% scientist globally, by Stanford University. He has received "Award of Excellence for Research & Innovation in Science", conferred by State Minister, Uttarakhand, 2024. He has been awarded with "Best Researcher Award" by INT Global Innovation Technologist Award in 2024. He has forty five authored/edited books with international publishers. He has been awarded with "Gandhian Young Technological Innovation (GYTI) Award", as Mentor to "On Board Diagnostic Data Analysis System-OBDAS", Appreciated under "Cutting Edge Innovation" during Festival of Innovation and Entrepreneurship at Rashtrapati Bahawan, India in 2018.

Professor Anita Gehlot, Head (Research & Innovation), Uttaranchal University, Dehradun, India has more than sixteen years of experience in academics & research. She has completed her Post Doctorate from Universidad Internacional Iberoamericana, Mexico.

Her area of expertise includes embedded systems, wireless sensor networks, and Internet of Things. She has been featured among top ten inventors for ten years 2010-2020, by Clarivate Analytics. She is listed among worlds' top 2% scientist, by Stanford University. She has been awarded with "Women Researcher Award" by INT Global Innovation Technologist Award in 2024. She has more than five hundred Indian patents, 63 International patent grants, 5 PCT and published more than four hundred research articles in SCI/Scopus journals.

She has forty five authored/edited books with international publishers. She has been awarded with "Gandhian Young Technological Innovation (GYTI) Award", at Rashtrapati Bahawan, India in 2018. She has been honored with "Certificate of Excellence" Organized by EET CRS research wing for excellence in professional education and Industry, for the category "Young Researcher", 2015.

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