

Problem Statement Area

The United Nations (UN) has formulated sustainable development goals (SDGs) for achieving social, economic, and environmental sustainability. The integration of Industry 4.0 enables to achieve of the SDGs sustainably. Industry 4.0 alludes to the fourth industrial revolution, which combines fast-expanding technologies such as the Industrial Internet of things (IIoT), artificial intelligence (AI), robotics, and advanced computing to drastically alter the manufacturing environment. Industry 4.0 is represented by the four primary technologies such as i) data, connectivity, computational power, ii) Intelligent Analytics, iii) Automation and iv) advanced manufacturing technologies. The following are broad problem areas that are inclined to Industry 4.0 conception.

IH 1. Manufacturing 4.0

Description:

Manufacturing is the procedure of creating products using equipment, machines, labor, and tools. The inclination towards Industry 4.0 is realized with the integration of digitalized technologies like IIoT, AI/ML, Robotics/Drone, Big Data, Blockchain, Digital Twins, AR, VR/XR, Cloud Computing, and Edge/fog computing. The integration of these technologies can be utilized in manufacturing for predictive maintenance, real-time supply chain monitoring, quality monitoring, intelligent machinery analytics, etc.

Resources:

- Duggal, A. S., Malik, P. K., Gehlot, A., Singh, R., Gaba, G. S., Masud, M., & Al-Amri, J. F. (2021). A sequential roadmap to Industry 6.0: Exploring future manufacturing trends. IET Communications. (DOI: 10.1049/cmu2.12284).
- Malik, P. K., Sharma, R., Singh, R., Gehlot, A., Satapathy, S. C., Alnumay, W. S., ... & Nayak, J. (2021). Industrial Internet of Things and its applications in industry 4.0: State of the art. *Computer Communications*, 166, 125-139. [<https://doi.org/10.1016/j.comcom.2020.11.016>].
- Singh, Rajesh. Embedded system based on ATMEGA microcontroller: simulation, interfacing and projects. Alpha Science International Limited, 2017. (<https://www.waterstones.com/book/embedded-system-based-on-atmega-microcontroller/rajesh-singh/anita-gehlot/9781783322800>).
- Singh, R., Gehlot, A., Singh, B., & Choudhury, S. (2017). *Arduino-based embedded systems: interfacing, simulation, and LabVIEW GUI*. CRC Press. (<https://doi.org/10.1201/9781315162881>)
- Chimata, R., Singh, R., & Singh, B. (Eds.). (2018). *Internet of Things in Automotive Industries and Road Safety*. River Publishers. (https://www.riverpublishers.com/book_details.php?book_id=569).

IH 2: Pharma 4.0

Description:

Pharmacy is a significant area, where the discovery, development, marketing, and supply chain of drugs are primary activities. The integration of IoT/IIoT, AI/ML, Robotics/Drone, Big Data, Blockchain, Digital Twins, AR, VR/XR, Cloud Computing, and Edge/fog computing in pharmacy can be used for quality monitoring, pharmacy analytics, smart electronic medical records, detection of anomalies in the supply chain, electronic prescription, real-time delivery system, personalized medicine, etc.

Resources:

- Rathour, N., Alshamrani, S. S., Singh, R., Gehlot, A., Rashid, M., Akram, S. V., & AlGhamdi, A. S. (2021). IoMT Based Facial Emotion Recognition System Using Deep Convolution Neural Networks. *Electronics*, 10(11), 1289. [<https://doi.org/10.3390/electronics10111289>].
- Singh, R., Gehlot, A., Rashid, M., Saxena, R., Akram, S. V., Alshamrani, S. S., & AlGhamdi, A. S. (2021). Cloud Server and Internet of Things Assisted System for Stress Monitoring. *Electronics*, 10(24), 3133. [<https://doi.org/10.3390/electronics10243133>]
- Beri, R., Dubey, M. K., Gehlot, A., Singh, R., Abd-Elnaby, M., & Singh, A. (2021). A novel fog-computing-assisted architecture of E-healthcare system for pregnant women. *The Journal of Supercomputing*, 1-25. [<https://doi.org/10.1007/s11227-021-04176-7>].
- Rathour, N., Khanam, Z., Gehlot, A., Singh, R., Rashid, M., AlGhamdi, A. S., & Alshamrani, S. S. (2021). Real-Time Facial Emotion Recognition Framework for Employees of Organizations Using Raspberry-Pi. *Applied Sciences*, 11(22), 10540. [<https://doi.org/10.3390/app112210540>].

IH 3: Energy Management 4.0

Description:

Renewable energy integration and energy efficiency are critical drivers for the transition of sustainable energy transitions and climate change mitigation. The integration of IoT/IIoT, AI/ML, Robotics/Drone, Big Data, Blockchain, Digital Twins, AR, VR/XR, Cloud Computing, and Edge/fog computing in Energy management can be used for smart grid, smart microgrids, fault detection & diagnosis, energy trading, energy storage, energy supply chain, smart meter, smart transformer, etc.

Resources:

- Thurai Raaj, V. B., Gorantla, S. R., Karunanidy, D., Dumka, A., Singh, R., Rashid, M., ... & Alshamrani, S. S. (2022). Dual Battery Storage Technique for Remote, Location-Based Solar PV System and Standalone Applications. *Energies*, 15(8), 2748. [<https://doi.org/10.3390/en15082748>].

- Sharma, V. K., Singh, R., Gehlot, A., Buddhi, D., Braccio, S., Priyadarshi, N., & Khan, B. (2022). Imperative Role of Photovoltaic and Concentrating Solar Power Technologies towards Renewable Energy Generation. *International Journal of Photoenergy*, 2022. [<https://doi.org/10.1155/2022/3852484>]
- Samkria, R., Abd-Elnaby, M., Singh, R., Gehlot, A., Rashid, M., Aly, M. H., & El-Shafai, W. (2021). Automatic PV Grid Fault Detection System with IoT and LabVIEW as Data Logger. *CMC-COMPUTERS MATERIALS & CONTINUA*, 69(2), 1709-1723. [<http://dx.doi.org/10.32604/cmc.2021.018525>].
- Malik, P., Gehlot, A., Singh, R., Gupta, L. R., & Thakur, A. K. (2022). A Review on ANN Based Model for Solar Radiation and Wind Speed Prediction with Real-Time Data. *Archives of Computational Methods in Engineering*, 1-19. [<https://doi.org/10.1007/s11831-021-09687-3>].
- Gehlot, A., Singh, R., Saini, D. K., Yadav, M., & Singh, B. (2018). IoT enabled smart microgrid..... rapid prototyping. *GBS Publication*.
- <https://novapublishers.com/shop/applied-soft-computing-techniques-for-renewable-energy/>.

IH4: Legal Practices 4.0

Description:

Legal practice is stated as a job done mainly for the objective of offering legal advice or representation. The integration of IoT/IIoT, AI/ML, Robotics/Drone, Big Data, Blockchain, Digital Twins, AR, VR/XR, Cloud Computing, and Edge/fog computing in legal practice can be used for digital documentation, e-hearing, legal Analytics, virtual legal assistants, virtual legal training and practices, automating creative processes, perform due diligence and research, etc.

Resources:

- Koulu, R., Kallio, L., & Hakkarainen, J. (2017). Law and digitalization: an agenda for the future. [<https://doi.org/10.3390/laws9020014>]
- Caserta, S. (2020). Digitalization of the legal field and the future of large law firms. *Laws*, 9(2), 14. [<http://doi.org/10.31885/2019.00007>].

IH5: Highways 4.0

Description:

The highway road transport system is one of the transport systems that enable to transit of goods and humans from one location to another location. The integration of IoT/IIoT, AI/ML, Robotics/Drone, Big Data, Blockchain, Digital Twins, AR, VR/XR, Cloud Computing, and Edge/fog computing in highways can be used for the smart highway lighting system, smart traffic, and emergency management system, renewable energy sources on highways, smart display, smart reflectors, etc.

Resources:

- Singh, R., Sharma, R., Akram, S. V., Gehlot, A., Buddhi, D., Malik, P. K., & Arya, R. (2021). Highway 4.0: Digitalization of highways for vulnerable road safety development with intelligent IoT sensors and machine learning. *Safety science*, 143, 105407. [<https://doi.org/10.1016/j.ssci.2021.105407>].
- Gehlot, A., Singh, R., Kuchhal, P., Kumar, A., Singh, A., Alsubhi, K., ... & Brenosa, J. (2021). WPAN and IoT Enabled Automation to Authenticate Ignition of Vehicle in Perspective of Smart Cities. *Sensors*, 21(21), 7031. [<https://doi.org/10.3390/s21217031>].
- Singh, R., Gehlot, A., Jain, V., & Malik, P. K. (Eds.). (2019). *Handbook of research on the internet of things applications in robotics and automation*. IGI Global. [10.4018/978-1-5225-9574-8].

IH6: Cities 4.0

Description:

A city is a place where an immense number of people live in close proximity. Cities typically have their governments and systems for maintaining and supplying the basic amenities to the resided people. The integration of IoT/IIoT, AI/ML, Robotics/Drone, Big Data, Blockchain, Digital Twins, AR, VR/XR, Cloud Computing, and Edge/fog computing in cities can be used for water quality management and supply management, waste management, air quality monitoring, streetlights, education, mobility, etc.

Resources:

- Singh, R., Baz, M., Gehlot, A., Rashid, M., Khurana, M., Akram, S. V., ... & AlGhamdi, A. S. (2021). Water Quality Monitoring and Management of Building Water Tank Using Industrial Internet of Things. *Sustainability*, 13(15), 8452. [<https://doi.org/10.3390/su13158452>].
- Akram, S. V., Singh, R., AlZain, M. A., Gehlot, A., Rashid, M., Faragallah, O. S., ... & Prashar, D. (2021). Performance analysis of IoT and long-range radio-based sensor node and gateway architecture for solid waste management. *Sensors*, 21(8), 2774. [<https://doi.org/10.3390/s21082774>].
- Gehlot, A., Alshamrani, S. S., Singh, R., Rashid, M., Akram, S. V., AlGhamdi, A. S., & Albogamy, F. R. (2021). Internet of Things and Long-Range-Based Smart Lampposts for Illuminating Smart Cities. *Sustainability*, 13(11), 6398. [<https://doi.org/10.3390/su13116398>].
- Singh, R., Gehlot, A., Jain, V., & Malik, P. K. (Eds.). (2019). *Handbook of research on the internet of things applications in robotics and automation*. IGI Global. [10.4018/978-1-5225-9574-8].

IH 7: Infrastructure, Mobility & Safety 4.0

Description:

Mobility plays a critical role in everyday life on a micro and a macro scale combined. Modernization in mobility would enable the establishment of a sustainable, digitalized, and informed society. The integration of IoT/IIoT, AI/ML, Robotics/Drone, Big Data,

Blockchain, Digital Twins, AR, VR/XR, Cloud Computing, and Edge/fog computing in Mobility can be used for enhancement of road environment, curbing driver distraction, adoption of electric vehicles, integration of low power computing units in vehicular networks, etc.

Resources:

- Duggal, A. S., Singh, R., Gehlot, A., Gupta, L. R., Akram, S. V., Prakash, C., ... & Kumar, R. (2021). Infrastructure, mobility and safety 4.0: Modernization in road transportation. *Technology in Society*, 67, 101791. [<https://doi.org/10.1016/j.techsoc.2021.101791>].
- Chimata, R., Singh, R., & Singh, B. (Eds.). (2018). Internet of Things in Automotive Industries and Road Safety. River Publishers. [https://www.riverpublishers.com/book_details.php?book_id=569]

IH 8: Villages 4.0

Description:

The United Nations (UN) 2030 Agenda makes it clear that growth and sustainable management are not confined to cities, but also those living in rural and villages. In addition, the villages are the heart of every nation, the villages not only support and maintain the geological ecosystem but also have a great impact on the economic and social ecosystem. The integration of IoT/IIoT, AI/ML, Robotics/Drone, Big Data, Blockchain, Digital Twins, AR, VR/XR, Cloud Computing, and Edge/fog computing in villages can be used for dairy & cattle management, agriculture, governance, education, health, minor forest produce (MFP), skill development, forest monitoring & management, etc.

Resources:

- Malik, P., Singh, R., Gehlot, A., Akram, S. V., & Das, P. K. (2022). Village 4.0: Digitalization of Village with Smart Internet of Things Technologies. *Computers & Industrial Engineering*, 107938. [<https://doi.org/10.1016/j.cie.2022.107938>].
- Singh, R., Thakur, A. K., Gehlot, A., & Kaviti, A. K. (Eds.). (2022). Internet of Things for Agriculture 4.0: Impact and Challenges. CRC Press. [<https://doi.org/10.1201/9781003161097>].
- Swain, M., Zimon, D., Singh, R., Hashmi, M. F., Rashid, M., & Hakak, S. (2021). LoRa-LBO: An experimental analysis of lora link budget optimization in custom build iot test bed for agriculture 4.0. *Agronomy*, 11(5), 820. [<https://doi.org/10.3390/agronomy11050820>]
- Singh, R., Gehlot, A., Akram, S. V., Thakur, A. K., Buddhi, D., & Das, P. K. (2021). Forest 4.0: Digitalization of forest using the Internet of Things (IoT). *Journal of King Saud University-Computer and Information Sciences*. [<https://doi.org/10.1016/j.jksuci.2021.02.009>]
- Singh, R., Gehlot, A., Prajapat, M. K., & Singh, B. (2021). *Artificial Intelligence in Agriculture*. CRC Press. [<https://doi.org/10.1201/9781003245759>].

IH 9: Industry 6.0

Description:

It is predicted that by 2050, technology will have advanced to the point of complete autonomy. The conceptual notion of Industry 6.0 incorporates innovations and developments in almost every domain. Advanced robotics, Medical healthcare and bioengineering technologies, multidimensional printing, robo-medics, assistive home-robotics, cumulative-alternative energy, and deep dive EEG are the few areas of Industry 6.0

Resources:

- Duggal, A. S., Malik, P. K., Gehlot, A., Singh, R., Gaba, G. S., Masud, M., & Al-Amri, J. F. (2021). A sequential roadmap to Industry 6.0: Exploring future manufacturing trends. IET Communications. [doi: 10.1049/cmu2.12284].

IH 10: Hospitality 4.0

Description:

Hospitality management is a vast field that encompasses supervising the day-to-day administration, operational, and commercial responsibilities of hospitality businesses like hotels, food and beverage, and catering. The integration of IoT/IIoT, AI/ML, Robotics/Drone, Big Data, Blockchain, Digital Twins, AR, VR/XR, Cloud Computing, and Edge/fog computing in hospitality can be used for Speedy and accurate customer service, Quality check, Automation of Check-In and Check-Out, regular monitoring of employee health and welfare, Cleanliness, Health and customer safety systems, etc.

Resources:

- <https://novapublishers.com/shop/innovations-and-challenges-in-human-resource-management-for-hr4-0/>
- Singh, R., Gehlot, A., Jain, V., & Malik, P. K. (Eds.). (2019). *Handbook of research on the internet of things applications in robotics and automation*. IGI Global. [doi: 10.4018/978-1-5225-9574-8].

IH 11: Arts & Humanities 4.0

Description:

Humanities are disciplines that study the representations of the human mind. Language, music, art, literature, theatre, and poetry are manifestations of such expressions. The integration of IoT/IIoT, AI/ML, Robotics/Drone, Big Data, Blockchain, Digital Twins, AR, VR/XR, Cloud Computing, and Edge/fog computing in Arts & Humanities can be used for Creative and Critical thinking, Speeches, Debates, Discussions on a public platform, Life-

Skills, etc. It provides and sets the Benchmark for Orators, and Newsreaders; it focuses on Personality Development and Presentations.

Resources:

- Raimo, N., De Turi, I., Ricciardelli, A., & Vitolla, F. (2021). Digitalization in the cultural industry: Evidence from Italian museums. *International Journal of Entrepreneurial Behavior & Research*. [https://doi.org/10.1108/IJEER-01-2021-0082].
- Zylinska, J. (2020). *AI art: machine visions and warped dreams* (p. 181). Open Humanities Press. [https://library.oapen.org/handle/20.500.12657/40042].
- Venkatesh, A. N. (2017). Connecting the dots: Internet of Things and human resource management. *American International Journal of Research in Humanities, Arts and Social Sciences, ISSN (Print), 2328-3734*. [https://ssrn.com/abstract=2913400]