Robotics and Internet of Things in Smart Domains
An Annotated Bibliography

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References

[1] *Agricultural Field Coverage Using Cooperating Unmanned Ground Vehicles*, ser. Dynamic Systems and Control Conference, vol. Volume 2: Modeling and Control of Engine and Aftertreatment Systems; Modeling and Control of IC Engines and Aftertreatment Systems; Modeling and Validation; Motion Planning and Tracking Control; Multi-Agent and Networked Systems; Renewable and Smart Energy Systems; Thermal Energy Systems; Uncertain Systems and Robustness; Unmanned Ground and Aerial Vehicles; Vehicle Dynamics and Stability; Vibrations: Modeling, Analysis, and Control, 10 2019. [Online]. Available: https://doi.org/10.1115/DSCC2019-8992

Faryadi and company's paper proposes a method of inspecting regions of interest (e.g. water stress, phenotype problems) of an agricultural field. Their method involves using a distributed algorithm in controlling a number of unmanned ground vehicles (UGVs) for inspecting the identified regions of interest. The problem was mapped into a locational optimization problem where the field is represented as a directional graph where each node and edge has a weight value that the algorithm has to take into account. Moreover, their method involves optimizing a distance cost along with dynamic partitioning of the

UGVs coverage regions using Voronoi partitioning.
On a high level, their algorithm relies on iteratively determining the coverage regions of the UGVs by calculating the current Voronoi partitioning on each iteration. Iteration is defined as the UGVs moving to a new node. This partitioning is used in minimizing a heuristic function that decides whether a UGV is responsible over a target node. A node here is the intersection that is created by a number of farm beds (that number is four in the paper). This heuristic function is defined as the summation of each iteration calculation of the distance between the target node and the UGV's location multiplied by a priority value of the node. Furthermore, this algorithm has an obstruction avoidance built into it. Any nodes or edges that have obstructions are weighted to some value which influences the heuristic function such that the UGV would avoid those edges/nodes.
Faryadi and company's paper is originally part of a bigger work that they were doing that proposes the use of unmanned vehicles for both sky and ground coverage of an agricultural field. This paper was focused on dealing with ground data collection and may be applied for other agricultural-related purposes as it is a generic algorithm that helps the robots to get to where they are needed to. The paper showcased an interesting use case of robots in the agricultural sector.

[2] C. A. Garcia, W. Montalvo-Lopez, and M. V. Garcia, "Human-robot collaboration based on cyber-physical production system and mqtt," *Procedia Manufacturing*, vol. 42, pp. 315–321, 2020, international Conference on Industry 4.0 and Smart Manufacturing (ISM 2019). [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2351978920306533

This study presents an advanced model for human-robot collaboration (HRC) utilizing a cyber-physical production system (CPPS) framework, integrated with the Message Queuing Telemetry Transport (MQTT) protocol. The authors, Garcia, Montalvo-Lopez, and Garcia, designed a collaborative system to enhance real-time communication between human operators and robots within manufacturing environments, aligning with Industry 4.0 standards. The CPPS framework enables seamless interaction by allowing robots to adjust to dynamic conditions based on real-time data inputs provided by human operators. Through MQTT, a lightweight messaging protocol optimized for IoT applications, the system achieves efficient and reliable data transfer between components, which is crucial for responsive manufacturing settings.

The study contributes to the IoT and robotics fields by demonstrating a robust approach to HRC that leverages MQTT for enhanced data exchange within CPPS environments. By reducing latency and ensuring secure data transmission, the proposed system enables adaptive control, increasing the operational safety and flexibility of robots working alongside humans. This setup is particularly beneficial for applications requiring high responsiveness and adaptability, such as complex assembly tasks and precision manufacturing processes. The authors highlight that this integration facilitates a more efficient and scalable HRC model that is accessible, resource-effective, and suitable for various industrial contexts where dynamic adjustments are necessary. Future recommendations include exploring MQTT's potential for integrating additional sensory inputs to enhance situational awareness and scalability in multi-robot systems, thereby expanding the use of CPPS and MQTT in broader smart manufacturing applications.

[3] Y. P. Kondratenko, *Robotics, Automation and Information Systems: Future Perspectives and Correlation with Culture, Sport and Life Science.* Cham: Springer International Publishing, 2015, pp. 43–55. [Online]. Available: https://doi.org/10.1007/978-3-319-03907-7_6

This study by Kondratenko looks into the future of robotics, automation, and information systems, especially in how they intersect with culture, sports, and life sciences. It discusses the use of robots in sports for performance analysis and training, such as robotic coaches or devices that help athletes track their skills and progress. The study also highlights the role of cultural differences in how people interact with robots. For instance, robots with facial expressions might be received differently depending on cultural norms, which is crucial for improving their design and user experience in various settings, including homes and sports environments.

The paper emphasizes the importance of global cooperation and research to further develop these technologies and their applications across diverse cultural contexts. Kondratenko cites international conferences and collaborations between countries like Spain and Ukraine as examples of efforts to advance the integration of robotics in cultural and sports practices. The research underscores that developing a deeper understanding of these cross-cultural dynamics is key to creating robots and automation systems that are adaptable to different societies, ensuring these technologies can be used effectively worldwide. This source is valuable for understanding the potential impact of robotics and automation on various aspects of life and how they can be adapted to meet the needs of different cultural and social settings.

[4] C. Liu and P. Jiang, "A cyber-physical system architecture in shop floor for intelligent manufacturing," *Procedia CIRP*, vol. 56, pp. 372–377, 2016, the 9th International Conference on Digital Enterprise Technology – Intelligent Manufacturing in the Knowledge Economy Era. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2212827116310514

Chao Liu and Pingyu Jiang's study introduces a Cyber-Physical System (CPS) architecture specifically designed for intelligent manufacturing on shop floors, aiming to enhance automation, data-driven decision-making, and operational efficiency. This architecture is structured into three interconnected layers. The physical connection layer integrates sensors and RFID devices into manufacturing equipment, enabling real-time data capture on various metrics such as temperature, vibration, and equipment status. The middleware layer facilitates communication and interoperability across these devices, standardizing data transfer and ensuring that diverse systems can work together seamlessly. Finally, the computation layer applies advanced data analysis and machine learning techniques to process the collected data, supporting adaptive control and intelligent decision-making that allow the manufacturing process to become more self-aware, efficient, and responsive.

[5] H. Liu and L. Wang, "Remote human–robot collaboration: A cyber–physical system application for hazard manufacturing environment," *Journal of Manufacturing Systems*, vol. 54, pp. 24–34, 2020. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0278612519300901

Other technologies include a remote HRC system developed specifically for hazardous manufacturing environments with restricted human presence. Hongyi Liu and Lihui Wang apply the principles of CPS through the use of a collaborative robot and an industrial robot by integrating them to control and operate through a lead-through mode without complicated programming as it requires guiding operators on the robots. This scattered HRC system uses four adaptive operational modes that offer a local collaborative robot and its counterpart, an industrial robot. It can be connected in real-time and see assembly tasks with model-driven presentations. According to the development of Industry 4.0, this application of CPS integrates computational and physical elements to create highly connected and responsive manufacturing environments. Experiments have confirmed that the system is resilient and able to perform tasks like radioactive or chemical material processing, in which it is hard for a man to access. In the last section, it provides clues on how remote HRC applications might be extended in hazardous environments and invites future optimizations for complex industrial tasks.

This paper contributes to the growth of robotics and IoT technologies by showing a remote human-robot collaboration (HRC) system for hazardous environments. In addition, it demonstrates how the IoT and real-time data can be applied to enhance robotic control, flexibility, and precision with the attachment of collaborative and industrial robots with CPS. Its system's intuitive lead-through guidance simplifies complex programming for usability enhancements within specific applications, and its model-driven display allows for remote visualization, which further increases the awareness and decision-making of operators. In line with Industry 4.0, the approach provides further enablers for intelligent, connected, and adaptive robotics, as new possibilities are opened up in the areas of automation of inaccessible and hazardous locations driven

by IoT.

[6] O. Palinko, F. Rea, G. Sandini, and A. Sciutti, "Robot reading human gaze: Why eye tracking is better than head tracking for human-robot collaboration," in *2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2016, pp. 5048–5054.

This study investigates the effectiveness of eye gaze versus head gaze tracking in human-robot interaction (HRI), with a specific focus on collaboration scenarios. The researchers developed a novel , calibration-free eye tracking system tailored for use in collaborative tasks with the iCub humanoid robot. The study employed a block-stacking experiment to compare the efficiency and accuracy of task performance between eye and head gaze tracking. The results demonstrated that eye tracking led to faster task completion and greater accuracy in object selection compared to head tracking.
This work underscores the importance of gaze-sensitive robots in enhancing the fluidity and effectiveness of human-robot collaboration, particularly in tasks requiring subtle communication and responsiveness, such as those found in manufacturing or healthcare. The findings are particularly relevant to the Internet of Robotic Things (IoRT) and Industry 4.0 applications, where IoRT enables connected devices and sensors to create intelligent, responsive environments. By improving robots' ability to interpret human intent accurately, eye-tracking technology holds significant potential for advancing collaborative capabilities in IoRT-enabled environments.

[7] H. Xu, W. Yu, D. Griffith, and N. Golmie, "A survey on industrial internet of things: A cyber-physical systems perspective," *IEEE Access*, vol. 6, pp. 78 238–78 259, 2018.

The study explores the Industrial Internet of Things (I-IoT) from a Cyber-Physical Systems (CPS) perspective, focusing on the integration of smart technologies in industrial environments for improved automation, efficiency, and safety. It examines the architecture of I-IoT, which includes control, networking, and computing systems, and emphasizes the importance of real-time control and data processing in industrial applications. The study categorizes industrial con-

trol systems into centralized, decentralized, and hierarchical, each suited for different industrial needs. In addition to control, it discusses networking technologies, such as 5G and software-defined networking, essential for supporting I-IoT's high-performance communication needs. Lastly , it addresses the challenges of implementing I-IoT, including latency, security, and the seamless integration of edge and cloud computing for scalable data processing.

This study on CPS provides essential insights for understanding the role of CPS in I-IoT, which is foundational to the main study on Internet of Robotic Things (IoRT). CPS in I-IoT enables the structured integration of physical and cyber systems, essential for robotic control and real-time operations in IoRT applications. By addressing control, networking, and computing layers, CPS frameworks facilitate the responsive and intelligent environments necessary for IoRT. This close alignment with IoRT's goals highlights CPS as critical for enhancing the operational efficacy, reliability, and safety of industrial robotics and IoT integration. CPS highlights the foundational architecture, control systems, and networking required for IoRT, demonstrating how these elements enable responsive, secure, and efficient environments critical to advancing industrial robotics within the IoT.