All-in-one middleware for industrial human-robotic-interaction

Industrial HRI Challenges

Version:
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1. Dismantling and assembly of high-value products

Challenge Story/Description: The challenge focuses on developing a collaborative Human-Robot Interaction (HRI) solution for dismantling and assembling high-value products. The goal is to automate tasks, enhance efficiency, reduce risks associated with hazardous materials and ensure worker safety, ultimately improving overall productivity. Key actors include collaborative robots, human workers, acoustic and luminous response devices, cameras and computer systems.

Key Capabilities: The system requires capabilities such as real-time 3D object perception to localize objects accurately, mixed reality integration for enhanced situational awareness, robust voice command recognition for effective interaction and efficient robot coordination to guide actions in real-time. The solution should also consider data protection and privacy principles, ensuring ethical handling of human-related data.

Inspiring Example – In a battery disassembly process, human workers supervise and make critical decisions, while a PC system calculates coordinates and coordinates robot actions. A dimensional camera captures images, and MR HoloLens glasses provide real-time visual information. The collaborative robot performs physical actions, such as selecting screws for disassembly, enhancing the efficiency and safety of the process. This integrated approach ensures a streamlined and effective disassembly process while maintaining high safety standards for human workers.

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2. Complex Product Picking in industrial warehouses

Challenge Story/ Description: This challenge involves developing an HRI solution for product picking in industrial warehouses, specifically addressing tasks with complex products. The goal is to enhance the efficiency and accuracy of picking operations, reduce manual labor and improve the handling of delicate products. The system aims to enable seamless collaboration between robots and human workers, ensuring worker safety while maximizing efficiency. The solution must adapt to the high variability in shapes and weights of products and integrate with IT systems for handling purchase orders.

Key Capabilities: The system must possess advanced object recognition and classification to accurately identify and differentiate various products. Real-time data processing and decision-making capabilities are essential to adapt to dynamic warehouse conditions. Integration with warehouse management systems is crucial for coordinating picking tasks and optimizing workflow. Additionally, the system should provide intuitive user interfaces and feedback mechanisms to facilitate human-robot collaboration and ensure effective communication.

Inspiring Example: In the example of fruit picking, human workers supervise operations using MR HoloLens glasses, which provide real-time visual feedback and instructions. A collaborative robot, guided by data from a camera and instructions from the MR glasses, performs the actual picking tasks. The system relies on seamless communication between the MR glasses, PC, robot and camera to ensure smooth and efficient operation. Key robotic critical functions include real-time 3D object localization, user interaction via voice commands and gestures, cognitive assistance for decision-making and optimization of the robot's trajectory to enhance task execution efficiency while maintaining high ethics and safety standards.

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3. Flexible Collaborative robots

Challenge Story/ Description: The challenge involves developing advanced HRI solutions to support operators, reducing production cycle time, increasing quality and improving working conditions in agile work environments. Manufacturing companies need flexible solutions to meet varying demands, requiring both versatile hardware, such as adaptable grippers and adaptable software, such as behavior flexibility and hardware independence. The goal is to provide a reprogrammable robotics workstation that adapts to variable production requirements, ensuring plug-and-play modularity for both hardware and software components.

Key Capabilities: the integration with company management systems to access product information, object recognition and localization to accurately identify and handle objects, and tray recognition to manage specific constraints. The system must support precise picking and placing operations, human-robot collaboration where operators can intervene in robot tasks and user-friendly interfaces like HMIs or voice command systems. Real-time posture monitoring is also essential to ensure ergonomic safety for operators.

Inspiring Example: Assembly and packing robotic assistant which a collaborative robot aids operator by providing components and performing fine manual operations, such as sorting heavy products into trays. The operator supervises the robot's activity, manages the packing area, and handles exceptions. The robot recognizes objects, picks them up and places them in trays based on pre-programmed sequences. Critical functions include force operations, fine manual operations and real-time communication between the operator and robot. The system must ensure safety, adaptability and efficient collaboration to optimize production processes.

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4. Smart Programming

Challenge Story/ Description: The challenge focuses on developing a robotics workstation that enables workers without programming skills to easily reprogram it for highly variable production needs. The system aims to provide intuitive interfaces and AI algorithms to ensure flexibility and ease of use, allowing operators to adapt the workstation's behavior without extensive coding knowledge. This approach enhances adaptability to different products while preserving operators' autonomy in agile manufacturing environments.

Key Capabilities: include the integration with company management systems to access product information, intuitive interfaces for operators to update programming easily and AI algorithms for behavior adaptiveness. The system must support natural language and gesture recognition for intuitive interactions, as well as the adaptation of robot behavior to optimize workers' ergonomics. Previous programming should be stored for potential reuse, and the system should ensure flexibility and adaptability to production variations.

Inspiring Example: Robotic kitting assistant, which the system enables operators to assemble kits by selecting products from the company's management system. The robot retrieves a list of objects and their locations and the operator updates the list as items are picked. The robot navigates autonomously or in follow-me mode, picking items from shelves or automated warehouses and placing them into the assembly kit bin. Critical functions include company system integration, automated warehouse interface, operator interface for list management and navigation capabilities for the robot. The system ensures accurate inventory tracking, quality checks and operator safety while promoting collaboration between humans and robots in the kitting process.

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5. Enhanced robot functionality through multimodal HRI interactions

Challenge Story/Description: aims to revolutionize human-robot interactions by leveraging advanced multimodal communication methods, including verbal cues, gestures and visual feedback. The goal is to enhance collaboration between non-roboticist/non-expert users and robots, particularly in assisted living contexts. The challenge addresses various aspects such as better detection of user engagement/disengagement, robust speech recognition and the integration of rich dialogue with user profiles.

Key Capabilities: The system must possess several key capabilities to meet the challenge requirements. These include advanced speech recognition and natural language processing for seamless communication, user profile representation and storage for personalization, activity recognition for understanding user behavior and facial expression/emotion recognition for enhanced interaction. Additionally, the system should employ adaptive learning algorithms to improve performance over time and support multimodal communication for effective interaction.

Inspiring Example A guided stretching session with an interactive robot which enables personalized interactions between the robot and patients. The robot assesses the user's needs, guides them through exercises using multimodal communication and adapts the session based on the user's progress and feedback. Critical functions include speech recognition, activity recognition, user profile storage, facial expression recognition and adaptive learning algorithms. The system ensures a human-centric approach to assisted living tasks, empowering users and providing personalized care experiences.

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6. Fetch & carry tasks in healthcare environments

Challenge Story/Description: focuses on developing and implementing robotic systems capable of autonomously performing fetch and carry tasks within healthcare settings. By automating these routine tasks, the goal is to alleviate the workload of medical staff, allowing them to concentrate on direct patient care and other critical responsibilities. Key objectives include improving the reliability of mobile manipulators, developing robust interaction flows, building trust among end-users and creating a safe social navigation system.

Key Capabilities: the system must possess several critical capabilities by including social navigation to navigate around humans in complex environments, navigation for social approaches when the robot needs to interact closely with humans, activity and group recognition for understanding human behaviour, speech recognition and natural language processing for seamless communication, people recognition for detecting humans and multimodal communication for effective interaction.

Inspiring Example: Asking for help while carrying medical samples, the system enables seamless interactions between hospital staff and mobile manipulators like PAL TIAGo. The robot autonomously navigates through the hospital environment, receives medical samples from staff members, and transports them to designated locations such as laboratories. Critical functions include social navigation to navigate around humans, speech recognition to understand voice commands and activity recognition to react appropriately based on detected human activities. The system ensures efficient and safe sample transportation, contributing to improved workflow and patient care in healthcare environments.

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7. HRI for improving the efficiency of workers in high precision flexible tasks

Challenge/Description: focuses on deploying Human-Robot Interaction (HRI) to enhance the efficiency of workers engaged in high-precision flexible tasks within manufacturing environments. These tasks often involve intricate processes and significant setup times, particularly in scenarios where zero-defect manufacturing standards must be met. By leveraging robotics, the aim is to streamline the workspace setup process, thereby reducing overall setup time and improving operational efficiency.

Key Capabilities: To address effectively, the system must possess several crucial capabilities. These include real-time 3D object detection for accurately identifying objects in the environment, robotic arm trajectory planning to efficiently execute pick-and-place operations, position-based visual serving for precise manipulation tasks and mobile robot navigation for optimized transportation of workpieces. Additionally, considerations for data protection and privacy, as well as the long-term implications of technology adoption, must be integrated into the system's design.

Inspiring example: PCB desoldering which system employs a collaborative robot to assist operators in reworking defective printed circuit boards (PCBs). The cobot autonomously prepares the workspace for operators by selecting and placing the necessary tools and functional components based on information extracted from the quality control check. This process involves real-time 3D object detection to identify tools and components, robotic arm trajectory planning to execute precise movements and mobile robot navigation for seamless transportation of PCBs. By offloading tasks such as tool selection and workspace setup to the cobot, operators can focus more on the meticulous task of soldering/desoldering, thereby enhancing overall efficiency and reducing physical and mental stress.

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8. HRI for improving ergonomics in high precision tasks

Challenge 8/Description: seeks to enhance human ergonomics and comfort during high-precision tasks through the deployment of Human-Robot Interaction (HRI) systems. Many precision manual tasks involve working with delicate objects and require dedicated fixed frames for proper positioning, leading to setup times that detract from operators' primary activities. Inappropriate adjustments of these frames can lead to long-term health issues such as chronic stiff necks. The challenge is to develop cobots capable of automatically positioning and holding workpieces according to operators' ergonomics and comfort.

Key Capabilities: To address the challenge, the system must possess key capabilities including speech command detection for seamless interaction, ergonomics and comfort recognition through machine vision and stress recognition for operator well-being. These capabilities enable the cobot to understand verbal commands from operators, detect physical parameters for ergonomic positioning, and recognize signs of stress to ensure a comfortable working environment.

Inspiring example: A workpiece holder where a cobot adjusts the position and orientation of a workpiece based on the physical characteristics of the operator. Utilizing machine vision, the cobot analyses the operator's height and neck length to determine the optimal position and orientation for the workpiece. Additionally, operators can verbally command the cobot to make further adjustments for comfort. This solution offers advantages over conventional methods by providing a wider range of adjustability and more intuitive interaction with the robot. Critical functions include speech command detection for understanding operator instructions, ergonomics and comfort recognition for precise positioning, and stress recognition for ensuring operator well-being. Overall, the system enhances ergonomics and comfort during high-precision tasks, contributing to improved operator health and efficiency.

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