SECTION 10.
AUTOMATION AND APPLIANCES MAKING

Vladyslav Yevsieiev
Doctor of Engineering Science, Professor,
Professor of Department of Computer-Integrated Technologies, Automation and Robotics
Kharkiv National University of Radio Electronics, Ukraine

Dmytro Gurin
Senior lecturer of the Computer-Integrated Technologies,
Automation and Robotics Department
Kharkiv National University of Radio Electronics, Ukraine

NEW CONCEPTS OF HUMAN INTERACTIONS AND COLLABORATIVE ROBOT-MANIPULATORS IN THE CONCEPTS OF INDUSTRY 5.0

Collaborative robotics is a part of robotics that studies, researches and practices the application of CPR in interaction (collaboration) with a person during the performance of various technological operations and tasks. Collaborative robots (cobots) are robots designed for direct H–R (human-robot) interaction in a shared workspace or where humans and robots are in direct contact. Collaborative robot programs differ from traditional PR programs, in which robots are isolated from contact with humans. As defined by the International Organization for Standardization, a cobot is a robot that can be used in collaborative operations where robots and humans work simultaneously within a defined workspace for manufacturing operations (this does not include robot-to-robot systems or co-located humans and robots working at different times). Collaboration (in the context of industrial robotics) is the process of joint performance of an operation, action or work by a person and a robot to achieve a set goal. Collaborative operations are a defined sequence of actions between a CPR and a person, which as a result leads to the performance of a specific task or work. Collaborative technological system (CTS) is a technological system in which CPR, with which people work together, is used as universal flexible means of automation. A collaborative workspace is a shared workspace of a person and a CPR in which collaborative operations are performed. Human – Robot interaction (Human – Robot interaction HRI) is a process of interaction between people and robots in various aspects of life. But the definitions proposed above are not enough, according to the authors, as a result, to describe the technological process using collaborative manipulator robots, new concepts can be introduced that expand and detail the interaction between a person and a robot in various phases of the production process. Below are new concepts proposed by the authors to expand the description of the technological process of human and cobot collaborative work:

- interactive motion control of a robot-manipulator (Interactive Motion Control) is a process in which a person directly controls individual actions of a robot-manipulator using gestures, voice commands or a special interface. The robot reacts to these commands in real time, adjusting the movement trajectories, ensuring the most accurate performance of the task. This increases the accuracy and speed of interaction in complex production processes.

- predictive human-robot interaction (Predictive Human-Robot Interaction, PHRI) - this approach assumes that the robot is able to predict the operator's actions based on sensor data, analyzing the operator's movements, position and even emotional state. Thanks to this, the robot can prepare for the next actions, minimizing waiting time and increasing the efficiency of the process.

- Adaptive Task Allocation is a technological scheme in which the system automatically determines which operations will be performed by a robot and which by a person, depending on the complexity of the tasks, the load on the operator, and the physical capabilities of the robot. This can be useful in scenarios where some tasks are better performed by a human due to its creative problem-solving ability, and others by a robot due to its ability to perform precise, repetitive actions.

- dynamic synchronization (Dynamic Synchronization) is the process of synchronizing the actions of a person and a robot in real time, when the manipulator robot constantly adjusts its movements in accordance with the movements of the operator. This allows you to perform precise operations, where a quick reaction of the robot to changes in the environment or human actions is required. Synchronization involves analyzing the trajectories and forces applied by both the human and the robot.

- intelligent feedback (Intelligent Feedback Loop) - in this case, the robot receives from a person not only sensory information about actions, but also analytical or emotional signals through special sensors. For example, the system can analyze a person's facial expressions or voice to determine the level of satisfaction with work and adjust its actions accordingly, increasing or decreasing speed, adjusting the force of capture.

- Virtual Control Zone is a concept according to which the manipulator robot has a virtual area that defines the limits of its actions. A person can use interfaces or sensors to change these boundaries, expanding or narrowing the robot's workspace depending on the specifics of operations. This allows you to control the robot in narrow areas of the workspace without reducing its functionality.

- Collaborative Precision Assembly is a specialized operation in which a person and a robot manipulator work together on complex prefabricated structures. The robot performs precise operations such as fastening or manipulation of small parts, while the human is responsible for quality control, inspection and possible adjustment of the robot in case of unforeseen situations.

- Multimodal H-R Integration is an approach in which various channels of perception are used for effective human-robot interaction - visual, auditory, tactile, as well as biometric data (for example, pulse rate or stress level). This allows the cobot system to adjust to the operator and ensure comfortable, safe and productive work.

- Coordination-Dependent Workflow is a process in which a person and a robot depend on each other during the execution of a task. The execution of certain actions by the robot is possible only after the completion of a certain stage by a person, and vice versa, the work of a person also depends on the robot. This sequential and synchronized operation allows complex tasks to be performed with increased accuracy.

- Interactive Learning System - this system allows the work to learn directly from the operator, remembering actions and improving its own algorithms for further tasks. This training can take place in real-time, where the robot manipulator prompts or co-operates with the operator, and automatically analyzes its performance and suggests adjustments.

These new concepts will help in creating efficient technological processes using collaborative manipulator robots, promoting deeper interaction between humans and robotic systems.

Conclusions. In the conclusions, it can be noted that new concepts of human interaction and collaborative manipulator robots within the framework of Industry 5.0 are aimed at increasing the efficiency, flexibility and safety of production processes. Interactive and predictive systems allow robots to adapt to operator actions in real time, ensuring accuracy and speed of task performance. Intelligent feedback, adaptive division of tasks and multimodal integration create conditions for more natural and harmonious cooperation between humans and robots, which is a key success factor in the new era of robotics, where personalization of production processes and orientation to human needs becomes important.

References:

1. Zafar, M. H., Langås, E. F., & Sanfilippo, F. (2024). Exploring the synergies between collaborative robotics, digital twins, augmentation, and industry 5.0 for smart manufacturing: A state-of-the-art review. *Robotics and Computer-Integrated Manufacturing*, *89*, 102769.
2. Rahman, M. M., Khatun, F., Jahan, I., Devnath, R., & Bhuiyan, M. A. A. (2024). Cobotics: The Evolving Roles and Prospects of Next-Generation Collaborative Robots in Industry 5.0. *Journal of Robotics*, *2024*(1), 2918089.
3. Gurin, D., Yevsieiev, V., Maksymova, S., & Alkhalaileh, A. (2024). MobileNetv2 Neural Network Model for Human Recognition and Identification in the Working Area of a Collaborative Robot. *Multidisciplinary Journal of Science and Technology*, *4*(8), 5-12.
4. Abu-Jassar AT, Attar H, Amer A, et al. Development and Investigation of Vision System for a Small-Sized Mobile Humanoid Robot in a Smart Environment. International Journal of Crowd Science, 2024, https://doi.org/10.26599/IJCS.2023.9100018
5. Gurin, D., Yevsieiev, V., Maksymova, S., & Alkhalaileh, A. (2024). MobileNetv2 Neural Network Model for Human Recognition and Identification in the Working Area of a Collaborative Robot. *Multidisciplinary Journal of Science and Technology*, *4*(8), 5-12.
6. Gurin, D., Yevsieiev, V., Maksymova, S., & Alkhalaileh, A. (2024). Using Convolutional Neural Networks to Analyze and Detect Key Points of Objects in Image. *Multidisciplinary Journal of Science and Technology*, *4*(9), 5-15.
7. Yevsieiev, V., & Gurin, D. (2023). *Comparative Analysis of the Characteristics of Mobile Robots and Collaboration Robots Within INDUSTRY 5.0* (Doctoral dissertation, European Scientific Platform).
8. Gurin, D., Yevsieiev, V., Maksymova, S., & Abu-Jassar, A. (2024). Effect of Frame Processing Frequency on Object Identification Using MobileNetV2 Neural Network for a Mobile Robot. *Multidisciplinary Journal of Science and Technology*, *4*(8), 36-44.
9. Yevsieiev, V., Maksymova, S., & Alkhalaileh, A. (2024). Improvement of SUSAN Image Filtering Method for PCB Quality Inspection. *Journal of Universal Science Research*, *2*(7), 106–116.