

We are pleased to introduce you to Fraunhofer TechFlash - Fraunhofer’s Flash News on latest and exciting technologies. This TechFlash is about a press release on >>**Cognitive Robotics**<<, an innovation for humans and machines working together effectively.

Cognitive Robotics, and new safety technologies for Human-Robot collaboration

Fraunhofer Institute for Factory Operations and Automations IFF, founded in 1991 in Madgeburg, Germany, a major Fraunhofer institute works on applied research for advanced industrial technologies in sustainable manufacturing & logistics (flexible automation and energy efficient production planning), energy systems (cross-sector system simulation and renewable system integrations), and human-robot collaboration (cognitive and collaborative robotics). They take a holistic product & process lifecycle approach: from ideation → digital engineering → prototype → pilot → scale-up → recycling.



Image 1 – visible light curtains around the workspace as safety lines

Researchers at the Fraunhofer Institute for Factory Operation and Automation IFF have developed advanced cognitive robot capabilities which can now master the complex, previously un-automatable, tasks for various applications including manufacturing. With >>**PARU**<< (Projection based Augmented Reality User safety system), patent pending, and >>**CAS**<< (Computer-Aided Safety), they are also presenting safety technologies and planning tools for close human to machine collaboration that can also safeguard the critical AI-generated robot movements.

The researchers have demonstrated the capabilities of cognitive robotics and how dynamic workspace monitoring works at Automatica in Munich from June 24 to 27, 2025.

- With new AI-based solutions, researchers at the Fraunhofer IFF are giving robots the cognitive abilities necessary to operate autonomously in unstructured, changing environments and to automate complex processes such as assembly and disassembly in industrial settings or the handling of objects in the healthcare sector.
- Projection and camera-based safety technologies enable robots with AI-based motion control to respond reliably to changes, adapt to new tasks, and operate the application safely.
- Cognitive robots can learn from experience, make independent decisions, and adapt to different scenarios.
 - For pick-and-place tasks that involve picking and placing components, a cognitive robot no longer needs to learn what the individual workpieces look like before it can pick them up. Instead, it uses its camera to capture the size, shape, texture, and condition of the object and adapts its behaviour, accordingly, coping with different environmental conditions and even handling different packaging materials.
- The experts use simulation environments to train the AI models they employ.
 - For example, they simulate assembly and disassembly processes – such as removing motherboards from a PC. In the digital space, any number of virtual robots can train in parallel and at a much faster pace without security concerns.



Image 2 – AI based pick & place task

Learning in digital simulation has many advantages, but also one weakness: the virtual learning environment never fully corresponds to the real world. The challenge for the researchers is to close the reality gap, also known as the Sim2Real gap, as much as possible.

Digital Twin: Machine learning models are trained extensively in simulation as identical to reality as possible or to cover as many variations of reality as possible so that the neural network used for the AI learns to generalize and navigate unfamiliar environments and is achieved by domain randomization. For example, we can change a set of parameters during training, like lighting. The robot doesn't learn to solve the exact simulation, but rather understands the abstract concept behind it. Reality essentially becomes a new version of a simulation for the AI.

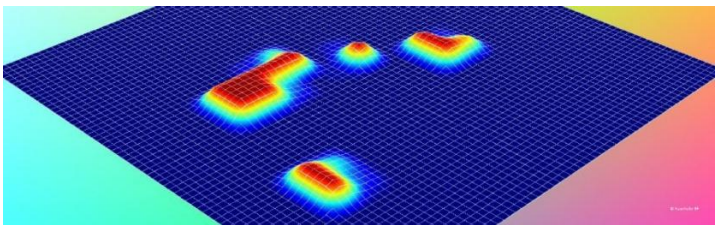


Image 3 – tactile sensor system for precise process monitoring

- >>**PARU**<< (Patent Pending): It uses modern projector and camera technology to project visible warning and protective fields directly around the machine and detect the intrusion of people into the safety zones.
 - After intelligent calibrating the projector and the two cameras, virtual expected images are first generated.
 - The projector then projects a visible light curtain around the robot and the component to be grasped according to the distance formula from the relevant standard (ISO/TS 15066).
 - This light curtain, acting as a safety line, visualizes the protective space for employees that must not be violated by humans. If a part of the worker's body encounters the line, it is interrupted. The cameras detect that the expected image and the actual image differ – depending on the need, the robot immediately stops its movement or slows down.
 - No other system allows a closer distance between humans and robots while complying with the normative specifications and at the same time requires such a small amount of space. This is possible because cameras and sensors detect not only the torso, arms, and heads, but even fingers.
 - The projection can also show the worker where the robot will move next, thus increasing confidence in working with machines. The additional coded visible safety lines function regardless of the ambient light. If cameras or projectors fail, the entire system is automatically shut down.
- >>**CAS**<<: it enables cost-effective and safe human-robot collaboration (HRC) applications. Unlike collision measurement, the safety acceptance tool operates entirely digitally. It considers parameters such as collision force and pain threshold and subsequently determines the maximum permissible speed of the robot. The modules can be integrated into any robot controller or existing simulation environment for planning purposes, allowing cost-effective specifications to be precisely aligned with applicable safety requirements. This prevents planning errors and saves engineering costs. Using systematically adjusted shock and clamp loads, the pain onset threshold was determined in more than 100 subjects.

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Founded in 1949, the Fraunhofer-Gesellschaft based in Germany is the world’s leading applied research organization. It offers contract-based R&D services for specific industry demand, application-oriented technology development from proof-of-principle up to market-readiness across the value chain and offers technical consultancy and feasibility studies to nearly all the industry sectors. The Fraunhofer-Gesellschaft currently operates 75 institutes and research units throughout Germany. Over 32000 employees, predominantly scientists and engineers, work with an annual research budget of €3.6 billion. Fraunhofer generates €3.1 billion of this from contract research. Our global footprint is very strong, with offices and research centres in the USA, Europe and Asia. Fraunhofer has been a long-time trusted innovation partner in India, collaborating with some of the major players in the fields of Material Science, Energy, Environment, Automotive, Electro-mobility, Production Technology, Microsystems and Smart Cities, working with Industry, Government and Public Sector.

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