Karlsruhe Institute of Technology

Division II – Informatics, Economics, and Society

KIT Center Information · Systems · Technologies (KCIST)

Institute for Anthropomatics and Robotics (IAR)
High Performance Humanoid Technologies (H²T)

The Humanoid Robot ARMAR-6

Collaborative Robot with Artificial Intelligence as Assistant in Industrial Environments

ARMAR-6 is a collaborative humanoid assistant robot for industrial environments. It can interact with humans and provide help when needed in a proactive way. The robot is the 6th generation and youngest member of the ARMAR family of humanoid robots developed at the Karlsruhe Institute of Technology (KIT). Thanks to its humanoid shape, it can use tools designed for humans, such as power drills and hammers. With its artificial intelligence capabilities, it can autonomously perform maintenance tasks in industrial facilities, recognize the need of help of its collaboration partner, and offer assistance. The robot has been designed to be versatile in its capabilities to allow acting in situations that are not foreseen at programming time.

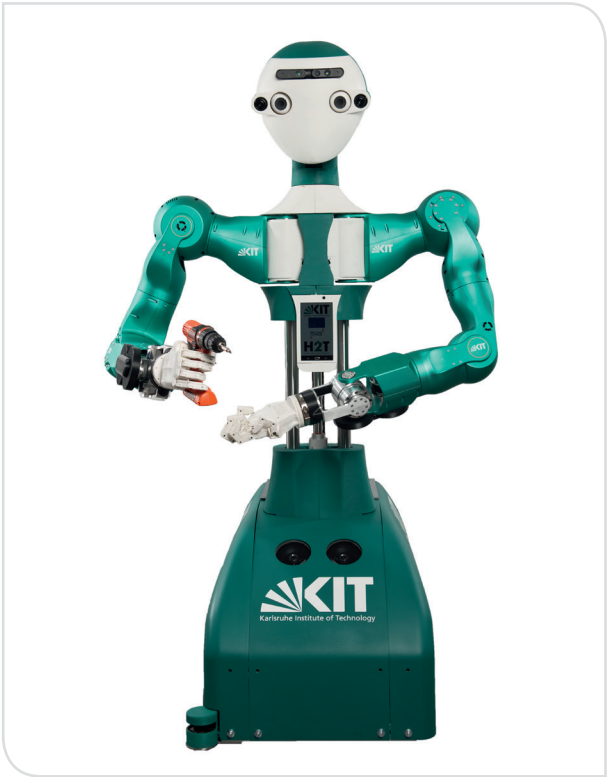

Fig. 1: ARMAR-6, a humanoid robot for human-robot collaboration.

Performant, Sensitive, Smart

Robots have been used in production and process automation for decades. They are usually highly specialized on executing a specific, repetitive task and work in safety cages separated from human workers. In contrast, Professor Tamim Asfour and his team of scientists at the KIT's Institute for Anthrompomatics and Robotics (IAR) developed ARMAR-6 to be a collaborative robot that directly interacts with humans. ARMAR-6 is equipped with 3D cameras to perceive its environment and recognize humans. Laser sensors in the robot's mobile platform ensure collision-free navigation in its environment. Precise torque sensors in all arm joints facilitate a safe and sensitive interaction when physically collaborating with humans. With its telescopic torso, ARMAR-6 can increase its working height by 40 cm to more than 240 cm and lift a weight of 10 kg per hand with its arms stretched out.

ARMAR-6 is equipped with artificial intelligence capabilities: By observing humans, the robot can learn new motion skills. These skills are improved over time by repeated execution. ARMAR-6 can decide how to grasp an object or tool depending on the next action to be executed with it. The robot explores its environment and learns to understand relationships between its actions and the perceived world. The robot's learning techniques range from purely explorative learning to teaching or coaching by humans. It can communicate with its human partner in natural language. As a real assistant, ARMAR-6 can recognize human activities and intentions, infer when a human needs help, and offer such help proactively.

Four computers in the mobile base of the robot provide the computation power required for control, image processing, and interaction algorithms as well as for machine learning and artificial intelligence methods. The software architecture is implemented in ArmarX. A battery allows for cable-free, completely autonomous operation. All joint

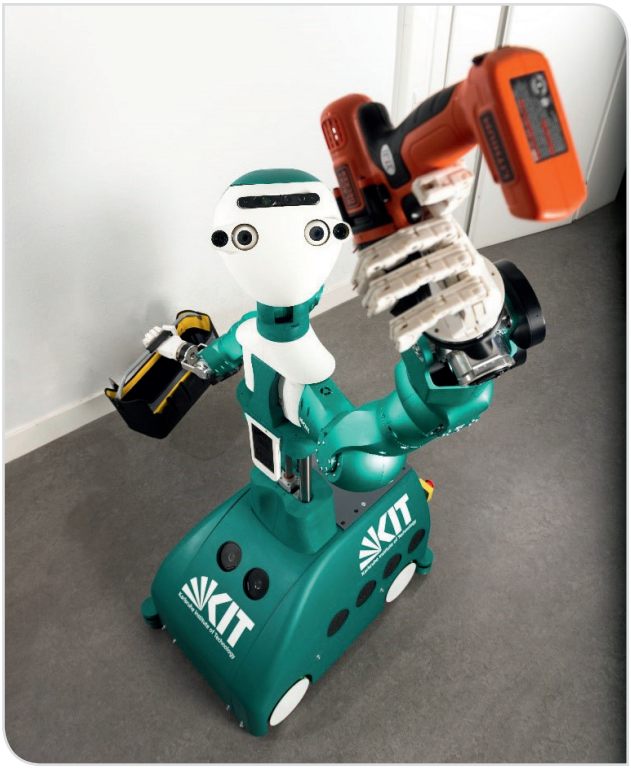

Fig. 2: ARMAR-6 assists humans proactively in difficult tasks.

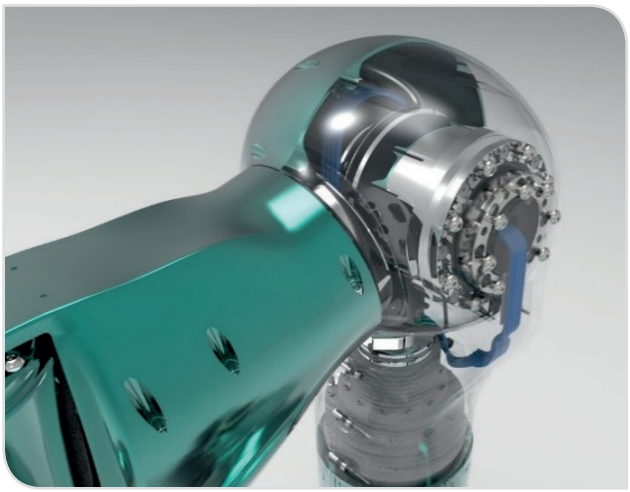

Fig. 3: Intelligent sensor-actuator-controller units.

actuators in the arms consist of specially developed, robust, encapsulated sensor-actuator-controller units containing an electric motor, reduction gear, sensors, electronics and controllers. Slip rings allow for the continuous rotation of the joints. Various control modes enable the execution of precise and force-controlled motions.

Technical Data

Characteristics	
Size	192 cm
Arm span	310 cm
Working height	0 cm – 240 cm
Weight	160 kg (without batteries)
Actuators	
Degrees of freedom	27
Lifting capacity per arm	10 kg (arm stretched out) 14 kg (average distance)
Speed	1 m/s (platform)
Sensors	
Joints	Position, IMU, torque, temperature
Interaction	6D force-torque sensors
Navigation	Laser scanners
Perception	Two stereo camera systems, depth camera, microphones
Software and computers	
Middleware	ArmarX
Computers	4 high-end PCs, 1 GPU
Bus system	EtherCAT

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The research leading to these results has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No. 643950 (SecondHands).

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