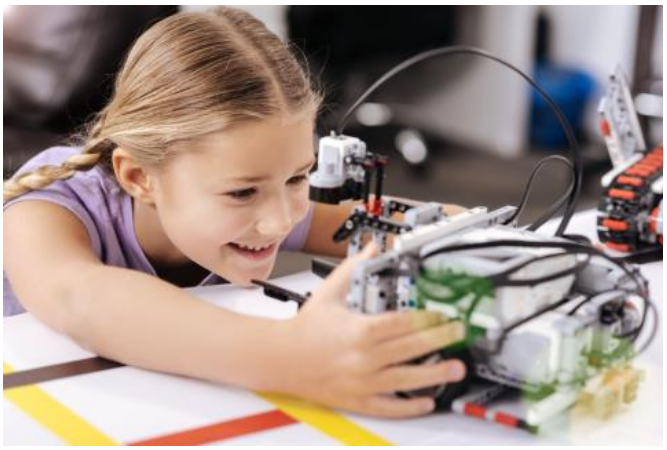
Fundamentals of robotics

Definition of Robots



Robotics is a sub-domain of engineering and science that includes mechanical engineering, electrical engineering, computer science, and others. Robotics deals with the design, construction, operation, and use of robots and computer systems for their control, sensory feedback, and information processing. A robot is a unit that implements this interaction with the physical world based on sensors, actuators, and information processing.

Areas of Application and Benefits of Robotics

Collaborative robots or cobots are becoming increasingly important. In a growing number of areas in industry, conventional industrial robots are being replaced by or backed up with collaborative robots. Cobots work together with humans in production processes and are no longer kept separate from their human co-workers with protective devices, like typical industrial robots. Compared to traditional industrial robots, collaborative robots are smaller, can be used more flexibly, and are easier to program.

Cobots don't replace human workplaces, they supplement them. Paradigm Electronics in Canada is a example: Productivity was increased by 50 percent by using cobots, and not one single job was lost. Staff carry out new tasks in newly created areas of activity, such as programming the machines and quality control at the end of the automatic production process. Experts from the Boston Consulting Group assume that in the future the use of robots will increase productivity per employee by up to 30 percent.

Industrial robots

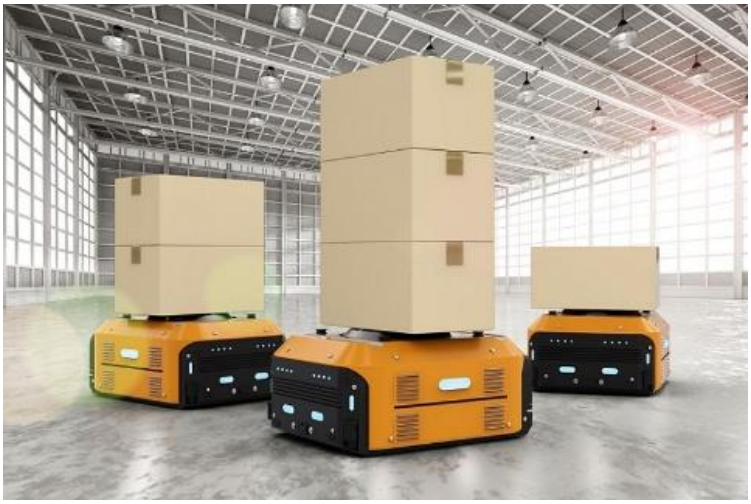
Industrial robots are programmable machines that are used to handle, assemble, or process workpieces in the industrial environment. Most of these robots consist of a robot arm, a gripper, various sensors, and a control unit. They can also carry out actions autonomously depending on how they are programmed.

Industrial robots in the automotive industry

In this key industry for robotics, machines have played an important role in automated production processes for more than 50 years to make workflows more efficient, safer, faster, and more flexible. The first industrial robot, Unimate, was integrated into the production process at General Motors in 1961. The robot was used there to remove injection molding parts. In 1973, the first industrial robot began working at VW in Wolfsburg, Germany. The in-house development, nicknamed “Robby” by its human co-workers, was used in the production process for the Passat.

Automated Guided Vehicles / AGV

An AGV is a driverless transport vehicle with its own drive that is controlled automatically and guided without touch. AGVs are typically used to transport materials in production facilities. In the industrial environment, they represent the development from the traditional, bulky conveyor belt to a space-saving, highly flexible solution. Warehouses are another popular operating place for AGVs, where individual goods or large ranges of goods are taken to defined packing stations where they are processed. This type of robot generally moves at approx. 1-2 meters per second and is able to transport payloads of up to roughly 2,000 kilograms.



Robots in medicine

As treatment aids, robots are especially used where patients have to learn how to reactivate their locomotor system after a stroke or neurological disease. People who suffer from paralysis learn to walk again and even climb stairs with the help of training machines. One robot can do the work of two therapists. Patients also receive direct feedback during the exercises. A wearable robot (exoskeleton) enables paralyzed patients to walk on their own. The step movements of the robot are triggered by the patients shifting their weight.

Robots in surgery

Robots are also found in operating theaters, where they do not replace the surgeon but are used as accurate assistants for minimally invasive procedures. Instead of using operating instruments such as scissors or forceps themselves, surgeons control a robot via a console with the help of a joystick and foot pedals. Procedures using an operation robot save time and are also less invasive for patients. Risks from human errors are minimized.

Benefits of Robotics in Healthcare

Using robotics in the medical field enables a high level of patient care, efficient processes in clinical settings, and a safe environment for patients and healthcare workers.

High-Quality Patient Care

Medical robots support minimally invasive procedures, customized and frequent monitoring for patients with chronic diseases, intelligent therapeutics, and social engagement for elderly patients. In addition, as robots alleviate workloads, nurses and other caregivers can offer patients more empathy and human interaction, which can promote long-term well-being.

Streamlined Clinical Workflows

Autonomous mobile robots (AMRs) simplify routine tasks, reduce the physical demands on human workers, and ensure more consistent processes. These robots can address staffing shortages and challenges by keeping track of inventory and placing timely orders to help make sure supplies, equipment, and medication are in stock where they are needed. Cleaning and disinfection AMRs enable hospital rooms to be sanitized and ready for incoming patients quickly, allowing workers to focus on patient-centric, value-driven work.

Safe Work Environment

To help keep healthcare workers safe, AMRs are used to transport supplies and linens in hospitals where pathogen exposure is a risk. Cleaning and disinfection robots limit pathogen exposure while helping reduce hospital acquired infections (HAIs)—and hundreds of healthcare facilities are already using them[1]. Social robots, a type of AMR, also help with heavy lifting, such as moving beds or patients, which reduces physical strain on healthcare workers.

Surgical-Assistance Robots

As motion control technologies have advanced, surgical-assistance robots have become more precise. These robots help surgeons achieve new levels of speed and accuracy while performing complex operations with AI- and computer vision–capable technologies. Some surgical robots may even be able to complete tasks autonomously, allowing surgeons to oversee procedures from a console.

Surgeries performed with robotics assistance fall into two main categories:

- **Minimally invasive surgeries for the torso.** These include robotic hysterectomy, robotic prostatectomy, bariatric surgery, and other procedures primarily focused on soft tissues. After insertion through a small incision, these robots lock themselves into place, creating a stable platform from which to perform surgeries via remote control. Open surgery using large incisions was once the norm for most internal procedures. Recovery times were much longer, and the potential for infection and other complications was greater. Working manually through a button-sized incision is extremely difficult, even for an experienced surgeon. Surgical robots make these procedures easy and accurate, with a goal to reduce infections and other complications.
- **Orthopedic surgeries.** Devices can be preprogrammed to perform common orthopedic surgeries, such as knee and hip replacements. Combining smart robotic arms, 3D imaging, and data analytics, these robots enable more predictable results by employing spatially defined boundaries to assist the surgeon. AI modeling enables robots to be trained in specific orthopedic surgeries, with precise direction for where to go and how to perform the procedures.

The ability to share a video feed from the operating room to other locations—near or far—allows surgeons to benefit from consultations with other specialists in their field. As a result, patients have the best surgeons involved in their procedures.

The field of surgical robotics is evolving to make greater use of AI. Computer vision enables surgical robots to differentiate between types of tissue within their field of view. For example, surgical robots now have the ability to help surgeons avoid nerves and muscles during procedures[2]. High-definition 3D computer vision can provide surgeons with detailed information and enhanced performance during procedures. Eventually, robots will be able to take over small subprocedures, such as suturing or other defined tasks, under the watchful gaze of the surgeon.

Robotics also plays a key role in surgeon education. Simulation platforms use AI and virtual reality to provide surgical robotics training. Within the virtual environment, surgeons can practice procedures and hone skills using robotics controls.