E-Newsletter nº4

Focus: robotics programming and main

Sector Skills Alliance
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skillman.eu

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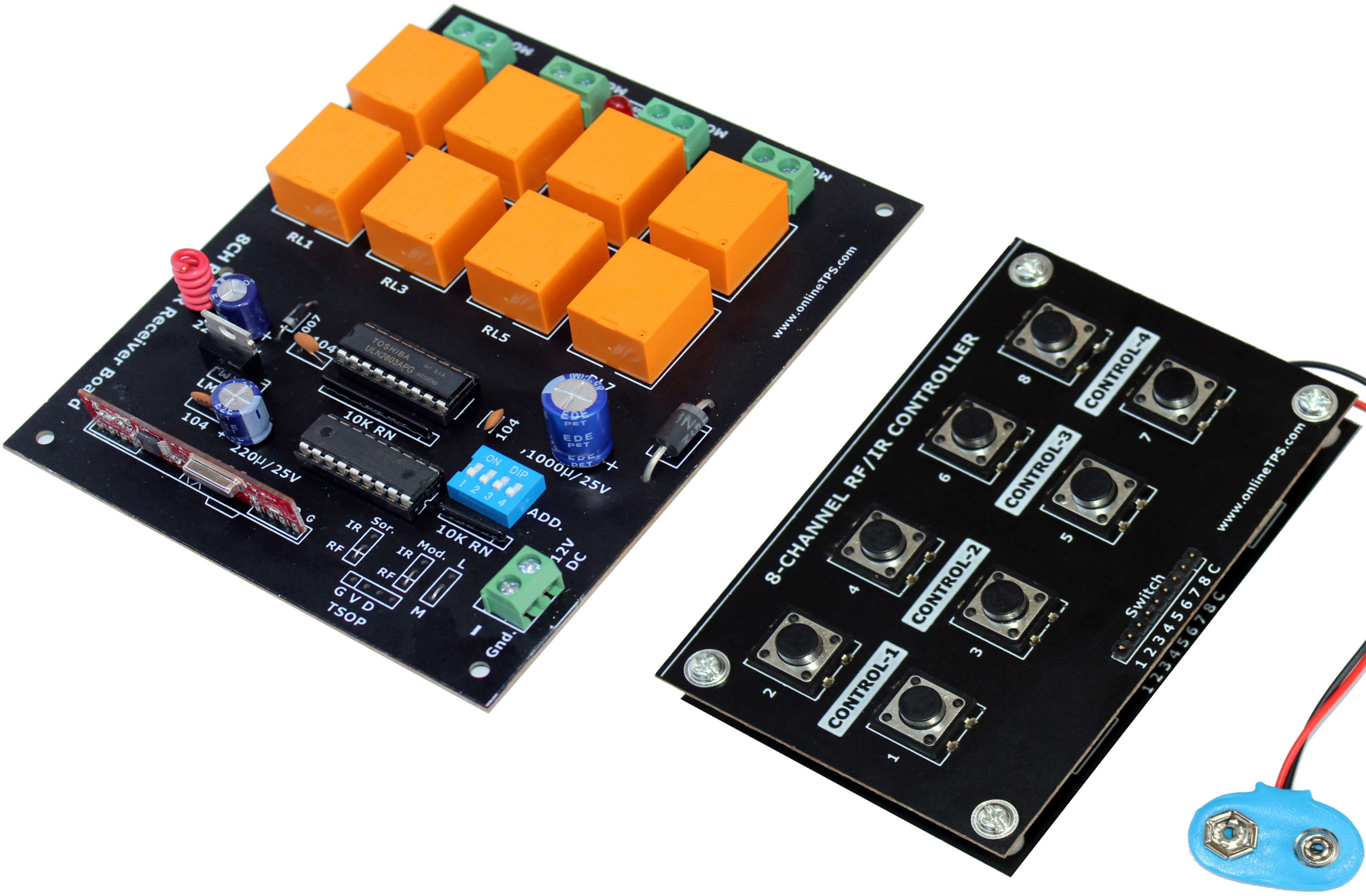


Improving Robots Sensors

Industrial robots are becoming smarter, faster and cheaper

One of problem areas, which the Sector Skills Alliance intends to answer is related to the advanced productions processes including robotics.

Industrial robots, in fact, are becoming smarter, faster and cheaper and are called upon to go beyond traditional repetitive, onerous or even dangerous tasks such as welding and materials handling. They are taking on more capabilities that are human and traits such as sensing, dexterity, memory, trainability, and object recognition. However most robots of today are still nearly deaf and blind. Sensors can provide some limited feedback to the robot so it can do its job. Compared to the senses and abilities of even the simplest living things, robots have a very long way to go. For that reason, one of the trends of research in robotics is to improve the sensing capability in regard of precise motion.

Sensor should send information, in the form of electronic signals back to the controller and give the robot controller information about its surroundings or the state of the world around it. Sight, sound, touch, taste, and smell are the kinds of information we get from our world. Robots can be designed and programmed to get specific information that is beyond what our 5 senses can tell us as for example contact, distance, light and sound level, strain, rotation, magnetism, smell, temperature, inclination, pressure or altitude. For instance, a robot sensor might “see” in the dark, detect tiny amounts of invisible radiation or measure movement that is too small or fast for the human eye to see. Sensors can be made simple and complex, depending on how much information needs to be stored.

A switch is a simple on/off sensor used for turning the robot on and off while a human retina is a complex sensor that uses more than a hundred million photosensitive elements (rods and cones). The visual sensing system can be based on anything from the traditional camera, sonar, and laser to the new technology radio frequency identification (RFID), which transmits radio signals to a tag on an object that emits back an identification code. Visual sensors help robots to identify the surrounding and take appropriate action by analyzing the imported image of the immediate environment. Touch sensory signals can be generated by the robot’s own movements and can be very useful, for example, to map a surface in hostile environment. A recent solution applies an adaptive filter robot’s logic based on an optimization algorithm that enables the robot to predict the resulting sensor signals of its internal motions. This new method improves contact detection and reduces false interpretation.

In the last years many studies addressed also the issue of using touch as a stimulus for interaction. In 2010, for example, it was built the robot seal PARO which reacts to many stimuli from human interaction, including touch. Robots can also use accurate audio sensors. Recent solutions combine e.g. piezoelectric devices to transform force to voltage and eliminate the vibration caused by the internal noise. Current voice activity detection (VAD) system uses the complex spectrum circle centroid (CSCC) method and a maximum signal-to-noise ratio (SNR) beamformer. The VAD system with two microphones enable the robot to locate the instructional speech by comparing the signal strengths of the two microphones.

Furthermore automated robots require a guidance system to determine the ideal path to perform its task. However, in the molecular scale, nano-robots lack such guidance system because individual molecules cannot store complex motions and programs. A way to achieve motion in such environment is to replace sensors with chemical reactions.

Improving Robots Smartness

What if robots and automation systems were not limited by on-board computation, memory, or software? Rather than viewing robots and automated machines as isolated systems with limited computation and memory, “Cloud Robotics and Automation” considers a new paradigm where robots and automation systems exchange data and perform computation via networks. Extending earlier work that links robots to the Internet, Cloud Robotics and Automation builds on emerging research in cloud computing, machine learning, big data, open-source software, and major industry initiatives in the “Internet of Things”, “Smarter Planet”, “Industrial Internet”, and “Industry 4.0.”

Consider Google's autonomous car. It uses the network to index maps, images, and data on prior driving trajectories, weather, and traffic to determine spatial localization and make decisions. Data from each car are shared via the network for statistical optimization and machine learning performed by grid computing in the Cloud. Another example is Kiva Systems approach to warehouse automation and logistics using large numbers of mobile platforms to move pallets using a local network to coordinate platforms and share updates on floor conditions.

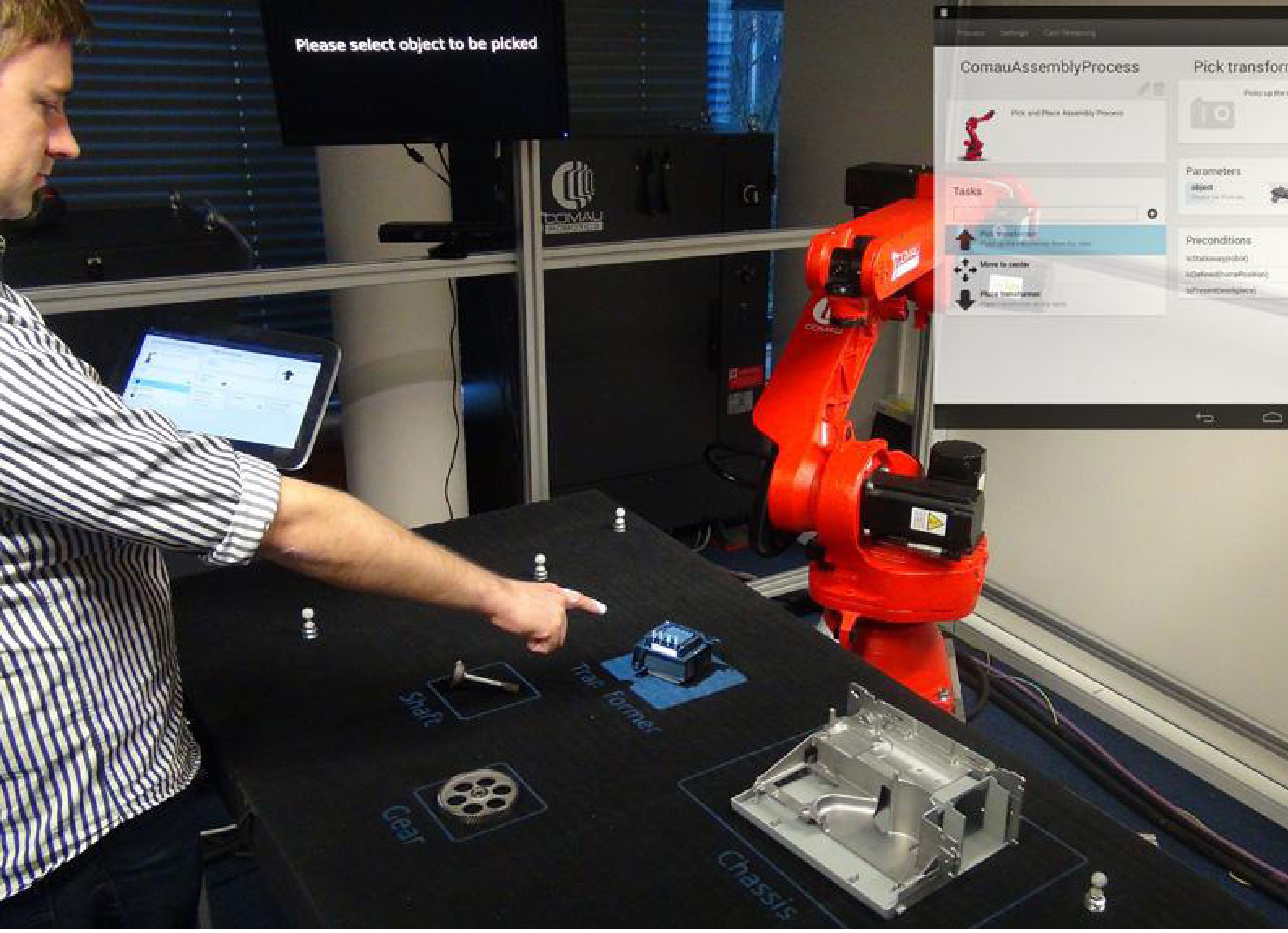
Google's James Kuffner coined the term "Cloud Robotics" in 2010. Cloud Robot and Automation systems can be broadly defined as any robot or automation system that relies on data or code from a network to support its operation, i.e., where not all sensing, computation, and memory is integrated into a single standalone system.

There are at least four potential advantages to using the Cloud:

- Big Data: access to updated libraries of images, maps, and object/product data;
- Cloud Computing: access to parallel grid computing on demand for statistical analysis, learning, and motion planning;
- Collective Learning: robots and systems sharing trajectories, control policies, and outcomes, and
- Human Computation: use of crowdsourcing to tap human skills for analysing images and video, classification, learning, and error recovery.

The Cloud can also provide access to a) datasets, publications, models, benchmarks, and simulation tools, b) open competitions for designs and systems, and c) open-source software. It is important to recognize that Cloud Robotics and Automation raises critical new questions related to network latency, quality of service, privacy, and security.

The term "Singularity" is sometimes used to describe a punctuation point in the future where Artificial Intelligence (AI) surpasses human intelligence. The term was popularized by science fiction author Vernor Vinge and Ray Kurzweil. Superintelligence, a 2014 book by Nick Bostrom, explored similar themes that provoked Stephen Hawking, Elon Musk and Bill Gates to issue warnings about the dangers of AI and robotics. Singularity is distracting attention from a far more realistic and important development that we might call "Multiplicity". Multiplicity characterizes an emerging category of systems where diverse groups of humans work together with diverse groups of machines to solve difficult problems. Multiplicity combines the wisdom of crowds with the power of cloud computing and is exemplified by many Cloud Robotics and Automation systems.



Human Robot Interaction (HRI)

Humans have interacted with robots since 1950s', from the early beginning of industrial robotics. This interaction was primarily unidirectional and specific consisting mainly of simple on-off control (e.g. using joysticks) for operating manipulator joints and remote vehicles.

Telerobotics or supervisory control of remote space or nuclear-plants robots has contributed to develop further HRI; the goal of teleoperation is to support a human to control a robot in an environment where it is inconvenient or unsafe to place a human and difficult to program a robot to autonomously perform complex operations. The telerobots represent robotic systems with own sensors, drives and computer/ decision control, however, capable of receiving supervision and tele-operation commands of human through the mediation of computers. Various interfaces have been developed in telerobotics such as various master-arms, parallel-robot masters, 6D space mice, instrumented data gloves, haptic devices (impedance displays), optical tracking systems, speech control etc.

The seminal master-slave teleoperation, tele-assistance and tele-manipulation, has evolved to more sophisticated HRI paradigms such as tele-presence, haptic rendering teleoperation with force-feedback, force-reflection etc., with improved transparency and fidelity of remote robot-environment interaction. Recent sophisticated ro bots and applications in minimal-invasive surgery (e.g Da-Vinci), for space (e.g. Robonaut), under-water and aerial robotics etc., include various forms of shared human-robot control in which both human and robot perform specific control functions in a dynamic communications. In presence of the human, the robot control provides stability and support through active constraints defined in four regions: safe, close, boundary and forbidden. For instance, after entering forbidden region the robot control provide haptic feedback amplifying the soft-tissue resistance and rendering it to the human.

Since the early development of advanced interactive robotic systems has been also more evolved in other specific fields, rather than in industry, such as rehabilitation and physical assistive robotics. To these groups belong powered lower and upper extremity active exoskeletons, active suites (i.e. wearable robots), human extenders and amplifiers etc. Specific for the initial prototypes, developed to assist disabled people with muscular dystrophy, was the adoption of specific solutions, such as switches and limited motor power, to constraint the joint motion and protect the human from injuries.

In 1990's technology and the costs limitations to make robots more flexible, intelligent and capable to work in real unstructured and varying environments, thereby performing complex skilled operations have highly motivated rapidly emerging research studies on HRI and collaborative/cooperative robots, also for industrial applications. It was widely recognized that considerable benefits will be gained if humans and robot work together, and thus combine advantages of both partners: precision, power and path control of robots, with human's dexterity, sensing, intelligence and experience. The paradigms of autonomous and fully automatic robots have been changed by new patterns, such as: semi-automation, collaborative and assistant robots. Instead to replace human, the new robot task is to help, assist and support him.

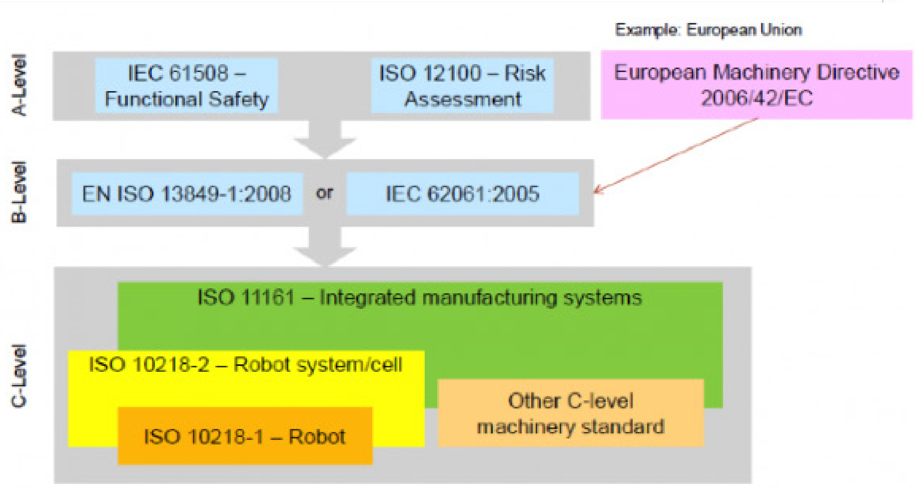
A dynamic emergence and final establishment of HRI as a specific research and application field can be definitely stated since 2000s. This period is characterized by broad and systematic studies on HRI and practical developments based on rapid advances of key enabling technologies (e.g. sensors, computation, communication, control, drives etc.). Especially actuator technology progress, from stiff drives towards motor torque control, direct drives, serial elastic (SEA) and variable impedance (VIA) technologies, have considerably contributed to the HRI systems developments. In this period also advancement on new robot and systems safety standards (ISO-10218, part 1 and 2 issued in a draft version in 2006 and as final standard at the end of 2011), has principally provided backgrounds for a wider application of HRI in industry. Namely, new ISO-10218 has revolutionized robot applications in industry allowing removing fences (so called cage-less robots), even more tolerating physical HRI (pHRI), as a most challenging interaction form in a very close proximity between human and robot. Namely, new ISO-10218 has revolutionized robot applications in industry allowing removing fences (so called cage-less robots), even more tolerating physical HRI (pHRI), as a most challenging interaction form in a very close proximity between human and robot. ISO-10218 robotic safety standard was also innovatory in this sense that it was the first case in robotic standardization that the regulations have not constrained the developments. On the contrary, they were avant-garde foreseeing application situations for which research had not mature solutions for applications. Even nowadays, we have more laboratory prototypes for safe HRI, than practical implemented solutions.

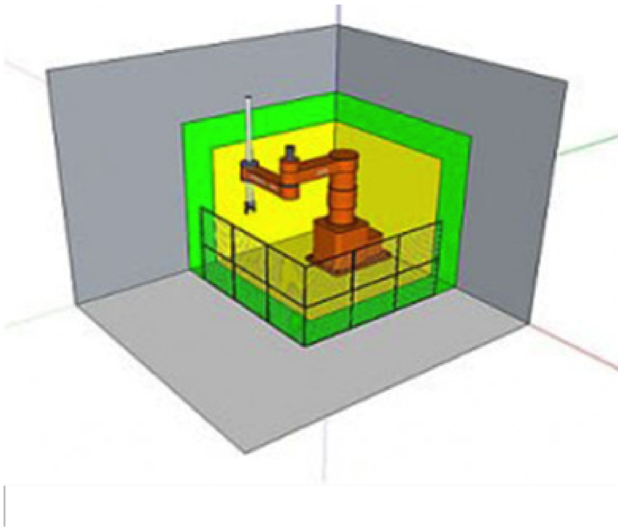
All these preconditions and rapidly growing research interest have contributed to develop new robotic paradigm. Instead of conventional: “robot design for precision, and control for interaction”, which was demonstrated to be costly, complex and always potentially dangerous, new guideline: “robot design for interaction and safety, and control for precision” has been established as most promising. Various prototypes of intrinsically safe and dependable (through both mechatronic design and control) robots have been recently developed following this paradigm.

In the industry, however, the number of practical HRI use-cases remains still insignificant in comparison to the service robotic field. It is worth mentioning several pilot-applications of Stanley-Cobotics power-assist devices (iLift and iTrolley modules and systems) mainly in USA (in Europe only one system has been implemented in Italy, before the company has been closed). A small number of Kobot systems developed by firma Schmidt-Handling and Fraunhofer IPK have been applied in Germany (Wiesheu GmbH and Wacker Chemie AG). These prototypes have been realized by enhancing power-assist handling systems with new power-assist and impedance control functionalities. In the last years, however, growing interest for HRI and power-assist devices and products can be observed in industry. The eepos-MOVE system, developed by eepos GmbH and Fraunhofer IPK and presented at MOTEK-2012 and Hannover-2013 fairs has attracted considerable interest from the automotive industry. The French company RB3D has put in 2013 a prototype of cooperative pHRI, referred to as cobot A6-15 at the market to support cooperative grinding operations. Further products have been pursued in 2014.

The workplace sharing robot co-worker have also recently gained entry in automotive industry. Universal Robot provide a certified integrated safety mode (matching Standard EN ISO 10218), supported by redundant encoders and motor current sensors that allow to safely detect contact and collision with human or environment and stop the robot motion. These novel functions allow UR-industrial robots to be able to work in the close vicinity of humans without protective housing. At BMW premises in Spartanburg (South Carolina, USA) a door sealant UR10 has been applied without fences in vicinity of a human-worker. At VW plant in Salzgitter (Germany), an UR-5 has been integrated in the cylinder head assembly section of the plant for the purpose of inserting glow plugs into the cylinder heads.

The positive experience with these seminal applications certainly opens the doors for a bigger acceptance and wider usage of collaborative and cooperative robots in industry. By using robots without guards, they can work together hand in hand with the robot. In this way, the robot becomes a production assistant in manufacture and as such can release staff from ergonomically unfavorable and non-skilled work.





New safety requirements for Collaborative Robots

Following the evolution of industrial robots, Safety Requirements for Collaborative Robots and Applications have been draw, considering the Safety Standards for Applications of Industrial Robots ISO 10218-1 and ISO 10218-2. Their definition have origin from the previous European Machinery Directive, and regulates the functions design of robotic parts, the minimum gaps to avoid crushing, the positioning of safeguard, the safety distances, the fixed and movable guards.

The Italian Organisation for National Standards, UNI, has published in 2011 the standard UNI EN ISO 10218-2, harmonizing the requirements for using safely industrial robots in the case of robot and human workspace over-position. The standard define three levels of space to be respected by the robot including the manipulated part:

- Grey area: a “maximum space” that may be reached by robot including the manipulated part.
- Yellow area: a “restricted space” that normally coincides with the “operating space”, identifying the workspace by the work program of the robot.
- Green area: a “safeguard space” defined by safety perimeter on the basis of ISO 10218-2; it may also coincide with the “restricted space”, but never may be smaller.

ISO/TS 15066:2016 Robots and robotic devices -- Collaborative robots

Self-learning Robots

A robot that can learn from watching other people could also tune fine its own actions through trial and error, essentially learning from its mistakes. That is what researchers at Lappeenranta University of Technology (LUT) in Finland had in mind when they developed a self-adjusting welding system.

LUT is developing an entirely new kind of welding system, one which solves quality and productivity problems related to automated and mechanised welding. The system is self-adjusting, flexible and adaptable, such that it can be integrated as part of different robotic systems and different manufacturers' power supplies.

It's self-adjusting properties are based on a new kind of sensor system which is controlled by a neural network program. Most often in welding a monitoring sensor is used which tracks the bevel angle, an essential part of the welding process. In the system being developed by LUT, there are also monitoring sensors for the thermal profile (the weld pool's heat values) and the weld form. The monitoring data are transferred from the sensors to the neural network, which is able to deduce and react to simultaneous changes in multiple variables.

'When a mistake is detected, the system is able both to correct it during the welding process and also calculate what other faults may arise. Thus the final product is flawless. The problem with welding automation systems is that certain values are set for the work, based on which the whole weld is carried out, and only then is it checked whether the result is good. Now the welding is monitored throughout the whole process', explains Project Manager Markku Pirinen.

In the gas-shielded arc welding process, factors affecting outcome quality include the welding current, the arc voltage, the wire feeding and transporting speeds, and the position of the welding gun. With the help of the neural network, a regulating window can be set for these system variables, and they can then be controlled so that they remain within certain limits, which ensures that final product is as required.

"In practice this means that when the welding values approach the boundary values set in the parameter window, the system corrects the process so that the welding values move back towards the centre of the value range and the possible defect is prevented."

The new system works very well with high-strength steel welding, as the parameter windows for the high-strength materials are significantly narrower than those for construction steel, and the harder the steel is, the more difficult it is to weld. High-strength steel is used, for example, in arctic steel construction work, where the materials used must be light, robust, and strong.

"In the Arctic, welds must be of higher quality than in warmer regions. In the North, errors would have catastrophic consequences. For example, the welds must be able to withstand temperature of up to -60 °C, and they must be flawless. Operating safety must be so high that no accidents occur at all", says Pirinen.

The market for the new system developed by LUT is worldwide. The system can be used, for example, in the manufacture and quality verification of pressure vessels, different kinds of containers, pipes and pipe systems, booms and beam structures. In Pirinen's opinion, the welding industry has been waiting for a control system such as this ever since automated welding came onto the market.

"This system will bring significant savings to the welding industry, as resources will no longer be required for post-welding checks and repairs. However, the system can only by used for mass-welding operations, so hand-operated welding will continue to be used for the kinds of work which the robotic welders cannot do."

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