NEW APPROACHES TO IMPROVE THE DESIGN OF HRC ROBOT APPLICATIONS (COMPUTER-AIDED SAFETY)

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Safe Human Robot Collaboration
Today's standards regarding HRC and safety

General information on HRC standards/safety

- A Robot cannot achieve CE marking, but only a declaration of incorporation, since it is an incomplete machine

=>

- An extensive risk assessment is mandatory
- The entire cell has to be considered, not only the robot (e.g. the processes, grippers, workpieces, sensors, system layout, etc.)
- There not “the” safe robot und not “the” safe sensor system
- Changes in application, layout, tool, workpiece require a new risk assessment
Safe Human Robot Collaboration
Overview of safety methods as defined by ISO/TS 15066 and EN ISO 10218

- **Safety-rated monitored stop**
  Robot stops in the moment a person steps into the collaborative space and stay in this condition after the person leaves.

- **Hand-guiding**
  Robot follow the motion commands of its operator given by a hand-guiding device (which is usually mounted close to the robot tool).

- **Speed and Separation Monitoring**
  Robot stops in case a human exceed a certain safety distance (physical contact to the moving robot is not possible).

- **Power and Force Limiting**
  Physical contact between human and robot is allowed (risk reduction due to biomechanical limit values).

- **Not in the focus today**
  Physical contact to the moving robot is not possible.
Simplifying the Realization of Safe HRC Applications

Experiences in implementing Human-robot-collaboration (HRC) applications

- High engineering effort for planning and installation (including CE process)
- High safety requirements (also considering the foreseeable misuse by the worker)
- Risk assessment validation with the robot application very extensive (use of biofidelic measuring device for collision tests with the robot in case of power and force limiting)
- Repetition/adaptation of the risk assessment in case of changes at the robot application (program, workpiece etc.)
- Autonomous robots: consideration/test/measurement of all eventualities not possible
- Challenge: risk assessment/CE-certification for autonomous/intelligent (not deterministic behavior) robots

→ Approach Fraunhofer IFF

- Determination of biomechanical load limits (volunteer studies) and from that creating precisely body models for collision simulation
- Digital planning and simulation tools tailored to HRC (Computer-Aided-Safety)
- Automated safety approval (Smart Safety)
Leistungs- und Kraftbegrenzung

Schutz des Menschen vor gefährlichen Kollisionen mit dem Roboter durch Einhaltung biomechanischer Belastungsgrenzen

- Taktiler Fußboden realisiert die Sicherheitsfunktion
- Auflösung ca. 10x10 cm
- Erkennt die Bewegungsrichtung und Annäherungsgeschwindigkeit von Personen
- Projektion nur zur Visualisierung von Sicherheits-, Warn- und Schutzbereich
- Interaktionsmöglichkeiten über ausgewiesene Schaltflächen
- Produktisierung des Fußbodens durch Firma Pilz ist in Arbeit
Simplifying the Realization of Safe HRC Applications

Computer-Aided-Safety: novel planning tools for HRC-applications

„Computer-Aided-Safety“: efficient tools for planning and developing safe Human-Robot-Collaboration

- Significant reduction of engineering effort for planning, design and installation of safe HRC applications (Computer-Aided Safety)
- Simulation of robot AND safety sensors AND plant layout, inclusion of safety standards and guidelines
  - early evaluation of key-performance indicators (cycle time, required space and investment)
  - Optimization of applications feat. HRC during the entire design phase
  - Using models and simulation data for virtual and on-site commissioning of the entire application
  - Preliminary validation of safety requirements and support of the CE certification process on-site
  - Plug-Ins for commercially available design and simulation tools

→ Approach of Fraunhofer IFF

- Providing cloud-based services for supporting the design of HRC applications
- Integrating the services into usual design tools as plug-ins

alignment of safety requirements from standards (ISO/TS 15066)
The application is a palletizing robot that stacks boxes coming from a conveyor.
Computer-Aided Safety
Power and Force Limiting
Challenge: safety vs. autonomous robotics !!

Autonomy:
- Sensory perception of the environment, intelligence in perception
- Independent task planning and motion execution by the robot
- Integration of machine learning and artificial intelligence methods/technologies
- Fault tolerant behavior / action of the autonomous robot

=> today’s safety approach (risk analysis, certification of robot system) usable?
Autonomous Robots and Human Robot Collaboration
Example “robot autonomy”: opening a hatch with unknown trajectory or doors
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