Computer-Aided Safety and Risk Prevention –
*Pushing collaborative robotics from isolated pilots to large scale deployment*

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Computer-Aided Safety and Risk Prevention
Overview of Presentation

- Introduction
- State of the art for design and implementation of collaborative robotics applications
  - Barriers to widespread use
- Challenging safety aspects
- Example of planning tools
- Our vision for Computer-Aided Safety (CAS)
- Implications of new approach
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Challenges, Motivation

**Challenges**
- Demographic change
- Lack of skilled personnel
- Production in high-wage countries
- Cost effectiveness
- Quality improvement
- New production concepts

**Motivation**
- Relief for humans of physical strain
- Flexible automation
- Merging of human and robot strengths
- Increase in efficiency, productivity and quality
- New facility concepts through omission of separating protective barriers

**Research priorities of the Fraunhofer IFF**
- Stationary and mobile assistance robots
- Development of new technologies for safe human-robot collaboration
- Intuitive human-robot interaction
- Intelligent robot systems

- Worker assistant with high-load industrial robots
- Capacitive sensors for proximity detection
- Manually guided robot/ safety/ ergonomics
- Tactile sensors for collision detection
- Mobile assistance robot “ANNIE”
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SoA - HRC door assembly, Adam Opel AG

Mensch-Roboter-Kollaboration
Türmontage im Fließbetrieb
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SoA - HRC door assembly, Adam Opel AG
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SoA - HRC hatchback interior paneling, Volkswagen AG
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State of the art - design and implementation of applications

1. Design phase
2. System build
3. Verification (with real system)
4. Productive operation
5. Program change (by expert)

(Multiple iterations)
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State of the art - design and implementation of applications

- Design phase
- System build
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(Multiple iterations)
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State of the art - design and implementation of applications
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Challenging safety aspects

- Incomplete information for analyzing robot motion (low granularity)
  - Robot braking distances
  - Reaction times
  - Collision forces
  - Complex interdependencies (payload, configuration, speed)

- Verification
  - Iterative process
  - Physical system needed (capital outlay)
  - Outcome unclear
  - Required after every program change

→ Economic uncertainty, low flexibility
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Challenging safety aspects

- System complexity

- Form of collaborative operation

- System integration (Sensors, Safety components)

- Process

Diagram showing the interconnection of human, robot, tool, part, and environment.
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Example of current tools

- A projection based workspace monitoring system for speed and separation monitoring has been developed in H2020 Project 4x3
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Example of current tools
Objective

- Determination of verifiable stress limits / thresholds of pain onset and injury onset (criteria for stopping tests: swelling or bruise)
- Development of an evaluated and statistically significant table on pain and injury onset thresholds (ISO/TS 15066)

Further objectives:

- Correlation between load and strain (loading variables include: geometry, area, velocity, mass)
- Testing the dependence between pain and injury onset (minor injuries)

Approach: Collision experiments with volunteers
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Study: Determination of biomechanical stress limits

Dynamic pain and injury onset (Studies 1 and 2)

Quasi-static pain onset (Study 2)
Studies on Human-Robot Collisions

Experiment: injury onset

Collision speed: 1.1 m/s
Effective mass: 16.6 kg
Maximum force: 292 N
Maximum pressure: 366 N/cm²

Result: Pain 3.5 NAS
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Our vision for CAS

Approach today

Planning

Setup/implementation

Changes

Iteration

Atlas of forces
ISO/TS 15066

Measure robot collision

Future planning/simulation tools

Planning

Setup/ implementation without iterations

Safety verification can first be done on real set-up, long process with high integration efforts

Safety verification possible during planning for early information about economic viability

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Implications

- Simplify robot programming
  - Expert knowledge no longer necessary
  - Organizational aspects
  - Human factors
- AI and safety
  - AI Sequencer
  - Reactive motions based on sensor input not previously validated
  - Transparency and acceptance

Lower economic cost of robotic systems
Open up new domains
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Implications

▪ Move verification from design-time to run-time

Where are limits of digital risk analysis?
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