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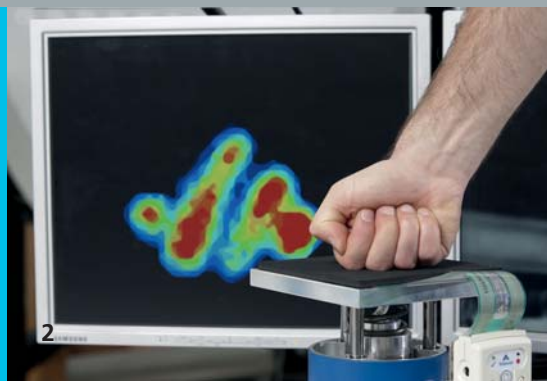

1 *IFA force measurement system.*
2 *Analyzing the pressure distribution of a fist.*

COLLISION ANALYSES FOR HUMAN-ROBOT INTERACTION

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Initial Situation and Motivation

Humans and robots will be collaborating and interacting in shared work areas in the near future. Then, people will no longer be protected by barriers from injuries but rather by a wide variety of technologies such as sensor systems and safe manipulators. Whenever a person touches a robot, a distinction is made between intentional contact and a collision. In neither case may people be exposed to any risk of injury.

Current Standards

The latest standards permit collisions that subject a human body to no more mechanical stress than what might cause slight injury to the skin, manifested by swelling or bruising. The maximum stress varies from one part of the body to another.

A comprehensive anatomical atlas, which summarizes the maximum mechanical stresses for all parts of the body, was compiled during the current standardization process. It draws a distinction between the maximum impact force and the maximum partial pressure within the stressed area in a collision and stipulates thresholds for every part of the body and both collision parameters. This anatomical atlas can be used to lay out workplaces with human-robot interaction with optimized processes, which meet with safety standards.

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Analyses of Collision Forces and Maximum Loads

A measuring unit developed by the Fraunhofer IFF has made it possible to perform collision tests with human subjects for the first time ever. The responsible ethics commission gave the Fraunhofer IFF its approval for tests with human subjects. A study of the measuring unit contracted by the German Social Accident Insurance's Institute for Occupational Safety and Health is currently being completed. Its objective is to use a scaling function to specify the relation between the maximum forces in collisions that pin a person and those that do not. In the future, this scaling function will be usable to convert measurable maximum forces of a collision that would pin a person for a situation in which people will be moving freely in space and the risk of injury is lower.

Furthermore, the Fraunhofer IFF is studying the physical and biomechanical effects of robot collisions on humans in order to identify principles of health risks and injury thresholds. Our current work is focused on measuring the maximum still tolerable stress on humans in a collision with a robot in a wide variety of cases.

Based on research findings obtained, function and design standards for the development of new technologies for safe human-robot interaction are formulated, implemented and evaluated. This entails designing tactile sensors and safe manipulators as well as establishing optimal responses of robots in the case of a collision.

Our Services

Its unique equipment and facilities enable the Fraunhofer IFF to measure every relevant physical parameter (force time curves, pressure distribution, momentum and compression) during a human-robot collision, regardless of what kind of robot is involved. We are not confined to any particular scenarios or applications. Our flexible and mobile measurement systems allow us to take measurements directly on robotic cells or on mobile robots in the Fraunhofer IFF's laboratory and at users' facilities. An entire scenario with human-robot interaction can thus be subjected to a complete and custom test in compliance with standards. We both evaluate measures conducive to safety, e.g. shock-absorbing materials, and develop custom measurement methods or systems.

Benefits

The results of collision measurements can be employed for risk analyses when laying out advanced workplaces with human-robot interaction. What is more, process flows and robot speeds in work areas with human-robot interaction can be tested and, if necessary, optimized.

Equipment and Facilities

The Fraunhofer IFF has extensive technical equipment and facilities for the systematic testing of human-robot collisions. These include a momentum measurement system, a high-resolution Tekscan pressure measurement system and a high-speed camera. The momentum measurement system is a mechanical pendulum which measures parameters relevant to collisions on human subjects. We have a one-of-a-kind, high-precision calibration system to calibrate any measurement system. The Fraunhofer IFF additionally has an IFA KOLROBOT measurement system. This system can be used to measure impact and clamping forces directly on robots. A combination of springs and shock-absorbing material reproduces various regions of the human body.

1 *Mechanical pendulum for collision tests.*
2 *Collision analyses with subjects.*
Photos: Fraunhofer IFF, Bernd Liebl