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Automation mechanisms for reduced physical demand at manufacturing workplaces

Human-Centred Factories Event

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Physical work demand in the factory

"Physical work demands – physical activity, movements, and postures at work – are amongst the dominant causes of long-term sickness absence. Physical work demands such as stationary standing, sitting, forward bending of the trunk, and arm elevation have been shown to be associated with sickness absence"

Source: Dencker-Larsen S, et al. Technically measured compositional physical work demands and prospective register-based sickness absence (PODESA): a study protocol. BMC Public Health2019

Physical Work Demand at the Workplace

- General physical activity
- Lifting
- Environment conditions (lighting, thermal environment, noise & vibration)
- Work postures and movements
- Repetitiveness

Source: Diploma of Advanced Studies (DAS) Work+Health University of Zurich and University of Lausanne

Challenges

- Introduction of automation mechanisms at the workplace (robots, active / passive exoskeletons) to increase **Productivity** and **Well-being**
  - Augmenting worker’s capabilities
  - Reducing exhausting and non-added value physical activities
  - Avoiding inadequate work postures
  - Assisting workers in prolonged and/or repetitive working tasks
  - Assisting with heavy loads

Physical Work Demand at the Workplace		
General physical activity	Lifting	Environment conditions (lighting, thermal environment, noise & vibration)
Work postures and movements	Repetitiveness	
Robotics adaptation cases	**Exoskeleton adaptation cases**	

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Robotics adaptation cases

A4BLUE project

Robotics adaptation cases

- Human-robot collaboration *(EFFRA's vision: Factories 4.0 and Beyond)*
  - Robots and workers as members of the same team throughout the factory
  - Safety and beyond (ergonomics, productivity, adaptability, acceptance)
  - Importance of human factors (user experience, trust, comfort, feeling of safety)
  - Higher levels of perception and adaptability

Deburring robot in coexistence with workers

- **CESA industrial pilot.** Auxiliary operations for the assembly process of the Retraction Actuator of the main landing gear of a single aisle commercial aircraft

- **Motivation**
  - **Improve safety conditions.** Reduction of metal chips impacts from the deburring operation
  - Improve **ergonomic** conditions of operators
  - The **automation** of a manual process **to reduce dependence on manual work,** reduce process variability
  - **Increase productivity** and **quality**

Demo video in the afternoon session

Deburring robot in coexistence with workers

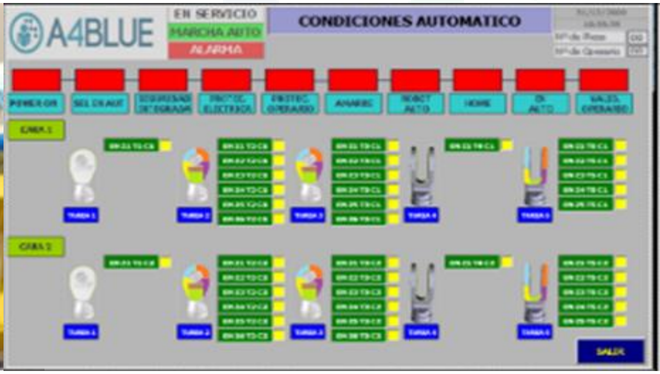
› **Challenges & Vision/Results**

Safety and ergonomics

- Remove repetitive, non-motivating operations
- Improve ergonomics
- Mitigate risks (metal chips)
- Increase satisfaction

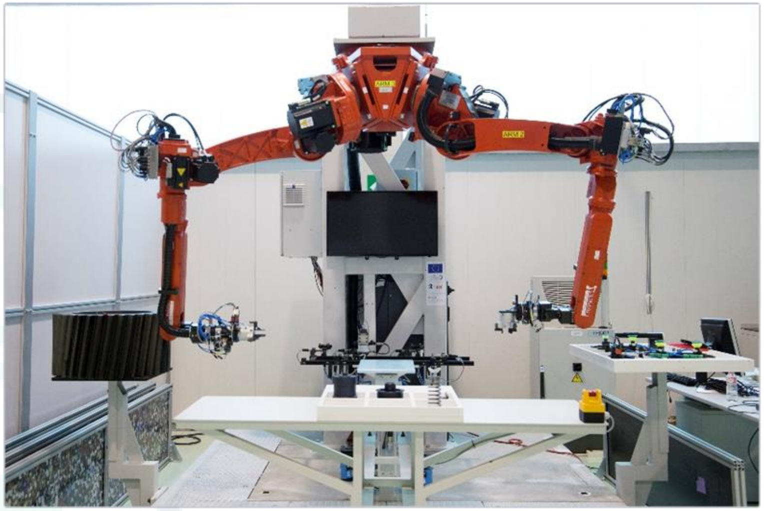
Automate deburring operation

- Reduce most exhausting phase of the process
- Workers perform more added value tasks
- Increase of productivity



Collaborative robot in assembly

- **IK4-TEKNIKER lab pilot.** Collaborative assembly of a latch valve in a fenceless environment, including auxiliary activities



- **Motivation**
  - Adaptation to **human variability** by reducing **work demands** (i.e. physical or functional capabilities or skills needed to perform a task) and **workers' physical/mental workload** through automatisms adaptation capabilities
  - Enhancing **close cooperation and co-existence** between human and robots.
  - **Rising safety** (and trust) in shared, fenceless, workplaces involving both industrial and mobile robots by introducing new active safety measures able to adapt the robots' behaviour to the context (i.e. considering both proximity and person and body part recognition);
  - Improving **usability** and **worker's satisfaction**.

Demo video in the afternoon session

Collaborative robot in assembly

› Challenges & Vision/Results

Adaptation to worker's profile

- Parametric programs that consider worker's anthropometric characteristics

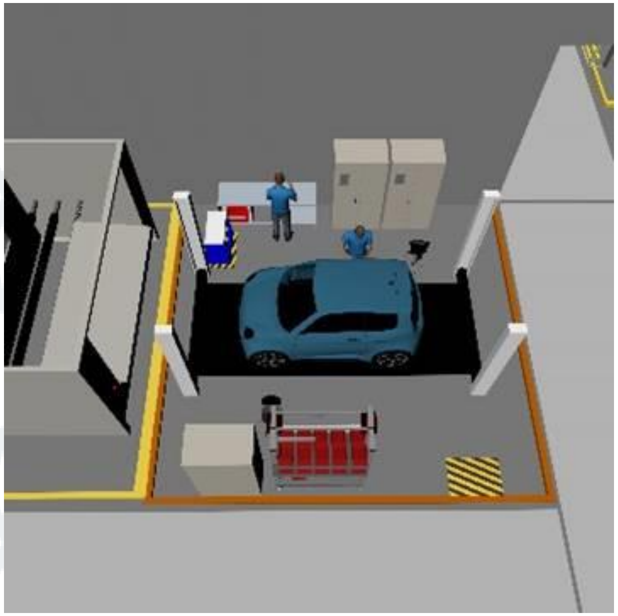
Active safety

- Adaptation of the robot behaviour (speed) based on safety related criteria
- Detection of human presence and proximity
- Identification of human body parts

Autonomous tool trolley in assembly

- **RWTH lab pilot.** Final assembly of small electric car (break module and rear lights) at the ramp-up factory Aachen, involving provision of required tools

- **Motivation**
  - Improving **ergonomics** of the tool supply process by eliminating the unfavorable pushing task of the heavy tool trolley and instead installing an automated, electric driving tool trolley in the assembly
  - **Minimizing** the **waste** in assembly by reducing non-valuable working time and effort (eliminating unnecessary ways such as tool fetching ways by moving the tool trolley to the worker automated)



Autonomous tool trolley in assembly

› **Challenges & Vision/Results**

Improving ergonomics

- Tool trolley (heavy weight) automatization avoid ergonomic problems

Minimizing non-added value activities

- Minimize / eliminate worker's way to get to the tool trolley and back
- Reduce worker's effort

Demo video in the interaction presentation and afternoon session

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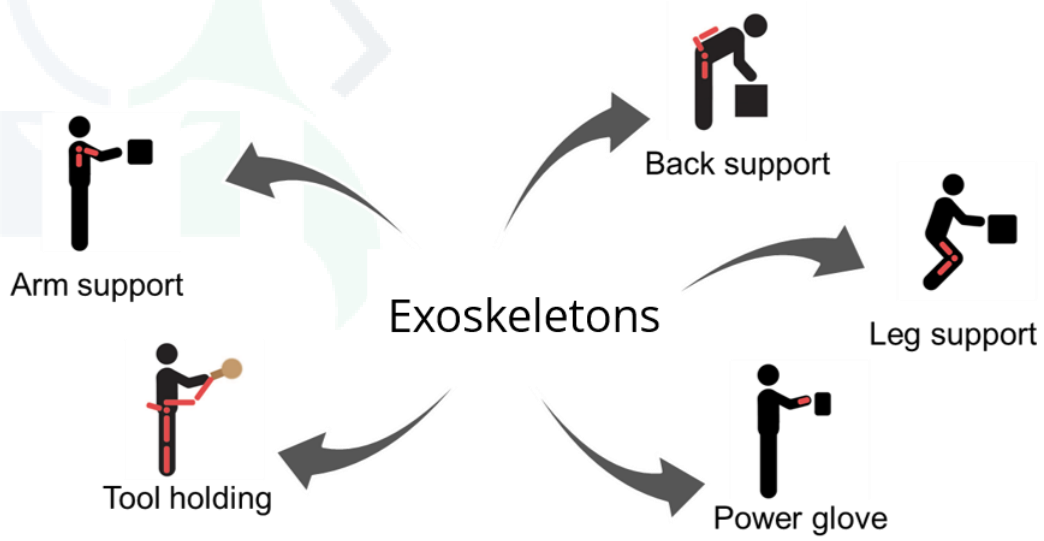
Exoskeleton adaptation cases

HUMAN project

Exoskeleton adaptation cases

- Despite automation is widespread in industrial workplaces, workers are still required to perform physically demanding tasks, such as manual handling of heavy goods in manufacturing and logistics.
- **Exoskeletons** as a new technological tool for tackling the occurrence of work-related musculoskeletal diseases by assisting workers in performing repetitive and even strenuous jobs.
- Exoskeletons can be categorized into passive and active devices, depending on whether they have powered actuators or not

- The HUMAN project selected two use-case scenarios where exoskeletons can be applied:
  - Overhead prolonged tasks
  - Repetitive lifting of boxes



Upper-limb exoskeleton

- **Use-case scenario:** Working activities in which operators have to work with their arms elevated for prolonged time periods during the entire shift can cause pain and injuries at the level of the shoulders articulation.

Examples from the state of art

- Passive **upper-limb exoskeletons** can relieve part of the arm weight and reduce the effort done by shoulder muscles.

Pelvic exoskeleton

- **Use-case scenario:** Repetitive lifting of heavy loads increases the risk of back pain and even lumbar vertebral injuries to workers.

Examples from the state of art

- Active **pelvic exoskeletons** can help workers lift loads by providing power assistance, and therefore reduce the moment and force applied on L5/S1 joint of human body when performing lifting tasks.

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Impact / Lessons learnt

Impact

- Increased productivity
  - Reduction of non-added value activities
- Increased quality
- Augmented worker's capabilities
- Improved well-being
  - Improved ergonomics (co-existing robot, anthropometric adaptation)
  - Reduced risk of injury (metal chips)
  - Reduced risk of developing work-related musculoskeletal diseases
  - Reduced physical fatigue
  - Increased trust in human-robot collaboration environments
  - Increased worker satisfaction

Lessons learnt

- Adaptive automation mechanisms introduction (robot) is perceived by workers as **helpful**. They are not received with reluctancy but as supportive in workers' tasks at the workplace
- **Trust** is identified as a key indicator overall in the pilots. Trust experiments are critical when introducing automation mechanisms that co-operate with workers
- **Adaptation** within automation mechanisms is reported to be an **enhancement** at the workplace, according to workers
- **Workers' opinion** is key, especially for acceptance, during the **design** and **development** of adaptive automation solutions
- **Prolonged overhead** and **repetitive lifting tasks** are use-case scenarios where the use of exoskeletons can provide benefits to workers from the point of view of receiving physical support
- To proper benefit from the use of exoskeletons, workers need **enough time to practice** with them

Thank you for your time

Any Questions?