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AI and Robotics Applications in Various Sectors - Human Factors Issues - Transportation/Warehousing

Occupational Exoskeletons: Challenges and Opportunities for Human Factors, Ergonomics, and Safety Disciplines in the Workplace of the Future

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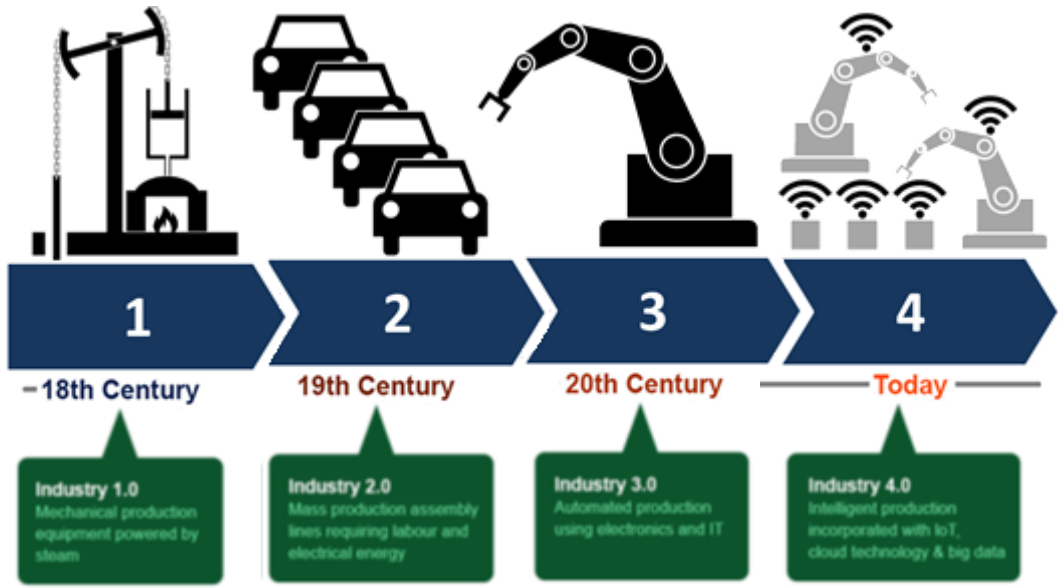
Introduction



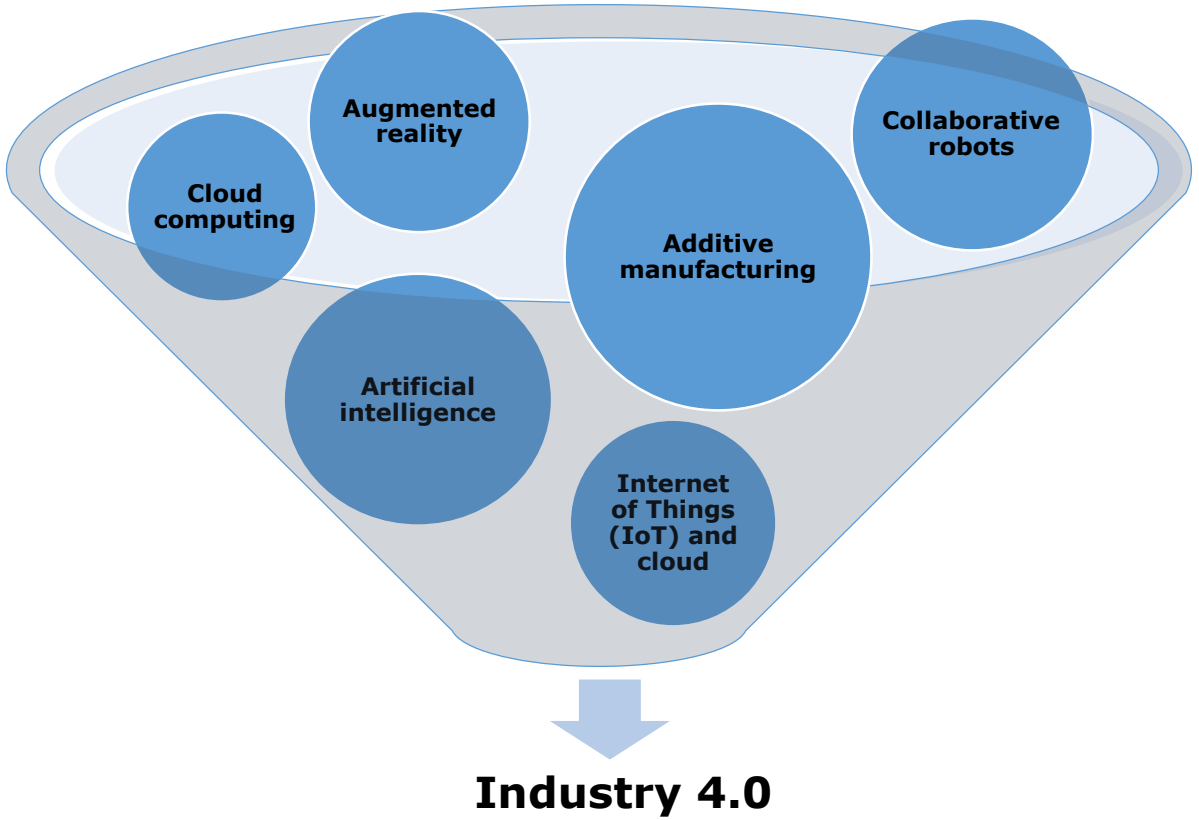
- The **new Industry 4.0 technologies will adds a new dimension of complexity in terms of the challenges machinery safety** and in this new context the European legislation have to move to innovative Essential Health and Safety Requirements (EHSRs) to guarantee safety levels at least equivalent with these current achieved.

Industry 4.0: news technological capabilities and processes

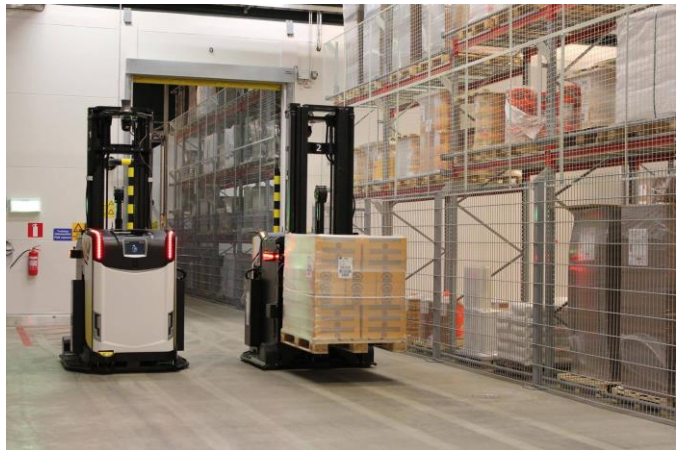
The **industrial revolution** and so **the products evolution** are always been very much driven by changes **relating to technological capabilities and processes**.

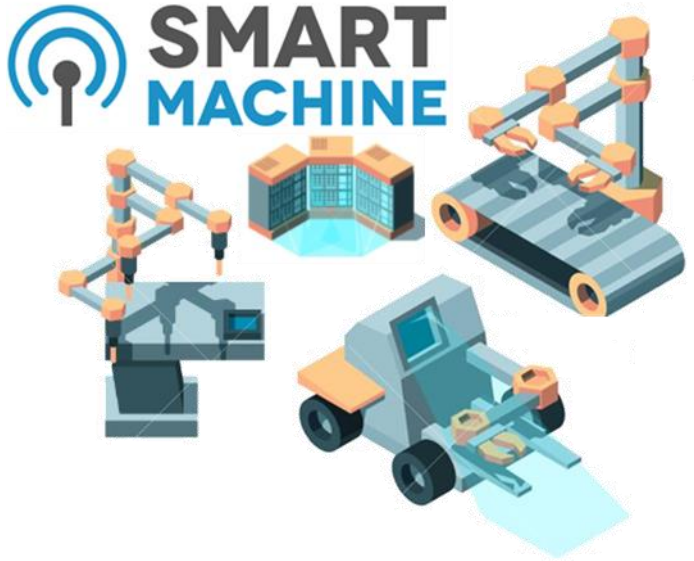
Now we are in the midst of a forth wave of technological advancement.

The **Industry 4.0 includes many pillars as news technological capabilities and processes**.



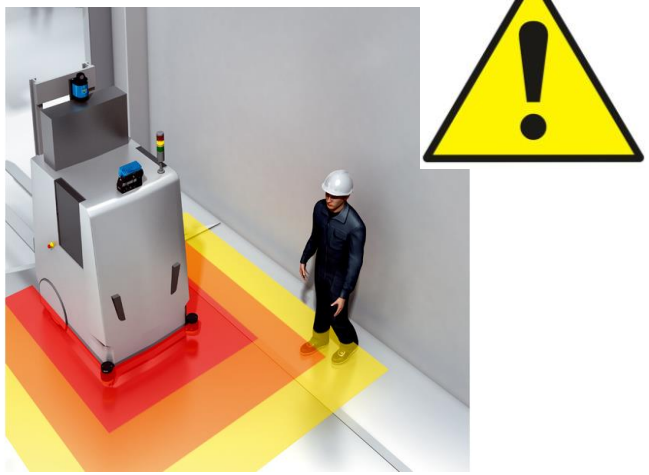
Examples AI and robot in Transportation/Warehousing sector





Examples AI and robot in Transportation/Warehousing sector

Automated Guided Vehicles (AGVs)



Autonomous Mobile Robots (AMRs)

Implications of embedded artificial intelligence on robot

1. **Limitations of the scope of existing EU legislation**
2. **Changing functionality of AI systems**
3. **Changes to the concept of safety**
4. **Robustness and accuracy**

The new European legislative framework on machinery

The **European Commission is preparing the revision of European legislative framework on machinery**. One of the objectives of the revision is **to address risks from robots and artificial Intelligence**.

Essential Health and Safety Requirement (EHSR)	Implications for robot and AI application
EHSR 1.1.2 - Principles of safety integration	Machinery should be also supplied with test procedures for updating and checking the embedded AI system.
EHSR 1.1.6 – Ergonomics	Machinery design should guarantee an adequate human-robot interfaces.
EHSR 1.3.7 Risks related to moving parts	It should be taken into account that man and automatic mobile robot share the same space without barriers and with the possibility of contact.
EHSR 1.2.1- Safety and reliability of control systems	It should be necessary developing new standard to test AI algorithm reliability when it replaces conventional systems that perform a safety function.
New EHSR related to cybersecurity risks (e.g. 1.1.9 Protection against corruption)	A new EHSR should be developed in order to take into account the emerging risks related to cybersecurity due to the connectivity between machines and others smart devices.

Case study: active occupational exoskeletons

To prevent work-related musculoskeletal disorders it becomes necessary to consider the use of exoskeleton… …tical or infeasible

Occupational exoskeletons: difficulty of acceptance by workers

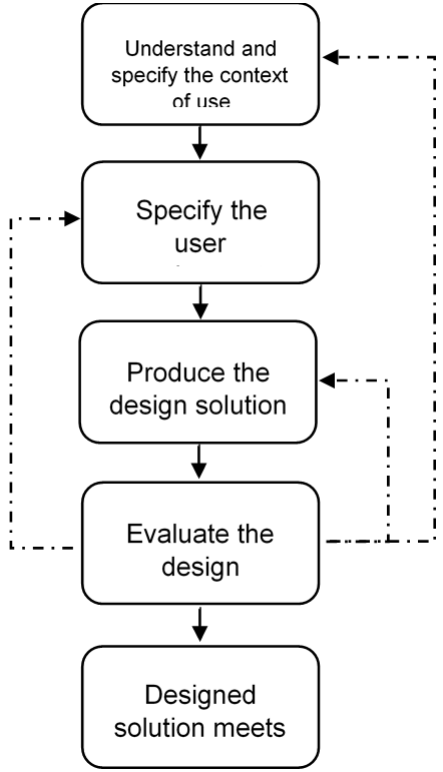
For workers wearing occupational active exoskeletons, several risk scenarios can be defined relating to their prolonged use:

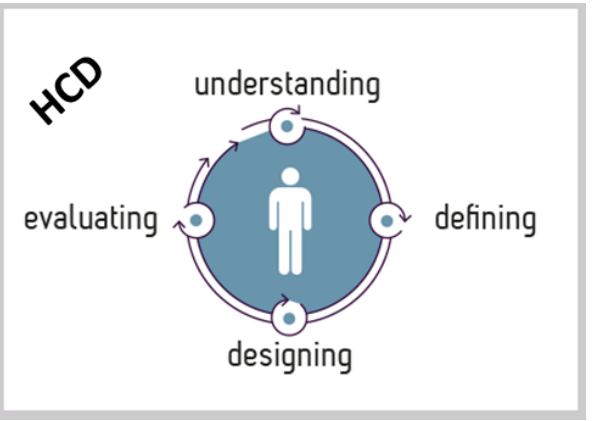
1. new potential health risks could occur for the redistribution of stress to other body regions;
2. the use of exoskeletons affects motor control, joint stability and altered kinematics of the workers body;
3. the active exoskeletons have a high weight which can affect the health of the workers;
4. ergonomic issues related to the level of discomfort associated with wearing the exoskeleton.

Furthermore the device must not only be safe, comfortable, useful and usable but, just as importantly, must be desirable to the end user. For this reason, it is advisable to resort to a human-centred design approach to involve the users (companies and workers) directly in the exoskeleton design process.

Human-centred design and occupational exoskeletons

- Human-centred design is an approach to interactive development that aims to make systems usable and useful by focusing on the users, their needs and their requirements, and by applying human factors/ergonomics, and usability knowledge and techniques.
- This approach enhances effectiveness and efficiency, improves human well-being, user satisfaction, accessibility, and sustainability, and counteracts possible adverse effects of use on human health, safety and performance.
- The EN ISO 9241-210:2019 aims to make this information available to help to develop systems following an interactive process, where appropriate. This standard is specifically for managing hardware and software design and redesign processes, but the approach can also be useful for other complex systems such as the design of an occupational exoskeleton.

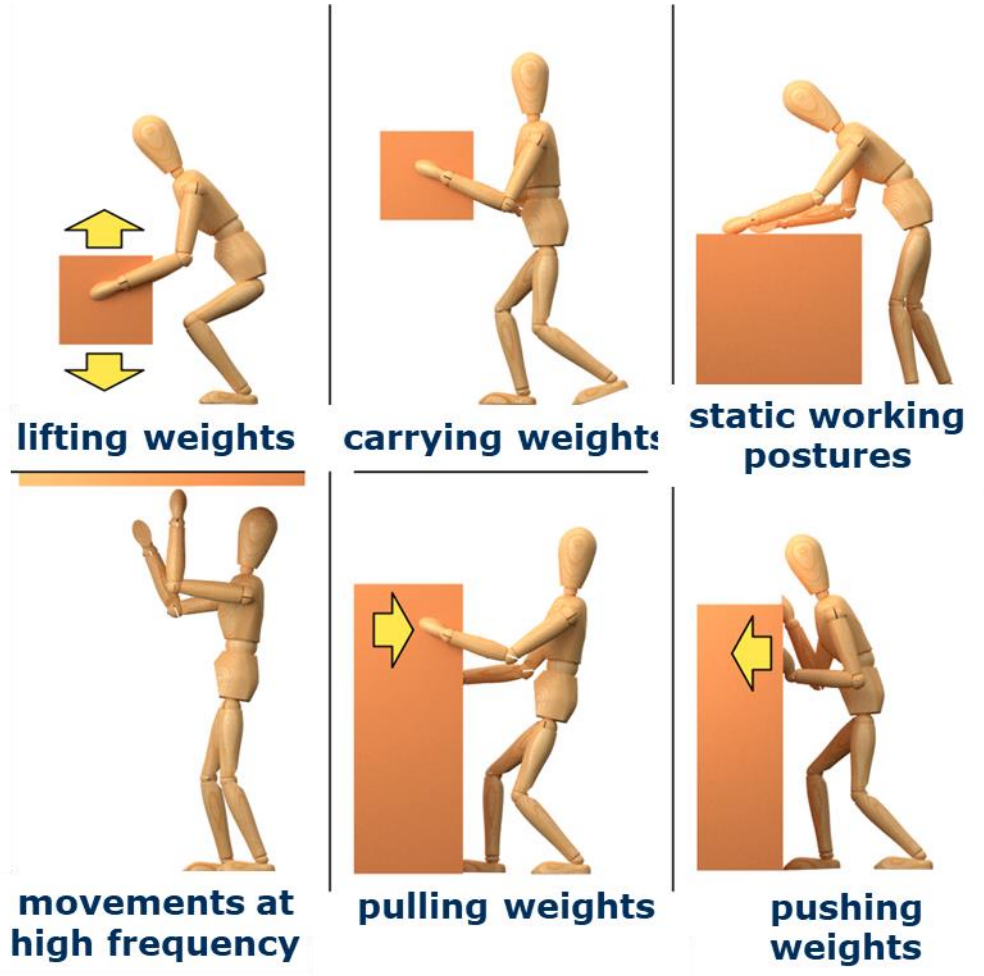




Design characteristics of a safe occupational exoskeleton with HCD process

When adopting the HCD process, understanding and describing the user context is the first step to take. Therefore, for occupational exoskeletons it is of great importance to define the characteristics of the workplace and the manual material handling (MMH) activities to be carried out by the worker. In this case it is useful to refer to the ISO/TR 12295:2014 technical report on the manual handling of loads and the evaluation of static working postures. Based on this procedure have to be define the tasks per-formed by the worker, such as:

- lifting and carrying weights,
- pushing and pulling weights,
- movements at high frequency,
- static working postures.



Design characteristics of a safe occupational exoskeleton with HCD process

Other aspects to consider at this stage relate to:

1. the handling load (e.g. mass, size/dimension, grip/handles),
2. work environmental aspects (e.g. temperature, outdoor/indoor activity, restricted spaces, work space features),
3. production conditions (e.g. times and working methods, price of the device),
4. workers' characteristics (e.g. gender, age, qualifications, skill).

Design characteristics of a safe occupational exoskeleton with HCD process

The second stage of the HCD process is specifying user requirements. In general, in the literature, the following main requirements have been identified:

1. freedom of movement (e.g. body postures, dimensions of the device),
2. comfort (e.g. postural and physiological comfortable angle),
3. environmental conditions (e.g. interaction between operators, caloric/metabolic expenditure),
4. wearability (e.g. material, shape of the device, adaptability),
5. intuitiveness of use (e.g. cognitive resources required),
6. biomechanical aspects (e.g. force/pressure in the different parts of the body, vibrations, noise, distribution of the weight on the operator's body),
7. physiological aspects and effects (e.g. right balance between activity and in-activity).

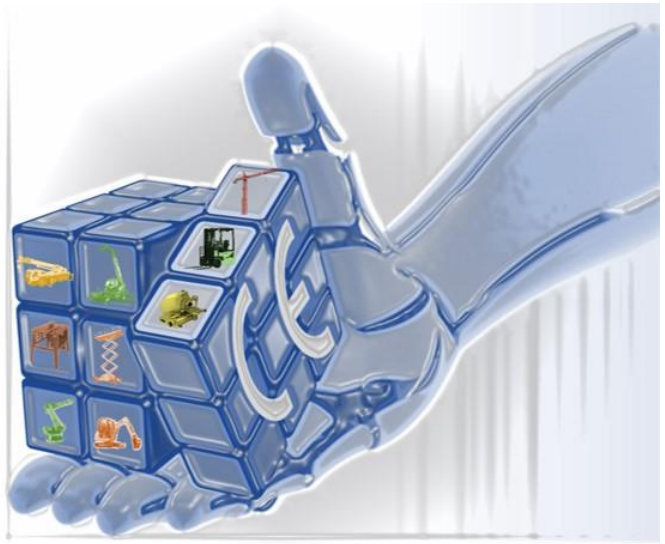
Furthermore, other secondary aspects can encourage the acceptance of the system, such as the aesthetics of the occupational exoskeleton.

Conclusions

In conclusion, the implementation of robot and artificial intelligence will adds a new dimension of complexity in terms of the challenges machinery safety.

In future, will be developed a new risk assessment methodology, that considering the new risk scenarios related with these technologies.

Also for active exoskeletons it will be necessary to develop new technical standard to approach the new risk scenario (e.g. specific methodologies for biomechanical risk assessment - The redistribution of forces applied to the body and the changes in kinematics and motor systems that the use of exoskeletons entails do not allow the application of existing biomechanical risk assessment methodologies). The HCD approach can be a tool to guarantee responding more and more precisely to the real needs that users manifest.



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Thank you for the attention!

Questions ?

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