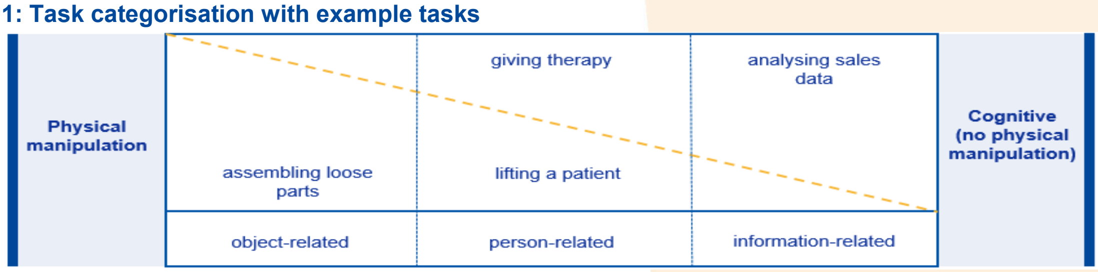
ARTIFICIAL INTELLIGENCE, ADVANCED ROBOTICS AND THE AUTOMATION OF TASKS AT WORK: TAXONOMY, POLICIES AND STRATEGIES IN EUROPE

The world of work is facing constant changes. Technological developments and innovations have been and still are key drivers in changing jobs and work tasks. Artificial Intelligence (AI) -based systems are not entirely new; however, development of information and communication technologies (ICT) and adaptive algorithms, facilitated by the extraordinary increase in computational power in recent years, has fostered a tremendous increase in the availability and performance of AI-based applications. Furthermore, the appearance and rapid development of new technologies such as robotic systems that can closely interact with humans have led to a revival of the debate on the automation potential of jobs and tasks as well as their consequences on occupational safety and health (OSH)[1]. The effects of technological changes on opportunities and challenges for OSH have always accompanied technological evolution. Yet, AI-based systems and advanced robotics hold the potential to bring about a qualitative shift in opportunities and challenges for OSH or even to create entirely new benefits and risks. Currently, there is no unified and conclusive definition of AI-based systems and advanced robotics for the automation of tasks. Two major stakeholders, the European Commission and the Organisation for Economic Cooperation and Development (OECD) have put forward independent definitions on the subject. Consequently, a taxonomy has been developed based on a task approach, high-level definitions of AI-based systems and technology characteristics. This taxonomy serves as a framework for future attempts to structure and assess opportunities and challenges for OSH associated with AI-based systems and advanced robotics and the automation of tasks.

Focus on the nature of tasks

A focus on tasks rather than jobs is a valid approach as (automation) technologies assist or substitute individual functions in specific tasks. Therefore, tasks are a better basis of analysis when investigating the impact of automation potential[2]. According to the focus programme 'Occupational Safety & Health in the Digital World of Work' established by the German Federal Institute of Occupational Safety and Health, tasks can be categorised based on their primary focus[3]. They are either **object-related**, **information-related** or **person-related.** Furthermore, the concept of routine tasks can be used to describe the nature of tasks. Whereas traditional automation technologies are mostly used for routine tasks, AI-based systems may also perform non-routine tasks. Differentiating between **routine** and **non-routine** comprises the first task categorisation layer within the developed taxonomy. To accomplish different tasks, cognitive functions, like information processing, and physical actions, like object manipulation, are necessary. As a result, the taxonomy includes the second more abstract layer of **cognitive** or **physical tasks**, which can be object-related, information-related and person-related to a variable extent. Within each category, routine and non-routine tasks can likewise occur.

Figure 1: Task categorisation with example tasks



Source: Author

[1] Frey, C. B., & Osborne, M. A. (2013). The future of employment: how susceptible are jobs to computerisation? Oxford Martin Programme on the Impacts of Future Technology.

[2] Bisello, M., Peruffo, E., Fernández-Macías, E., & Rinaldi, R. (2019). How computerisation is transforming jobs: Evidence from the Eurofound's European Working Conditions Survey (No. 2019/02). JRC Working Papers Series on Labour, Education and Technology. https://ec.europa.eu/jrc/sites/jrcsh/files/jrc117167.pdf

[3] Tegtmeier, P., Rosen, P. H., Tisch, A., & Wischniewski, S. (2019). Sicherheit und Gesundheit in der digitalen Arbeitswelt. [Proceedings of the autumn conference of the German Society for Ergonomics]. GfA-Press.

For example, the assembly of parts is a typical object-related physical task, whereas analysing sales data is a typical information-related cognitive task. Person-related tasks can be both cognitive and physical. For example, one can perform a cognitive task, such as giving a person therapy, or a physical task such as lifting a person (see also figure 1).

Heterogeneous definitions of AI-based systems

The assistance or substitution of functions to complete different tasks requires AI-based systems that entail various technological characteristics. When it comes to the definition of AI or AI-based systems, there is no single definition that is commonly accepted among scholars, practitioners or policy-makers. Different stakeholders and disciplines put forward various definitions. The OECD[4] as well the EU Commission[5] each have put forward a definition created by high-level expert groups. The OECD (2019) defines AI-based systems as follows:

> An AI system is a machine-based system that is capable of influencing the environment by making recommendations, predictions or decisions for a given set of objectives. It uses machine and/or human-based inputs/data to: i) perceive environments; ii) abstract these perceptions into models; and iii) interpret the models to formulate options for outcomes. AI systems are designed to operate with varying levels of autonomy.

The independent high-level expert group on artificial intelligence, set up by the European Commission (2019), presents the following definition:

> Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals. AI-based systems can be purely software-based, acting in the virtual world (e.g., voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g., advanced robots, autonomous cars, drones or Internet of Things applications).

Both definitions of AI-based systems commonly state that systems perceive their environments in some way, analyse information and act in response. A major differentiating aspect among AI-based systems lies in their ability to perform **physical manipulations** or actions in their environment. Hence, the **frontend (device)** layer is included in the taxonomy. One main area that has introduced many innovations to support **physical manipulations and actions** in recent years is the field of **robotics**. The range of robot types has expanded. Traditional caged and fixed robots capable of lifting heavy payloads and designed for speed and precision are no longer the mainstay in robotics. Systems with less payload as well as new generations of sensors and actuators have enabled innovative types of robots to emerge. They allow closer forms of human-robot interaction (HRI) in less structured and more complex environments outside traditional manufacturing industries. These types of systems are often referred to as **cobots** or **lightweight-robots**.

Modern information and communications technologies (ICT) are mainly deployed to support or substitute **cognitive tasks** where **no physical handling of objects or persons** is required. The entities can range from **desktop computers** and **mobile devices (smartphones, tablets)** to **wearables** like **smartwatches** or **smart glasses**. Many of these technologies have found their way into everyday life, not only in many workplaces but also in private lives. The scope of cognitive functions that ICT is able to support is steadily increasing. Along with displaying information, innovative systems are easily capable of monitoring actions as well as providing context-sensitive information in real-time. However, the analysis of existing technologies revealed that not only are ICTs used to support cognitive tasks, but a number of robotic systems also partly or wholly support cognitive tasks.

A task-based taxonomy for workplace applications and OSH

For both robotic applications and ICT, an algorithms' complexity or the degree of artificial intelligence that is implemented within these systems determines their scope of capabilities and usage potential[6]. This is represented by the **backend (software)** layer in the taxonomy. However, many robotic systems used for

[4] https://www.oecd.ai/wonk/a-first-look-at-the-oecds-framework-for-the-classification-of-ai-systems-for-policymakers

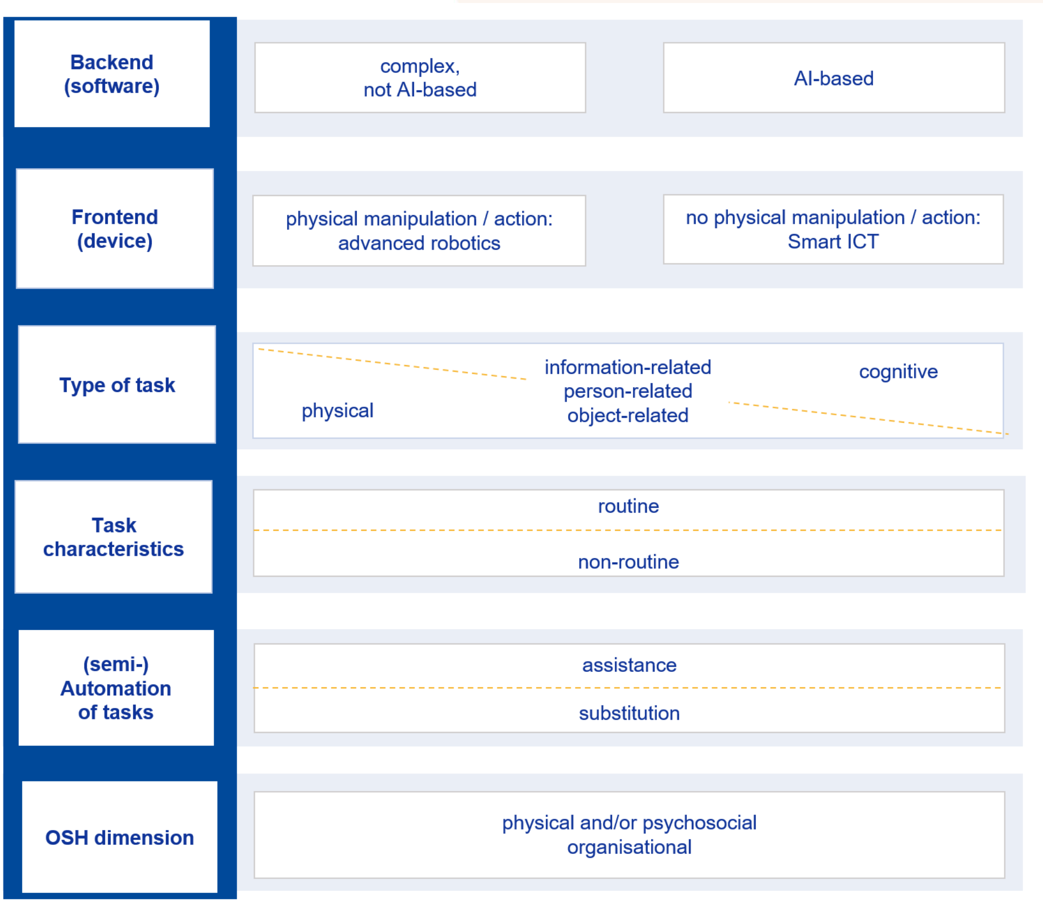
[5] European Commission, Independent High-Level Expert Group on Artificial Intelligence (2019). A Definition of AI: Main Capabilities and Disciplines. European Commission.

[6] Hämäläinen, R., Lanz, M., & Koskinen, K. T. (2018). Collaborative systems and environments for future working life: Towards the integration of workers, systems and manufacturing environments. In C. Harteis (Ed.), The impact of digitalization in the workplace. Professional and Practice-based Learning, Vol. 12 (pp. 25-38). Springer, Cham.

the automation of tasks are not purely AI-based. They rather perform their programmed task, which could be advanced, yet every action is predetermined and defined in the system's programming architecture. To also include these systems, the backend layer holds the categories **artificial intelligence** and **complex, not AI-based**. Combining artificial intelligence methods or techniques for data analytics such as **machine learning**, **artificial neural networks** or **deep learning** with advanced machinery and hardware enables AI-based systems to emerge. These can range from larger systems like advanced robotics to very small nanotechnologies in computer chips with high performance integrated into smart devices.

Hence, it is not the hardware technology that creates substantial changes in workplaces and in the interaction between workers and systems. It is the combination of the specific backend with the individual technological frontend that creates new challenges and opportunities for OSH. To address the consequences that AI-based systems have for workers' safety and health, the relevant **OSH dimensions** are also integrated into the overall taxonomy. To provide meaningful advice for prevention, policy and practice regarding AI-based ICT systems and intelligent robots in the workplace, all relevant components of a work system are considered. This includes the physical and psychosocial work environment as well as the social and organisational context[7]. Potential OSH risks and opportunities can be aligned to these dimensions accordingly. Therefore, the three global OSH dimensions of **physical**, **psychosocial** and **organisational aspects** are included in the taxonomy. Physical aspects include outcomes related to physical health like the occurrence of musculoskeletal disorders. Outcomes related to the psychosocial dimension include, for example, factors like wellbeing, motivation, stress or fatigue. Outcomes from the organisational dimension are, for example, related to the implementation process or health indices, such as productivity or absence. The complete taxonomy is presented in figure 2.

Figure 2: Taxonomy for AI-based systems and advanced robotics for the automation of tasks



Source: Author

[7] Leka, S. & Jain, A. (2010). Health impacts of psychosocial hazards at work: an overview. World Health Organization. https://apps.who.int/iris/handle/10665/44428

Overview of policies and strategies

All major European OSH relevant stakeholders present some strategy or initiative regarding artificial intelligence and its potential impact on workplaces. Most stakeholders present some form of requirements or demand principles for AI-based systems to be applied, which show similarities and shared values. Such principles for example are provided by OECD[8], the EU Commission[9], ETUI[10], ETUC[11] and the European Social Partners Framework Agreement on Digitalisation[12]. The principle that finds the highest consensus is **system transparency**, which is addressed in nearly every initiative and also in EU-OSHA's foresight study[13]. The principle of the **human being in control or preserving workers' autonomy** also finds frequent mentioning. Furthermore, the OECD and EU Commission both demand **technical robustness** as well as the **respect of human rights**, **diversity** and **non-discrimination** for AI-based systems. **Fairness** is also explicitly mentioned in the social partners' shared framework agreement. Here, within the EU Commission principles and the ETUI initiative, the aspect of **data privacy** and **data governance** are also pointed out. The aspect of **accountability** is explicitly mentioned by ETUI and the EU Commission. However, all initiatives, strategies and programmes address AI-based systems on a more general level. Yet, the addressed values and principles are to some extent related to OSH, especially to psychosocial risks and will therefore be investigated with priority in EU-OSHA's reports: "Artificial Intelligence and automation of cognitive tasks: Implications for occupational safety and health" and "Robots, cobots and Artificial Intelligence for the automation of physical tasks: Implications for occupational safety and health", as well as in the upcoming EU-OSHA's Healthy Workplaces campaign on digitalisation, starting in 2023.

Regarding national regulation, there currently is nothing specific being prepared in terms of legislation on AI-based systems and OSH, though expert level discussions with business representatives are ongoing. Standards are being discussed on AI and biometrics in cooperation with other European standardization experts. Much of the present (European and Member State) legislation covering OSH is at some level applicable when using AI-based systems and advanced robotics. Most countries report activities regarding not legally binding national initiatives, programmes or campaigns. Some countries name sectoral social partner's initiatives or guidelines, and others report recommendations by major stakeholders like ministries, research organisations, worker unions, employer organisations or manufacturers. An example of relevant activities by different stakeholders is presented for Germany in the info-box.

Germany reports campaigns on advanced robotics and smart ICT and their use in the workplace as part of the governmental **AI strategy**[14] as well as the **HighTech Strategy 2025**[15] set up by the Federal Ministry of Education and Research. Germany also mentions the German Standardisation Roadmap on Artificial Intelligence. Furthermore, Germany has two relevant initiatives worth mentioning. The platform '**Lernende Systeme – Germany's Platform for Artificial Intelligence**'[16] was launched by the Federal Ministry of Education and Research. Its aim is to bring together expertise from science, industry and society, consolidating the current state of knowledge on self-learning systems and AI. Within seven working groups comprising experts from science, companies, government and civil society, developments and the introduction of self-learning systems are discussed, actions areas are identified and practical recommendations are given. Among the seven working groups for example are 'Future of Work and

[8] OECD. (2019). AI Principles overview. Retrieved 14:37, 28 April 2021, from https://www.oecd.ai/wonk/a-first-look-at-the-oecds-framework-for-the-classification-of-ai-systems-for-policymakers

[9] European Commission. (2020). White paper on Artificial Intelligence: A European approach to excellence and trust. Retrieved 11:43, 13 April 2021, from https://ec.europa.eu/info/publications/white-paper-artificial-intelligence-european-approach-excellence-and-trust_en

[10] ETUI contributors. (5 November 2020). A law on robotics and artificial intelligence in the EU?. The European Trade Union Institute. Retrieved 09:19, 13 April 2021, from https://www.etui.org/publications/foresight-briefs/a-law-on-robotics-and-artificial-intelligence-in-the-eu

[11] European Trade Union Confederation (ETUC). (2020, July 13). Resolution on the European strategies on artificial intelligence and data. Retrieved 09:45, 13 April 2021, from https://www.etuc.org/en/document/resolution-european-strategies-artificial-intelligence-and-data

[12] European Trade Union Confederation (ETUC). (2020). European social partners framework agreement on digitalisation. https://www.etuc.org/system/files/document/file202006/Final%2022%2006%2020_Agreement%20on%20Digitalisation%202020.pdf

[13] Stacey, N., Ellwood, P., Bradbrook, S., Reynolds, J., Williams, H., & Lye, D. (2018). Foresight on new and emerging occupational safety and health risks associated digitalisation by 2025 – Final report. https://osha.europa.eu/en/publications/foresight-new-and-emerging-occupational-safety-and-health-risks-associated

[14] https://www.ki-strategie-deutschland.de/files/downloads/Fortschreibung_KI-Strategie_engl.pdf

[15] https://www.bmbf.de/SharedDocs/Publikationen/de/bmbf/pdf/fortschrittsbericht-zur-hightech-strategie-2025.pdf?__blob=publicationFile&v=2

[16] https://www.plattform-lernende-systeme.de/home-en.html

Human-Machine Interaction,' 'Mobility and Intelligent Transport Systems' or 'Health Care, Medical Technology Care.' The second initiative, '**Platform Industry 4.0**'[17] is specifically directed towards the manufacturing sector. It was also launched by the Federal Ministry of Education and Research as well as the Federal Ministry for Economic Affairs and Energy. Within this platform, there are also six working groups consisting of experts from businesses, associations, work councils and academia. They develop concepts, solutions and recommendations on key topics of 'Industry 4.0' among the working groups. The initiative further provides a transfer network for small and medium-sized enterprises (SMEs) as well as a network for international cooperation.

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[17] https://www.plattform-i40.de/IP/Navigation/DE/Home/home.html