ROBOTIC SYSTEM FOR PALLETISING AND DEPALLETISING PRODUCTS (ID7)

1 Introduction

Automating tasks through technological advancements has been an ongoing process in many industries. This development can also significantly impact occupational safety and health (OSH) in a work environment. It enables the removal of workers from hazardous situations and can improve the quality of work. This can be accomplished by automating cognitively strenuous tasks using an artificial intelligence (AI)-based system or by ‘delegating’ repetitive tasks to accurate and tireless machines like intelligent robotic systems. Some tasks might not be fully automated, but workers can still receive support through, for example, collaborative robots (cobots) operating in a shared space with workers. An increasing number of companies employ AI or advanced robotics. Although still in their infancy in terms of deployment, AI-based systems for the automation of both cognitive and physical tasks, as well as intelligent cobots, show promise in a variety of sectors. However, more information is needed on how they are implemented and managed in the workplace to help ensure workers’ safety and health in present as well as in future applications.

EU-OSHA has developed a number of case studies with the aim of investigating the practical implementation of AI-based systems for the automation of physical and cognitive tasks and of intelligent cobots in the workplace, their impact on workers, how OSH is managed in relation to such systems, and to gain a better understanding of the drivers, barriers and success factors for the safe and effective implementation of these systems.

To develop these case studies, several key informants at the EU and international levels, such as workers’ representatives and industry associations representing the targeted sectors, were consulted. Initially, 16 cases were identified and preliminary information was collected through a questionnaire. Hereafter, 11 of them were further developed into cases studies, including higher levels of information collected at the workplace level.

2 Methodology

The primary data source for the case studies was interviews held with different stakeholders within companies. For each case study, up to five interviews were conducted with workers of the company from different work areas. The participants included operators, data protection officers, health and safety engineers, managers work-councillors and technology officers.

The interviews had a duration of 1-1.5 hours each and were performed in the participants’ native language, if possible, or alternatively in English. The interviews were conducted using an interview guide, while the results of the interviews were anonymised.

3 General company description

This case study is the result of a collaborative effort. Both the system developer and system user contributed to the information in this case example. **The primary user of the technology is a Danish multinational company.** It was founded in the 1930s in Denmark. Today, the company focuses on industrial machinery manufacturing for a wide variety of markets, from the automotive industry to wastewater engineering. They operate on a global scale with sales in more than 100 countries and currently employ around 40,000 workers. This classifies them as a large company.

Currently, their company policy is focused on sustainability and decarbonisation. To achieve that they offer their customers sustainable, smart solutions to move towards carbon neutrality. Among other goals, they aim for their technology to create healthier indoor climates. Part of their business philosophy is a focus on supporting their workforce to grow personally and professionally.

The company has a history of 'striking a cord' between innovative and sustainable technology. Hence, they strive to make their production as efficient as possible. They are already using a range of advanced technologies and an AI-based system. This specific case study came from a collaboration with a German AI company and three robotic system integrators: It is a hybrid system connecting an unfenced multi-axial robot and an AI-vision system.

A company founded in Germany in 2015 created the AI used to facilitate the system. They currently employ fewer than 50 people, so they are classified as a small company. **They specialise in providing hardware and software solutions in the area of 3D sensors to enable robotic systems to 'see'.** This 'seeing' is based on their AI software, which uses real-time data analysis to perceive its environment and classify objects. In combination with advanced robotics, the technology can be used to automate a wide variety of tasks, from 3D navigation on automated guided vehicles (AGVs), to plant health analysis in the agricultural sector, to object manipulation in industrial processes, to logistics-related tasks like depalletising and palletising items.

There is also the continuous effort to expand this technology. More than 2,000 different possible products the company currently uses could be analysed and saved to a database that is accessible not only at the Danish location but also at others.

3.1 Description of the system

The technology solution the company has created is used in depalletising and palletising products. In that specific location in Denmark, they aim to perform on-demand production, without a warehouse. However, supply chain issues led them to look for automated solutions, to reduce stress on their 24-hour production cycle and workers. The supply delivery process can be broken down into three parts: removal from the delivery truck; removing the items from their pallets and repositioning them on special setting boards for further production; and, lastly, a quality control step that ensures all items on the setting board are placed correctly.

The process of moving the pieces from the pallet onto the specialised setting board was fully automated before the system was introduced. However, the robot-AI solution cut cycle times in half. Quality control was previously performed by a worker, but it is now also automated.

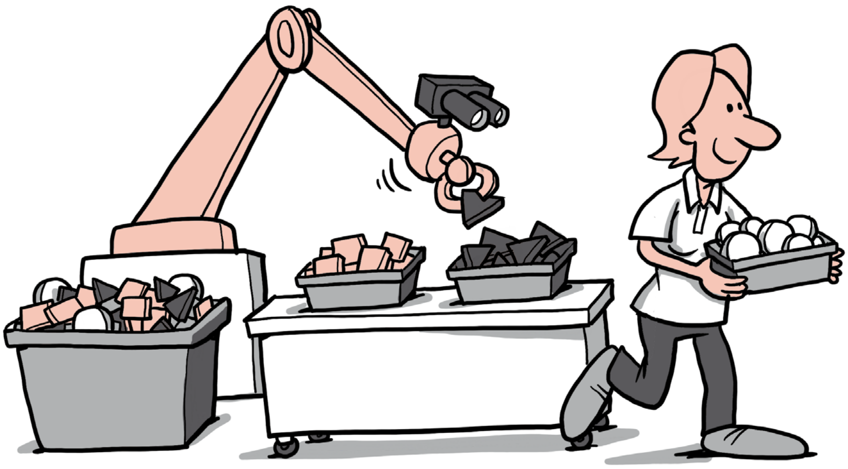
The underlying technology is a combination of a **multi-axial robotic system in combination with a 12-megapixel dual-camera system. The camera system provides the visual input for the AI-based algorithm.**

The system uses a location estimation algorithm to perceive pallets and items. It recognises the location of the target object in a completely randomised design (CRD) model of the object. Edge-based detection or point cloud is used in the second step to further identify the objects in the images. The final CRD model of the object is then used to train a neural network. Then the robot is provided with instructions on what to do or how to grip a recognised target item. To simulate the pallet and subsequent distances of the environment, stereo images using the semi-global matching (SGM) method are employed. SGM is a computer vision algorithm to estimate a dense disparity map from a stereo image pair.

This subsequently means that once a model of the object the robot is supposed to grip exists, and the environment is rendered, the algorithm can be trained without needing to record or label any on-site data. This has important implications not only for efficiency but also for data privacy.

A cartoon-style representation of the system, performed tasks and interaction with workers, including some of the challenges and opportunities for OSH is presented in Figure 1.

Figure 1 Robotic system for palletising and depalletising products



3.2 Taxonomy-based categorisation

To categorise different types of technology, a taxonomy specific for different important criteria of AI-based systems and advanced robotics was developed by EU-OSHA.[1] This taxonomy includes, among others, the type of backend and frontend being used and the type of task performed, as well as which category it falls under (information-related, person-related or object-related). It distinguishes between routine and non-routine task characteristics as well as the degree of automation in the form of assistance or substitution. Finally, the taxonomy takes into account different OSH dimensions (physical, psychosocial and/or organisational) that are impacted by the technology.

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

[1] EU-OSHA – European Agency for Safety and Health at Work, *Advanced robotics, artificial intelligence and the automation of tasks: definitions, uses, policies and strategies and Occupational Safety and Health*, 2022. Available at: https://osha.europa.eu/en/publications/advanced-robotics-artificial-intelligence-and-automation-tasks-definitions-uses-policies-and-strategies-and-occupational-safety-and-health

In combination, the system at hand automates both physical and cognitive tasks. To be able to perform these tasks, it relies on an **AI-based software**. The goal of the system is to automate a physical, object-related task. However, to perform these tasks, it first needs to perform **cognitive** object-related tasks. This work is a routine task, and the system substitutes human labour. Human intervention in the system is reduced to interventions for error cases that the system cannot handle.

The job content of the worker who previously performed this task has changed significantly. Previously, they needed to provide support during repalletisation and repositioning of items. Now they are assigned other tasks. The OSH implications include **psychosocial and physical impacts**. However, the automation has allowed **organisational steps to improve OSH for the workers**.

Regarding their job structure, workers have also experienced a change. The worker does not directly collaborate with the system. They rather take on a supervisory position to intervene in error cases. The jobs that are primarily impacted by the automation are machine operators who work on the shop floor.

The system previously in place involved human workers placing parts in a tray, which were then assembled by an automated system. The error tolerance of this automated system was low, as the robot that picked up the parts required precision to work. While external steps were taken to ensure parts were always in the correct position, human error could not be ruled out completely. So, now, instead of putting all the responsibility on the human operator, responsibility is placed on the AI-based vision system to ensure that all parts are placed in the correct spot before the robot is allowed to handle the part.

Regarding the **remaining job content and routine** of the worker, one can see a noticeable shift based on the implementation of the AI-based system. Prior to the automation, a manual operator moved, assembled and put forward all the parts in a product. Production has therefore shifted from being close to 100% manual labour to being around 20% manual labour. The operators are mainly there to ensure that the machinery is running correctly and that the AI-based system has what it needs. Much of the remaining manual work is assisting when the AI-based system has made an error of some kind. The work is more of a monitoring task now, and it includes problem solving if the AI-based system goes into an error state.

4 Implementation process

A key factor for the successful integration of technology into a new work environment is the implementation process. Several factors, such as the identification of objectives and goals prior to implementing the technology, design decisions and participation, worker involvement and training, as well as the inclusion of guidelines or legislation, can influence it. In addition, some of the most important steps are the assessment of whether the intended goals have been reached, documentation of what challenges were faced, and finally consideration of how these lessons influence future company plans regarding the implementation of either new systems or more of those already implemented.

4.1 Motivators and goals

Setting **goals** prior to implementing a technology can help quantify the success of the implementation and also inform what kind of technology is needed to reach them. The interviewees expressed a number of objectives and goals for the introduction of the technology.

One goal was to improve the **supply chain process**. While this is also a financial consideration, the company was aware that given the right automation they could improve their workers' work–life balance by reducing the need for night shifts significantly. The supply chain had been a point of conflict over the years. As the company focuses on **just-in-time production**, they do not have their own warehouse system. Hence, smooth production is dependent on seamless delivery. As the company has a multitude of suppliers, they not only have to coordinate this process but also organise the unloading according to each delivery. The unloading process contains several steps that were previously partially automated, however, to avoid errors later in the production, extensive human supervision was needed. The AI-based system was intended to provide greater flexibility between the different deliveries as well as less dependence on human intervention.

In addition, the company has a strong focus on their **workers' safety and health**. It has also been an objective to ensure that they create a smooth and fast-running production, and that any new technology is to improve that in all areas — including ergonomics and safety of the operators. Night shifts are strenuous on workers' health. So, introducing an AI-based solution could potentially reduce the number of workers needed during the night shift. Ergonomic design and a positive impact on the workplace of a new technology are established in the company's standards and were requested from the delivering company from the start.

4.2 Implementation

Before a new technology can be introduced into a workplace, there are a variety of factors to consider and often several stakeholders to involve. The implementation process can differ from company to company. With AI-based systems and advanced robotics being so customisable in their application, the general implementation differs for each case study. Nonetheless, there can be common implementation steps taken, with regard to who is involved in the process. The standards considered to implement a technology are equally important, both with regard to which are widely used and which are relevant to a specific case study. Furthermore, the individual difficulties and challenges are as vital to understanding the success of a case study as the ones more broadly shared among several case studies.

This automation was the result of two processes. On the one side, there was the above-described wish to improve the supply and delivery chain. However, it was from a prior project that the Danish integrator was already aware of the German AI company's solutions. There had already been a previous project in that area, but without the use of AI. The Danish company was then provided with a test system and identified three possible case studies. One of them is the presently described system.

4.2.1 Implementation steps

The implementation and development was a collaborative process, as several shareholders were involved over several years. The company also collaborated with experts from robotic installations to create a system that could perform the task at hand. From the company's side, automation engineers were involved as well as the workers council. The workers council is involved every time a new process is introduced to evaluate if it fulfils the standards of the company regarding safety. The developers of the AI-based system and processes used the knowledge workers had from being operators for many years. They took the workers' experience into account as they built the AI-based system to address issues related to the task that would be automated.

Before the system was put to use, it needed to be calibrated to operate optimally. **Once the system was in place, the integrator provided training to the company's operators.**

4.2.2 Standards and regulations

For the implementation of the camera system, the integrator worked in accordance with Danish and European requirements, as well as **the General Data Protection Regulation (GDPR).** Furthermore, they adjusted their calibration method after the workers council requested a change. The calibration system now only perceives the camera calibration grid; so, the most there is to see of any worker involved would be their fingertips holding the calibration card.

4.2.3 Difficulties and challenges during the implementation

The **implementation process was a joint effort of several companies, hence collaboration and communication were crucial**. No larger issues were encountered outside matching the underlying technology of the AI-based system to the operating system used in the company. This hurdle could however be overcome.

The AI-based system had challenges in terms of recognising reflection correctly, as some parts have mirror-like surfaces. This led to an increased failure rate in part recognition compared to matte surfaces. This, however, has improved over time, as the system learned to handle them better.

The interviewees noted that no matter how much one tries to make a complex AI-based system function smoothly from day one of operations, there are always a number of unforeseen issues to solve when it goes into real-time production. In the beginning, the AI-based system's behaviour did not match the expectations of the operators, so they had to pause its involvement briefly and identify and solve the errors causing this deviation. An important skill described by the interviewees to manage these unexpected errors is to manage one's expectations, and to take on the mindset that error correction is part of the process. They reported that over time, the AI-based system has been successfully integrated in the production line, and now everything is running very smoothly.

4.3 Worker involvement

Worker involvement during the implementation process can contribute to the success of a technology's implementation. Depending on the circumstances, this involvement can start at the design stage, or once training to use the technology starts. While there are external factors that can limit the extent to which workers can be involved, companies seeking to introduce AI-based systems should consider at what stage worker input can be included.

4.3.1 Training and worker qualifications

Worker training and education is a major element for the success of technology implementation.[2,3]

The system integrator offers two types of training. One of them is provided to other integrators. As described above, this system is frequently paired with lightweight robotic systems. The integrator training allows them to install the system without an expert of the AI integrator on site. The training is typically performed remotely. Operator training is also provided by the AI integrator. This typically takes 1-2 hours and is performed remotely as well, if possible. Beyond this training, they also provide an integrator support that responds to specific calls for aid. This has been especially useful if it is the first time such a system is integrated in the company.

One of the concerns, when it comes to the automation of tasks through advanced robotics and AI-based systems, is the process of deskilling. Automation like this is generally seen as a starting point for one of three skill developments: **deskilling, reskilling or upskilling**.

The Danish company sees the use of the AI-based system as an opportunity to **upskill** their workers. It is not possible to transition from manual operation to AI-based operation without training. While the skill that the technology automates requires precision, it is not a highly complex one for a human worker. Placing the items manually is a skill that could be relearned in a comparatively short amount of time, so it is not actively considered deskilling.

4.3.2 Feedback system and report handling

Worker feedback was an essential part of developing the AI-based system. There has always been very direct communication in all parts of the project, and the operators' experience has been taken well into consideration. By including their knowledge of the process, the robotic developers could adjust the system in parts of the process that are more difficult to automate and, in the end, develop a technology that assists the operators the most.

Now that the system is in use, feedback from the active operators is still continuously collected. There is a **daily meeting** where everyone involved gathers; this includes specialists from testing and development and the project leads. They then exchange with the operators what has worked and what has not worked since the last meeting. Then, responsibilities to address any issues are assigned.

Ease of use was a central requirement for the company. The system has been able to deliver this. Feedback regarding the use of the system in real time is positive, especially through the comprehensive interface.

4.3.3 Level of trust and control

An adequate level of human trust towards the interacting system promotes appropriate system use,[4,5] while extreme forms of trust can lead to adverse effects. Excessive trust can lead to automation complacency,[6] whereas insufficient trust may lead to neglect of the technology.[4]

The users report a high level of **ease of use** with the system. They generally trust the AI-based system to perform its job sufficiently. After the initial implementation phase, most of the unforeseen errors could be resolved, so that the AI-based system now works smoothly and reliably.

In addition to trusting the system, a worker's **level of control** can have a significant influence on a number of factors. In this case, workers have limited control over the AI-based system. They are not controlling the AI-based system's motion or influencing its workplace or decision-making. Using the AI-based system is **mandatory**. Even though this demonstrates a low level of control over the AI-based system itself, workers now have more control over their work and schedule in general.

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[2] Waldeck, N. E. (2000). *Advanced manufacturing technologies and workforce development*. Garland Press.

[3] Fraser, K., Harris, K., & Luong, L. (2007). Improving the implementation effectiveness of cellular manufacturing: A comprehensive framework for practitioners. *International Journal of Production Research, 45*(24), 5835-5856. https://doi.org/10.1080/00207540601159516

[4] Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. *Human Factors, 39*(2), 230-253. https://doi.org/10.1518/001872097778543886

[5] Hancock, P. A., Kessler, T. T., Kaplan, A. D., Brill, J. C., & Szalma, J. L. (2020). Evolving trust in robots: Specification through sequential and comparative meta-analyses. *Human Factors, 63*(7), 1196-1229. https://doi.org/10.1177/0018720820922080

[6] Parasuraman, R., & Manzey, D. H. (2010). Complacency and bias in human use of automation: An attentional integration. *Human Factors, 52*(3), 381-410. https://doi.org/10.1177/0018720810376055

4.3.4 Company culture and structure

The system has not had too significant an impact on the larger company structure or culture. However, for individual operators, their social engagement has increased thanks to the automation. In a traditional operator job, they have their own dedicated workspaces, where they typically work alone. Now that the AI-based system is in place, the operator will have more social exchange with other people, including the robotics specialists and developers.

While a singular system does not spark larger structural changes in the company, the general process of automation does. One can see a shift from manual labour performed by workers to workers supervising AI-based or robotic systems. Automation of tasks is an ongoing process in the company.

Positive attribution to cultural change could be made regarding the reduction of night shifts. Workers can work fewer night shifts, which leaves them open to engage in more social activities, either in relation to their workplace or outside of work.

4.4 Future developments

There is continuous effort to expand this technology. The Danish company has more than 2,000 different possible products. For each, a model needs to be created and the system needs to be given proper instructions on how to handle each part. Once more products are represented and saved in a database, the system can be made available for other locations. Then, no single factory needs to train the system when it is installed but can benefit from this shared data. This is also intended to bring a high level of standardisation to the production process at different locations.

Speaking more generally, the Danish company is looking into several avenues to automate their processes, using modern technology. They develop both their own automation solutions as well as technology in cooperation with partners like the aforementioned German company.

5 OSH impact

The introduction of an AI-based system or a collaborative robot can have a wide impact on OSH. It can pose a number of challenges as well as opportunities unique to each case study. In addition, it is important to identify possible barriers and drivers to consider them in future projects. These new forms of task automation can even lead to changes in the overall OSH management of a company. Through the interviews, a number of these factors for this specific case study have been identified and discussed.

AI-based systems can impact OSH in a number of ways. While most commonly assume that systems with physical representation, like a cobot, mostly target physical aspects and that non-embodied systems, like AI-based software, affect psychosocial factors, this presumption does not necessarily reflect the complexity of today's world of work and technology. This system firstly highlights that one system can automate a number of tasks and subtasks to work towards its larger goal. Secondly, a technology can also lead to structural changes that affect OSH more globally.

5.1 Challenges

As cobots allow highly individualised solutions for a company, they might also face challenges specific to their case study. In addition, more universal challenges can emerge, which the company then has to address. The interviews revealed a number of OSH challenges the company had to face, both during the implementation phase as well as in ongoing production.

5.1.1 Mental workload

The changes that the AI-based system brought to the production line came with a shift in job content and job demand for workers. Their tasks are less repetitive and more geared towards problem solving with a lowered degree of routine. Some workers, however, did not mind and even preferred their predictable, routine-based work. The new work environment could possibly mean a heightened mental workload for these workers, which may be perceived as straining.

5.1.2 Performance pressure

When working with the AI-based system, workers can experience internal pressure to compare their performance with the AI-based systems. The AI-based system can perform the task generally quicker, and without tiring throughout the day. This can result in workers feeling inadequate in comparison to the AI-based system. However, the robot is performing the task not in competition with workers but to reduce the time they spend on repetitive tasks. Nevertheless, comparing oneself to an AI-based system can result in a negative experience.

5.1.3 Fear of job loss

In isolated cases, workers might experience fear of job loss in the larger context of task automation in the Danish company. The experience in other factories of this company does not support these fears as the production has become more automated, yet people were not let go. They were reassigned to other tasks. Yet, some workers still experience a fear of job loss.

5.2 Opportunities

The introduction of AI-based systems to the production site also held numerous OSH benefits and opportunities.

5.2.1 Job structure

The most significant impact for OSH occurred through organisational changes. The system allowed the company to restructure their work cycles and reduce night shifts. Night shifts are associated with numerous adverse health risks, such as cardiovascular disease, cancer, diabetes and injuries. These negative effects can be avoided to a certain extent if workers need to work fewer night shifts, or no night shifts at all. Thanks to the vision system, the delivery process needs significantly fewer workers, who can now work primarily on the day shift.

5.2.2 Physical workload and health

Given that a physical task is ultimately automated with the help of the AI, it does have physical OSH implications. Previously, workers performed part of the depalletisation themselves. This time-consuming, repetitive task could be not only cognitively strenuous but also physically demanding. Furthermore, repeating the same type of motion again and again can be strenuous on hands, elbows and shoulders.

5.2.3 Mental workload

The positioning of the workpieces needs to be precise. While this is not a complicated task, it does require the worker to be attentive. In combination with the repetitive nature of the task, this can be **mentally tiring**. **The interviewees described the change as time passing faster, because their workday has become** more exciting, compared to previously performing the same task over and over again.

5.2.4 Safety

In addition, there was a residual risk of physical injury. The workpieces are not heavy, but they can have sharp edges on which workers might cut themselves. Now they only handle the workpieces in rare cases, so the risk of physical injury is reduced.

5.3 Barriers and drivers

Many companies go through the process of integrating an advanced robotics or AI-based system to their workspace for the first time. The present case study encountered a variety of barriers and drivers throughout this process. Identifying these can help this company as well as others avoid barriers and promote drivers for their process automation.

5.3.1 Barriers

The implementation process was a joint effort of several companies, hence collaboration and communication were crucial. No larger issues were encountered outside matching the underlying technology of the AI-based system to the operating system used in the company. This hurdle could however be overcome.

A possible barrier is workers with a high aversion to change. There are a number of workers who are content in their current job structure and daily tasks. Introducing advanced robotics or AI-based systems changes their daily routine and possibly leads to them having to perform new tasks. People who do not wish for their routine to change can slow down automation efforts.

5.3.2 Drivers

One major factor **that propelled the project was the ability to work remotely**. The technology itself is able to simulate its environment and target workpieces digitally, hence, once models were created, all major work with the AI could be done remotely. Supervision of the integrator, installation of the hardware and so on in person are typically very time- and resource-consuming processes, when working on a European level. Hence, having the digital infrastructure and a system that allowed remote preparations enabled cooperation over hundreds of miles to be effective and time-efficient.

Within the Danish company, operators who are interested in educating themselves and who have a **high affinity for technology and robotics** played a major role in the successful implementation of not only the described AI-based system but also other systems in the same factory. These workers support change and adapt to the new technology more easily. They can also provide helpful feedback for the developers, so that the technology can be adjusted to fit the workplace and their needs better.

5.4 OSH management

New technologies can lead to a change in work procedure. This also includes OSH, the expectations placed on the technology and subsequent OSH management.

5.4.1 Expectations for OSH

The expectations for OSH were to firstly reduce repetitive manual labour and the need for night shifts. Now that the AI-based system is in place, both expectations have been met. The company generally sees automation through both advanced robotics and AI-based systems as an opportunity to not only improve physical ergonomics of their workplaces but also cognitive ergonomics. By having their workers perform less repetitive and monotonous tasks, because these are automated by an AI-based system, they can create workplaces that offer more interesting and challenging tasks.

5.4.2 Emerging OSH risks and monitoring

The Danish company has several systems in place to not only collect feedback but also monitor and communicate emerging OSH risks of their technologies. Firstly, there is the previously mentioned daily department meeting where operators can let technicians know about any disruptions or errors that need to be fixed. Then there is a weekly follow-up meeting on projects like this AI-based automation that contains a report on how the project is progressing.

The technical engineers also provoked failures to see if the system would catch them, to test the system. It has performed well during these tests. They are still fine-tuning tolerances to decrease errors further, however, as the system is comparatively new, the process is still ongoing.

The AI-based system itself also collects data on its operation. So every time there is a disruption in the workflow, the technical engineers can inspect the logs to identify any issues. This process is performed for the general workflow, but also contains the monitoring for OSH risks, should they emerge.

5.4.3 Communication strategies

Most communication is done in either the daily meetings or weekly meetings, where everyone is updated on the latest changes and developments. This includes updates and information regarding OSH developments. Of course, there is also internal communication within work teams. The general structure of communication, however, has not changed due to the introduction of the AI-based system.

5.4.4 Organisational and social impact

Currently, there are **no reports on any social changes** within the company triggered by the introduction of the AI-based system. A case can be made that operators now have more social interaction with their co-workers, as they are less bound to their workstations, however there is no official data to quantify this. While the organisational impact currently is also considered small, the company does acknowledge that organisational changes could potentially happen over time. They are working on other projects with similar technology, and it is proposed to increase production rates and ease pressure on operators. Increased automation of the entire production would result in an organisational restructuring. The details, however, in how this restructuring would present would need to be seen over time.

5.4.5 Integration of OSH management

Introducing the AI-based system into the workplace has not resulted in any specific changes to OSH management as it was previously in place. The technology is currently still quite new, so **long-term developments cannot yet be foreseen**. It is possible, should there be more systems like this introduced, that OSH management adapts to the implementation of an AI-based system. The exact way to change it remains to be seen over time.

5.4.6 Need for action

The system integrator formulates a heightened **need for action on the legislators' side**. The current state of legislation is proving to be a barrier and a point of concern for them. Criteria like completeness make implementation difficult, as this demands coverage of rare corner cases and exceptions. They acknowledge that regulation is important to ensure safe and sustainable work, however, they see a potential risk in overregulation. This could have an adverse effect on OSH as systems and whole productions that would otherwise be implemented in Europe might be moved overseas. AI-based systems not being installed in European workplaces would therefore not only hinder improvement in OSH but also negatively impact the economy.

They see a need to categorise the system less for its underlying technology and more for the intended task. For example, an AI-based system for video footage analysis can have drastically different implications for OSH when it is used to detect product errors versus monitoring a workspace for productivity.

5.4.7 Cybersecurity

With technology becoming increasingly interconnected and data itself being a resource needed by some AI-based systems to improve their functionality, the topic of cybersecurity becomes prevalent in companies employing these technologies. The way that cybersecurity is handled at a company level is a key factor in securing the data when it comes to AI-based systems. Some systems require additional safety measures, depending on their use.

Firstly, the implementation process of this AI-based system was in compliance with both Danish and European requirements, and the AI system was in compliance with the GDPR.

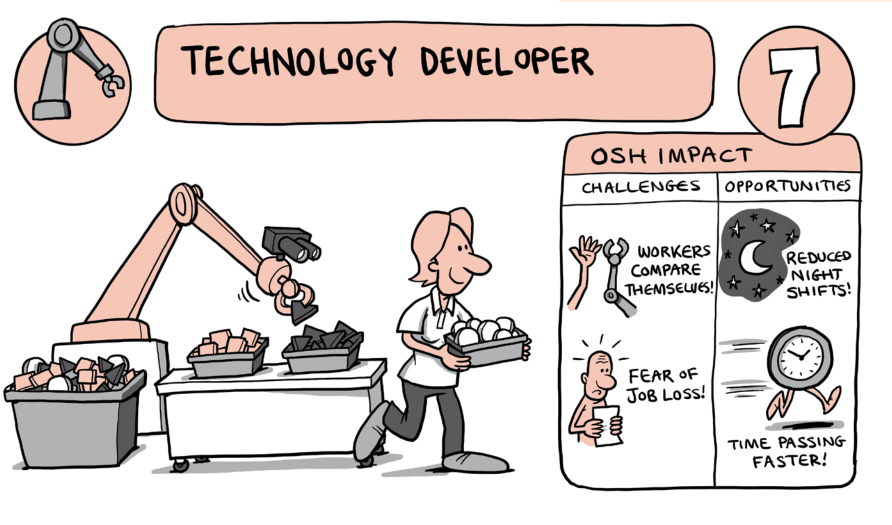
Regarding cybersecurity as well as data protection, the system is considered very safe. As mentioned above, after the initial workpiece and pallet model has been created, no further on-site video material is needed to train the system. The calibration is also anonymous. Furthermore, the system does not record by default. The system can record to provide material for debugging purposes. This, however, is never done without the operator's knowledge. The video material then has to be sent directly to the system developer for debugging purposes, otherwise they would have no access to it.

The **system does not make any decisions or inferences but simply observes if a set of parameters is adhered to**. This is why the company and integrator describe it to be distinct from AI being employed to work with sensitive data like in decision-making or profiling.

Virus protection and updates were a big topic during the implementation. The way the system currently is, nobody can access it without SSH (*Secure* Socket Shell is a network communication protocol that allows two computers to communicate and share data) and an individualised password. The integrator keeps these passwords so that the end user cannot accidentally trigger any security risks.

A cartoon-style representation of the system, including some of the challenges and opportunities for OSH is presented in Figure 3.

Figure 3. Robotic system for palletising and depalletising products, posing challenges and opportunities for OSH



6 Key takeaways

Using the CRD model to create a virtual representation of the object and a dense disparity map to simulate the goal pallet **allows this AI system to be trained entirely remotely**. The two companies went even further when it comes to data protection. For the initial camera calibration, a video containing a calibration grid has to be recorded. However, in the calibration video, anything that is not the grid is automatically cut out. Therefore, even though camera-using AI-based systems tend to be at the centre of the data privacy debate, it is important to acknowledge and communicate when the system a worker is using is explicitly not collecting any data.

This case study reveals that advanced robotics and **AI-based systems can facilitate change within a company or production site that goes beyond the task(s) they automate**. Here, one goal of the automation was to reduce night shifts, as the company was aware of their adverse nature to health and safety. The used technology helped to automate a task that previously made more night shifts necessary. Approaching automation efforts not only from an efficiency point of view but also from an OSH perspective can help companies identify these pivotal tasks; tasks that, when automated, allow larger, structural changes to benefit OSH.

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