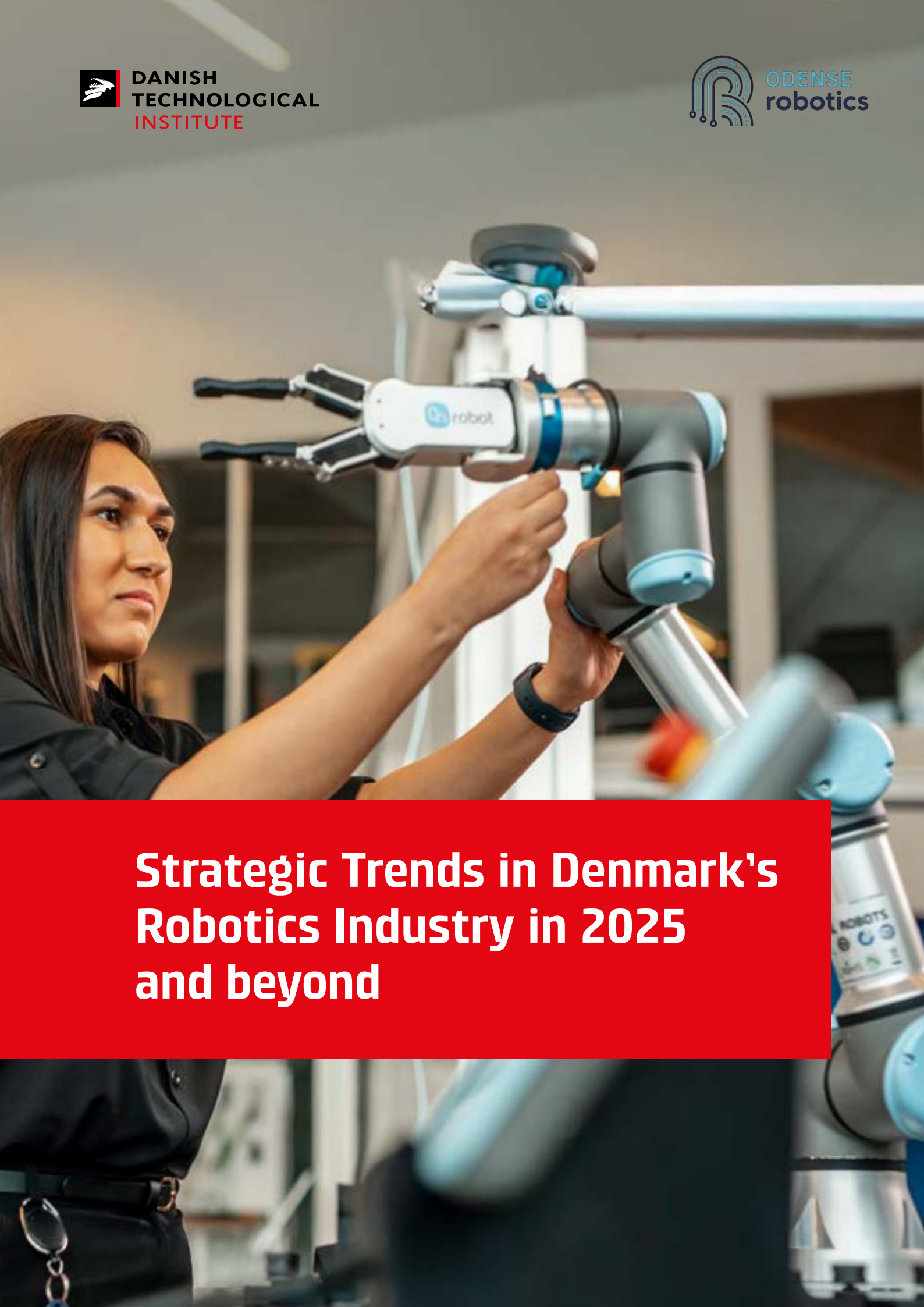
DANISH TECHNOLOGICAL INSTITUTE

ODENSE robotics



Strategic Trends in Denmark's Robotics Industry in 2025 and beyond

The report was prepared by Danish Technological Institute
in collaboration with Odense Robotics

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> **The report highlights key areas where technological advancements create new business opportunities.**

Preface

I am pleased to present this comprehensive report on trends in Denmark's Robotics Industry prepared by Danish Technological Institute. As the Danish cluster for robotics automation and drone technologies, Odense Robotics is dedicated to fostering innovation and growth within the field of robotics. This report highlights our commitment to understanding and leveraging the trends that will shape the future of robotics.

Odense Robotics has played a pivotal role in establishing Denmark as a hub for technological advancement, particularly in robotics, automation, and drones. Our ecosystem is designed to support the development of cutting-edge technologies by providing a platform for collaboration among industry leaders, startups, and academic institutions. By promoting partnerships and facilitating knowledge exchange, we aim to enhance the global competitiveness of Danish robotics companies.

This report explores the potential of robotics across various sectors, such as manufacturing, healthcare, and agriculture. It provides valuable insights into the trends that shape Denmark's robotics industry today and will continue to do so in the future. The report highlights key areas where technological advancements create new business opportunities, including intelligent and adaptive systems, as well as the growing significance of interoperability, security, and strategic simplification. However, the report also indicates that Europe as a whole is falling behind in filing patents for robotics innovations compared to regions like China and the USA.

Understanding these trends is essential for navigating the complex landscape of modern robotics and identifying upcoming opportunities. By aligning with these trends, businesses can develop innovative solutions that meet emerging market demands and capture new growth opportunities.

We hope this report will serve as a valuable resource for companies, researchers, and policymakers, inspiring them to harness the potential of robotics to address societal challenges and drive economic growth.

Søren Elmer Kristensen
CEO, Odense Robotics

Summary

The Danish robotics industry has seen remarkable growth and innovation over the past 15 years, as robotics is becoming increasingly utilised in both familiar industries and new markets. It is the most widely used in manufacturing, where its benefits are well recognised. In the healthcare sector, robotics is being explored as a solution to labour shortages and growing operational costs. In agriculture, drones and autonomous machinery enhance precision farming, resulting in more effective and environmentally friendly production methods. In construction, prefabrication techniques have the potential to streamline processes and alleviate labour shortages. Finally, drones and related anti-drone systems have transformed warfare in the defence industry.

The continuous evolution of the industry is driven by technological advancements and changing business models. This transformation creates new opportunities for companies regarding operational methods and the products and services they can offer. This report highlights four trends that are shaping the Danish robotics landscape:

Intelligent and adaptive systems enhance efficiency and adaptability across various sectors. This progress is supported by advancements in AI and machine learning, which improve the capabilities of robotics to execute complex tasks and optimize processes in industries that require automation to stay profitable and sustainable. The continuous development in this field opens new possibilities for the end users of robotics, automation and drones.

Interoperability is another major trend these years. There is an increasing emphasis on integrating diverse systems to boost operational efficiency and scalability. Robotics companies are adopting open communication protocols and modular designs to facilitate seamless connectivity and allow for more customised solutions. For the end users, this means easier integration of new machinery into existing systems.

Security is becoming increasingly important. Companies are implementing robust measures to protect their operations, data and the integrity of their customers' systems. This includes aligning with regulations like NIS2 and the Cyber Resilience Act to ensure the integrity and safety of robotic systems. The heightened focus on security from robotics leads to better protection and reduced risks from cyber threats for users.

Strategic simplification is the fourth trend explored in the report. Robotics companies are focusing on standardisation and specialisation to reduce complexity and costs, making their technologies easier to implement and use, thereby enhancing profitability. This approach helps overcome market entry barriers and supports business growth. For potential new users, the simplification and lower costs will reduce the entry barrier and make the technology more accessible to a wider audience.

Looking at the geographic distribution of robotics innovation, as measured in robotics-related patent applications, Europe has lost conside-

rable ground to both East Asia and the USA over the past 15 years. Within Europe, Denmark is the seventh most patent applying country per capita, ahead of the European average but well behind Sweden and Switzerland. While the number of Danish patent fillings related to robotics has grown remarkably since 2010, the growth rate is actually slightly lower than the global growth rate. So, while the Danish robotics industry is moving fast, it may still be falling behind in the global innovation race.

> Technological advancements are now bringing Danish robots, drones and automation to a broader audience than ever before.

Introduction

Robotics is considered a national technological and commercial strength in Denmark.[1] With a well-functioning ecosystem centred in Odense, the Danish robotics industry has developed substantially over the past 15 years, leading to an increase in both turnover and job creation.

In a time of labour shortage in many industries in Denmark, robots, automation, and drones are part of the solution. Many robotics companies also believe that their biggest competitors are not other robotics firms but rather structural hurdles or a lack of interest or willingness to innovate among potential customers. Nonetheless, technological advancements are now bringing Danish robots, drones and automation to a broader audience than ever before.

Technological innovation is an important driver of change in all industries, including robotics. The most recent financial figures show that the robotics industry in Denmark generated a

Key industries

The adoption of robotics varies significantly between sectors. The potential is almost untapped in some sectors, while others are more mature. Manufacturing is by far the most prominent sector for innovation, based on the number of patent applications filed. However, robotics offers great opportunities in many other sectors, which are industry-specific as well. This report outlines the potential for robotics in some of the most promising sectors.

Table 1. Number of Robotics-related Patented Innovations that can be Attributed to Selected Sectors

Industries	Patent applications
Manufacturing	94,569
Healthcare	13,139
Agriculture	4,927
Construction	4,027
Defence	731

Ranking of the number of patent applications attributed to selected application domains. Source: Based on 199,396 patent applications related to robotics technology filed in 2010-2022. Data was obtained via PatSnap.

turnover of DKK 27.5 billion (EUR 3.7 billion) in 2022, of which almost half, DKK 13.1 billion (EUR 1.8 billion), came from exports.[2] More than 600 robot, automation, and drone companies employ 18,500 people – 13,700 in Denmark and 4,800 abroad. The industry expects a stable annual growth of 14 % in Danish employees.

The robotics industry is not only growing but also influencing other areas of business. It is also evolving and continuously being shaped by key trends. These trends affect the focus of companies and the possibilities for marketing robotics to new industries. This report explores the use of robotics in five key fields: manufacturing, healthcare, agriculture, construction, and defence. It then presents and analyses four trends in the Danish robotics industry: intelligent and adaptive systems, interoperability, security, and standardisation. Several company cases are presented throughout the report to illustrate how these trends affect Danish companies.

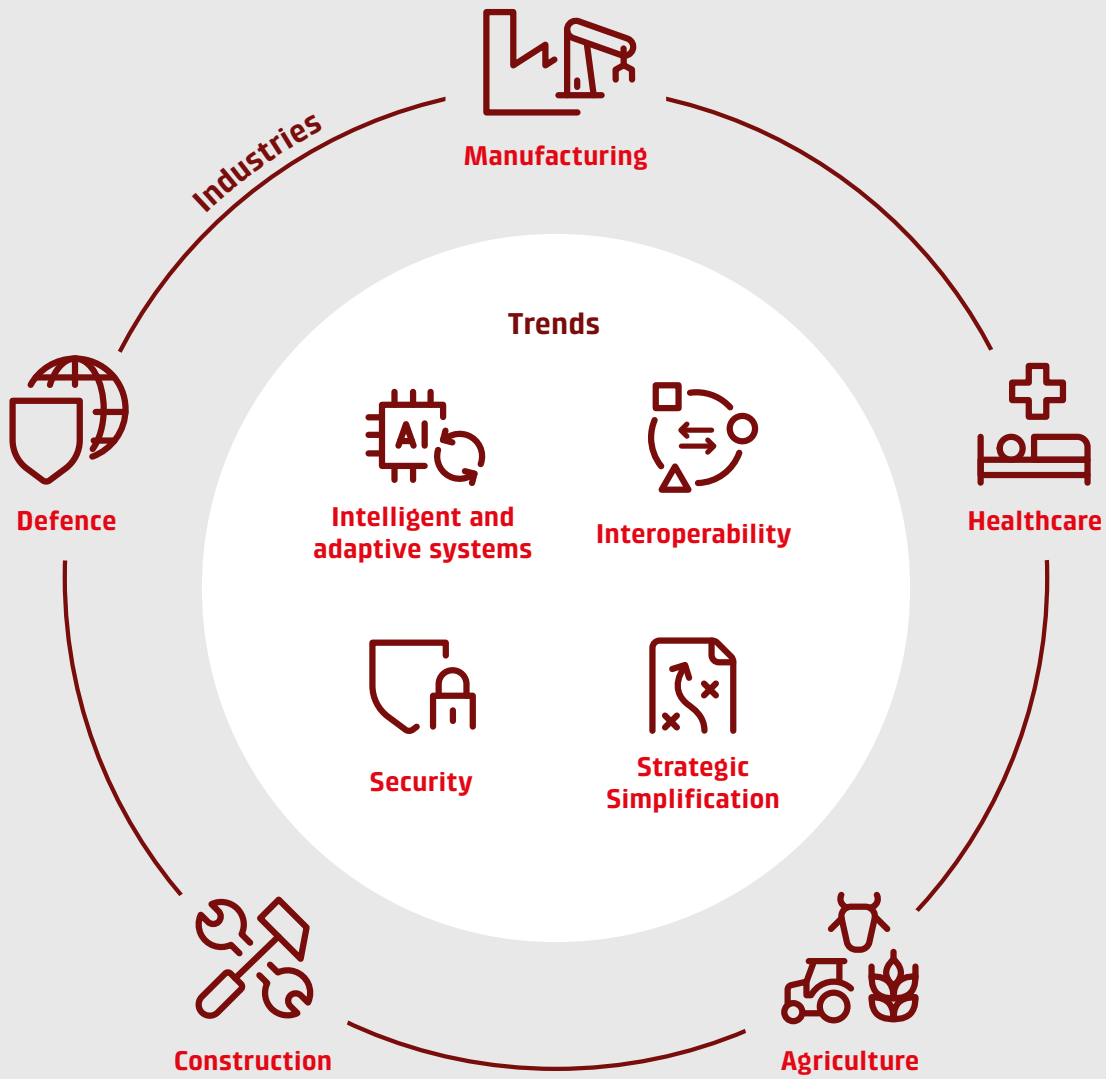
The target audience for this report and its insights are twofold: end users of robotics looking to understand the potential in their sector and how the evolvement of the technology opens new opportunities for integrating robotics, automation or drone technology. And Danish robotics companies looking to understand what trends to watch in the coming years and gain inspiration to strategically align the business to the most prominent technological tendencies.

The Project, Method and Data

This report is based on a project financed by the Danish Agency for Higher Education and Science through the Danish business cluster, Odense Robotics, and executed by Danish Technological Institute. It is based on in-depth interviews with industry professionals from 25 Danish robotics companies and five industry experts from Danish Technological Institute, which took place between August and November 2024. Industry experts and company representatives were invited to discuss the subject and preliminary findings at a workshop in November held at Universal Robotics' offices in Odense. The findings of the study were subsequently analysed and are presented in the following pages.

The final chapter of the report presents a quantitative analysis of robotics innovation based on patent filings related to robotics from 2010 to 2022. 199,396 robotics-related patent applications were identified via the service PatSnap and subsequently analysed. These quantitative data provide a measure of robotics innovation and a basis for international comparison.

Figure 1. Trends and Industries



Manufacturing

Manufacturing remains by far the largest industry for robotics. This is clearly reflected in the Danish robotics landscape, where most robotics companies primarily support the manufacturing industry. Moreover, manufacturing is also the domain where most patent applications are filed globally.

The widespread use of robotics in manufacturing reflects a broader societal challenge. As many developed economies face shrinking workforces and higher wage levels, companies look for ways of improving their production output without having to find more employees or outsource their production to other countries. Robotics are an obvious answer to this challenge, automating some tasks and making individual workers capable of solving other tasks more quickly. Through the successful use of robotics, manufacturing companies in developed economies may be able to keep up with their competitors in countries with much lower wage levels.

Against this backdrop, the manufacturing industry increasingly uses automation to enhance efficiency and productivity. As companies strive to remain competitive in a global market, the integration of advanced robotics and automation technologies offers significant advantages in terms of speed, precision, and cost-effectiveness. Four aspects of robotics are especially relevant to manufacturing:

Mobile robots are increasingly deployed to manage internal logistics and transportation needs. These robots offer adaptable transport solutions, efficiently moving raw materials, components, and finished goods across production floors. By automating the transportation process, mobile robots reduce the reliance on manual labour, thus minimising bottlenecks and streamlining operations. This leads to reduced downtime and lower operational costs, contributing to a more efficient production cycle. Equipped with advanced sensors and navigation systems, mobile robots can operate safely in environments shared with human workers.

Robotic arms have become integral to modern manufacturing processes, contributing to assembly, welding, packaging, and painting tasks. These versatile machines operate tirelessly, ensuring consistent quality and increasing throughput in production lines – especially in a time with labour shortages. A noteworthy advancement in this field is the development of collaborative robots, or cobots, designed to work alongside human employees seamlessly. Unlike traditional industrial robots that operate in isolation, cobots have enhanced safety features, allowing for direct interaction with human workers. This collaboration can relieve workers from monotonous and physically demanding tasks, enabling them to focus on more complex and creative problem-solving activities. Integrating cobots may not only elevate efficiency but also improve workplace safety and enhance job satisfaction by reducing the risk of injuries. Additionally, the ability of cobots to be reprogrammed for different tasks makes them a flexible asset in industries characterised by frequent production changes.

The concept of mobile manipulators represents the combination of mobile robots and robotic arms. These systems have robotic arms that can automate tasks, while their mobile platforms make it easier to switch between several tasks and working places, depending on what is required. They are typically used in the same way as robotic arms, but with much greater flexibility.

AI and machine learning are becoming indispensable in optimising manufacturing processes and quality control. These technologies enable manufacturers to analyse vast amounts of data from various sources, allowing AI systems to predict equipment failures, scheduled maintenance, and adjust production parameters in real time. This proactive approach can lead to more optimal performance and minimise downtime. Machine learning algorithms enhance quality control by identifying defects and inconsistencies that human inspectors might overlook, ensuring that products meet the highest standards. By utilizing AI-driven insights, manufacturers can make informed decisions that enhance efficiency and reduce waste. Moreover, AI technologies continuously evolve, offering new opportunities for innovation in predictive maintenance and autonomous decision-making.[3]

Digital twins in manufacturing refer to the creation of precise virtual replicas of physical production lines. These digital models facilitate the simulation and testing of production processes before implementation on the factory floor. By using digital twins, manufacturers can identify potential issues and optimise workflows in a virtual environment, reducing errors and improving design processes. This approach accelerates time-to-market for new products by allowing for quicker prototyping and testing. The use of digital twins also aids in resource management, enabling manufacturers to predict and respond to changes in demand dynamically. As technology advances, digital twins are expected to play an even more crucial role in manufacturing, offering unprecedented insight and control over production processes.

The future of manufacturing will see continued advancements in robotics technology, with robots becoming more autonomous, intelligent, and capable of performing a wider range of tasks. The integration of AI in manufacturing is expected to grow, with new applications emerging in areas such as predictive maintenance, autonomous decision-making, and real-time process optimisation. These innovations will enhance the efficiency and flexibility of manufacturing operations even further.

Healthcare

Many countries are facing a significant demographic challenge within their healthcare sectors. As populations age, the demand for healthcare services increases, putting strain on systems that have a relatively smaller workforce. Essentially, there are fewer people to meet growing healthcare needs. Healthcare robotics could be part of the solution to this societal issue.

Robotics have been implemented at hospitals to perform various logistical tasks, such as transporting linen, food and equipment and organising and sorting archives. These automation systems essentially serve the same purpose as they do in industry; they enable a more effective handling of logistical tasks. Since automation systems may set demands for the infrastructure and layout of a hospital, planning for automation is becoming a central consideration in the construction of new, modern hospitals.

Surgery and diagnostics robots can perform familiar operations with improved precision or speed or allow some scanning to be carried out with less specialised staff. The Da Vinci robot – a master-slave system where a surgeon controls the arms of a robot – is probably the best example of an internationally successful robotic surgery system. This type of robotics must meet exceptionally high standards of

Robotics present four main potential benefits for the healthcare industry[4]

Automated tasks
Some tasks can be automated in part or entirely, freeing time for healthcare personnel or logistical staff. This is particularly relevant to tasks that do not involve patient contact.

Augmented tasks
Robotics can augment some tasks, allowing staff to perform their jobs faster or with greater precision or perform new, more complicated tasks, such as advanced surgery.

Physical assistance
Robots can assist in physically demanding tasks, such as heavy lifting, providing a better physical working environment for employees, which can ultimately reduce injuries and early retirement.

Increase availability
Robots can increase the availability of healthcare services to more people by making them less dependent on the physical presence of healthcare personnel.

safety to be approved for medical use due to their invasive nature and the possible consequences of their actions for patient health and safety. The Danish companies ROPCA and Life Science Robotics have developed robots that conduct arthritis scans and pregnancy scans, respectively, using AI to compare images to databases and detect patterns. These robots generally do not diagnose patients themselves. Instead, they alert doctors when they identify suspicious image patterns that may require further attention.

Rehabilitation robots can support patients in their rehabilitation process and reduce their dependence on physiotherapists. The robots typically help the patient perform various movements while providing an appropriate level of resistance. Rehabilitation robots can be particularly relevant for rehabilitation centres, where they enable one or a few physiotherapists to facilitate the rehabilitation of more patients at once, rather than requiring one-to-one interaction.

The healthcare sector has been exploring robotics for several years, but the implementation has faced significant obstacles. A 2022 study identified several barriers to the adoption of robotics.[5] First, the lack of standardisation across hospitals makes it difficult for robotics companies to develop universally applicable products, limiting scalability and market attractiveness. Second, hospitals' unique IT systems and stringent data security requirements, driven by laws like GDPR, pose significant integration challenges, increasing costs and deterring companies from entering the market. Third,

due to the public nature of many hospitals, procurement, through lengthy public tenders, strains companies' financial resources, as these processes demand extensive resources with limited upfront payments. Lastly, the high costs and risks associated with purchasing new robotic systems make decision-makers cautious, as they fear unforeseen expenses and implementation issues. Although resistance from healthcare staff was noted, this has become less of a concern as professionals increasingly recognise the potential time-saving benefits of robotics.

As healthcare workers grow more accustomed to using robots and recognise the significant benefits of automating logistical tasks in hospitals, the favourable conditions for healthcare robotics are improving, especially considering the demographic challenges faced by both Western and East Asian societies. However, as highlighted by the previously mentioned barriers, security and standardisation remain critical trends and key challenges within the healthcare industry today.

UVD Robots: Keeping Hospitals Clean with Automated Modular UV Disinfection

UVD Robots, a part of Blue Ocean Robots, delivers automated UV disinfection to the healthcare sector and pharmaceutical industry, both of which have high hygiene standards. UVD Robots' product can autonomously navigate hospital surroundings and use UV light to kill bacteria and viruses, ensuring a high standard of hygiene. The controlled operational environment in hospitals and the pharmaceutical industry ensures that the robot can operate reliably, reducing the need for manual intervention and allowing healthcare staff to focus on patient care.

UVD Robots emphasises modularisation to simplify scaling and servicing. Modules can be manufactured in different locations and sent for local assembly, which is part of their strategy to expand their presence in the USA. This also enables local technicians to efficiently service robots by replacing modules instead of the entire unit, minimising downtime and repair costs for hospitals and pharmaceutical companies, e.g., if a wheel breaks on the robot.

Agriculture

The agricultural sector increasingly incorporates robotics to address the need for greater food production and more sustainable farming practices. Robotics offer promising solutions for enhancing productivity, precision, and resource efficiency in agricultural operations, which is particularly important given the industry's labour shortages and economic pressures. The sector employs various kinds of robotics to this end.

Drones have become a cornerstone of precision agriculture, offering farmers detailed aerial insights into crop health, soil conditions, and pest infestations. These unmanned aerial vehicles (UAVs) are equipped with sensors and imaging technologies that enable them to gather data over large areas. This data aids in making precise decisions about crop management, such as the targeted application of fertilisers and pesticides, which can reduce waste and minimise environmental impact. Drones are also used for tasks such as planting seeds and monitoring livestock.

The advent of autonomous tractors and machinery is also changing traditional farming practices. These self-driving vehicles, guided by GPS and AI algorithms, can perform tasks such as ploughing, sowing, and harvesting with minimal human intervention. The shift towards lightweight, autonomous machinery aims to reduce soil compaction and improve efficiency in field operations. These technologies have the potential to alleviate the physical demands on farmers and enable continuous operation, thereby increasing overall productivity. Autonomous machinery is also adapted to handle various terrains and crop types, making them a solution to more and more farming needs.

Robotic systems designed for harvesting and weeding have entered the market to address labour-intensive tasks in agriculture. These robots utilise vision technology and AI to accurately identify and harvest ripe produce or eliminate weeds, minimising damage to crops. Such innovations help mitigate labour shortages and improve efficiency by operating continuously under various conditions. Additionally, robotic systems are developed to perform delicate tasks such as fruit picking, which requires precision and care to avoid damaging the produce.

AI and machine learning are integral to modernising agriculture, providing predictive analytics and decision support tools. These technologies process data from various sources, including satellite imagery and IoT sensors,

to forecast weather patterns, predict crop yields, and optimise supply chains. This capability enables farmers to make data-driven decisions that enhance operational efficiency and reduce risks associated with climate variability. In this regard, AI is central to developing innovative farming solutions that promote sustainable practices and efficient resource management. AI is also used to create predictive models for pest and disease outbreaks, allowing for timely interventions that can save crops from widespread damage. The integration of more IoT devices with robotic systems in the future will provide better real-time monitoring and control, allowing for more responsive and adaptive farming practices.

The future of agriculture will increasingly rely on technology to develop more resilient and adaptive farming systems that can function in an ever-changing environment. However, the successful implementation of these technologies will depend on overcoming existing barriers, such as the prohibitive cost of technology adoption and the need for rural infrastructure improvements. Additionally, policies and incentives are needed to encourage the adoption of sustainable technologies and practices in agriculture and ensure that the benefits of robotics are accessible to farms of all sizes.

Construction

The potential for applying robotics technology in the construction industry is growing. A growing market for using prefabrication techniques offers potential, while the possibilities on the construction sites are also increasing as the technology evolves.

Prefabrication involves the manufacturing of building components in a controlled factory environment, which are then transported to the construction site for assembly. In general terms, this means applying the nature and workflow of manufacturing to the construction industry. This approach addresses the acute labour shortages faced by the industry while enhancing efficiency and reducing on-site construction time. Offering flexible products and solutions that can be easily applied in construction thus holds great business potential for robotics companies.

Despite this, the adoption of prefabrication is impeded by significant cultural barriers. The construction industry is conservative by nature and has entrenched methods and workflows. To maximise the benefits of prefabrication, it is essential to integrate it into the initial stages of project planning and design, adopting a design-for-manufacturing mindset. This involves using standardised modules to enhance quality control, reduce waste, and simplify construction processes.

Robotics technology faces challenges in the unique environment of construction sites, which are often unstructured and unpredictable. Automation in such settings is complicated by the technical and financial difficulties of deploying robots that can operate under these conditions.

This taps into the trend of delivering intelligent and adaptive systems. Technologies that can optimise material usage in prefabrication or learn to navigate the challenging environment of a construction site are likely to be in high demand in a few years.

For instance, technologies that can optimise material usage, such as 3D printing with concrete, are emerging as effective solutions for streamlining the construction of similar housing structures. Danish COBOD International is one of the leading companies in this technological development. Additionally, digital workflows for cutting wood elements, as demonstrated in projects supported by GMT Robotics, showcase how automation can reduce material waste and improve efficiency.

While prefabrication offers significant opportunities for the construction industry, its success depends on the ability to overcome cultural resistance and site-specific challenges. By embracing innovation and leveraging intelligent systems, the construction industry can enhance productivity, address labour shortages, and contribute to a more sustainable future.

Defence

One of the most important trends in the defence industry is the shift towards smaller and more autonomous systems.[6] This is evident on the battlefields of Ukraine, where thousands of unmanned aerial vehicles (UAVs) or drones are used and lost every month.[7] These drones are particularly useful for reconnaissance missions, i.e. gathering intelligence about the area or enemy movements, and for outright attacks, where one or more drones are loaded with explosive payloads.

The increased use of drones in battle is driven by three interrelated factors: 1) drones are cheaper than ever and mass-producible, 2) drones are getting smaller, making them less obvious targets, and 3) payloads such as sensors are being developed in equally miniaturised versions. This means that drones are more useful and cheaper to deploy, making them a cheaper alternative to conventional weapons, such as rockets or reconnaissance platforms, whether airborne vehicles or soldiers on the ground. Besides aerial systems, ground-based drones have also been developed for tasks such as clearing mines, and submarine drones could well take a more prominent role in maritime conflicts in the future.

The increased use of UAVs has created a parallel trend towards more anti-drone systems on the battlefield. These systems can have different kinds of sensors capable of detecting and identifying enemy autonomous systems, but they may also have offensive capabilities to jam, spoof or physically harm enemy drones. Anti-drone systems can be stationary, mounted on vehicles or worn by individual soldiers in the field, depending on the specific technology. Moreover, systems to detect and identify drones are increasingly used to protect critical infrastructure, such as airports or harbours, from drone disruption.

AI and edge computing are enhancing military drones. Through AI, drones on the battlefield have become much more apt at spotting combatants on the battlefield and distinguishing friendly vehicles from enemy vehicles, etc. This enables autonomous reconnaissance systems to report back on hostile activity much faster – or even engage the enemy themselves if configured appropriately. Moreover, by utilising edge computing on autonomous systems, they can process the data captured by their sensors more quickly and effectively instead of transmitting large volumes of data back to a central computer for processing. This again allows the drones to react more rapidly, but it also helps secure the data they transmit by reducing the data volume.

Similarly to other industries, the defence industry is also seeing a greater shift towards automation of production to drive down costs and increase production capacity. The technologies used here are the same as those used in manufacturing in general, discussed above.

MyDefence: Countermeasures against Drone Attacks

MyDefence has carved out a significant role in defence technology, mainly focusing on developing advanced anti-drone systems. Established in 2013, the company initially aimed at protecting soldiers from improvised explosive devices (IEDs) in Afghanistan. However, recognising the growing threat posed by drones in both military and civilian contexts, the company pivoted towards anti-drone technology, leveraging its expertise to develop robust solutions for detecting, identifying, and neutralising hostile drones.

MyDefence uses multiple sensor types, including radio frequency, radar, and acoustic sensors. This multi-sensor strategy allows for comprehensive protection against drone threats, which makes their systems adaptable to various environments and operational needs. A key aspect of their technology is the open Application Programming Interfaces (APIs), which facilitate seamless integration with existing Command and Control (C2) systems. This interoperability ensures that their solutions can be tailored to the specific needs of military units, critical infrastructure, and private security firms.

The company's anti-drone solutions detect and identify potential threats and incorporate jamming technologies to disrupt drone communications. This capability is crucial in modern warfare, where drones are increasingly used for reconnaissance and offensive operations. MyDefence's systems are designed to be portable, allowing soldiers on the battlefield to quickly deploy them in response to emerging threats.

> **Intelligent and adaptive systems leverage AI, machine learning, and sensors to adapt to changing conditions in real-time.**

Trend 1

Intelligent and Adaptive Systems

In the context of robotics, intelligent and adaptive systems refer to robotic systems that can perceive their environment, make decisions, and adjust their behaviour based on changes in the environment or task requirements. These systems utilise artificial intelligence (AI) techniques to process sensory information, learn from experience, and improve their performance over time. By continuously adapting to new situations and uncertainties, such systems can perform complex tasks with high autonomy and efficiency.

Intelligent and adaptive systems leverage artificial intelligence, machine learning, and sensory inputs to perform tasks more efficiently and adapt to changing conditions in real-time. These systems are often capable of learning from data, utilising machine learning algorithms to improve their performance over time.

In the following, we explore some of the enabling technologies and their role in intelligent and adaptive systems before focusing on some of their applications and benefits.

AI and Machine Learning

AI is a megatrend across most industries today and a key part of what is often referred to as Industry 4.0, which denotes the merging of the physical and digital worlds in industry. With better sensor technology combined with data processing capabilities, robotic systems have become far more adept at manoeuvring the world while autonomously learning about it.

Machine learning, specifically, is not new to the robotics industry. The technology allows robots to be trained with datasets and experiences to perform specific tasks and continue learning from new data and experiences. With machine learning, robots can adjust their strategies or movements based on feedback, allowing them to navigate changing environments or handle unforeseen obstacles, such as a forgotten box on the floor. Machine learning can also be used to identify movement patterns and objects, such as drones in the sky. By leveraging machine learning, companies can develop adaptive robots that are not only capable of performing complex tasks but also constantly improving their performance through experience.

At a practical level, generative AI services with natural language interfaces are simplifying robot programming and can make robotics programmers far more productive and help troubleshooting, while reducing the need for specialized coding skills, making robotics coding more accessible to a broader range of users.

Improved Sensor Technology

One factor currently driving the trend towards more intelligent and adaptive automation systems is the advancements and price reductions in many sensor technologies. Intelligent and adaptive systems often rely on sensors, such as cameras and LiDAR, that provide a detailed understanding of their environment. This is crucial for tasks like object recognition and navigation.

Enhanced sensor technology is a pivotal driving force behind the development of intelligent and adaptive systems in robotics. As technology advances, sensors such as cameras, radio frequency sensors, and acoustic sensors are becoming more advanced, cost-effective, and reliable. These sensors enable robots to gain a detailed understanding of their surroundings, which is vital for navigating and performing tasks autonomously.

One of the most significant benefits of enhanced sensors is their ability to improve the robot's perception of its surroundings. Using advanced image recognition and object classification supported by AI, robots can adapt more quickly to changing environments and make decisions in real-time. This is especially crucial in dynamic sectors such as manufacturing and logistics, where conditions frequently change quickly and unpredictably.

A challenge associated with the increased use of sensors is managing the large amounts of data they produce. The data must be effectively transformed into actionable information that the system can utilise. AI and machine learning are essential in this process, as they can assist in filtering and analysing the data.

Digital Twins Pave the Way for Future Robot Innovation

Digital twin technology is used to develop intelligent and adaptive systems by creating virtual copies of physical robots, systems or environments. Digital twins serve as an advanced simulation tool and are valuable for improving design, operation, and maintenance.

Intelligent Systems: Transforming Robotics with Twin Technology

Intelligent Systems develops advanced control systems for automated machines and processes in the robotics industry. Through the development of flexible and scalable systems, they focus on making robot technology more accessible and user-friendly for their customers.

A central part of Intelligent Systems' work is the application of digital twin technology. By creating a virtual copy of physical systems, the company can experiment, test, and optimise without the risks and costs associated with changes in the real world. Intelligent Systems sees great potential in integrating digital twins with emerging technologies to create even more advanced fleet management systems that can handle coordination and communication in an increasingly complex and heterogeneous robot environment. Here, the technology can contribute to tailoring robot solutions to specific needs and challenges.

By creating these virtual copies, robot companies can simulate and test various scenarios, thus solving problems before they occur in the physical world, enabling the development of more cost-effective robots and facilitating development processes. Digital twins allow for adjustments, improvements, and testing in a safe virtual environment before implementing changes. This will enable robots to handle more complex challenges while reducing installation risks, thereby lowering costs.

Robot companies consider digital twin technology increasingly necessary to stimulate development processes, optimise robotic techniques and systems, and create more advanced code. Digital twins are regarded as an important technology for developing advanced and reliable solutions and promoting innovation and efficiency in their own processes within robot companies. They can enhance inventory management, quality control design processes, and a host of other areas.

Self-learning Systems that can Optimise their own Performance

AI opens numerous opportunities in terms of production, processes, and operational tasks in almost every sector and industry.[8] In the robotics industry, various applications of AI depend on companies' technological focus and core business. AI can manage large datasets, thereby improving robot performance or being used for quality control in production through visual inspection systems.

Systems can be designed to make real-time decisions through adaptive control mechanisms, allowing them to adjust their actions based on immediate feedback. For example, a robot can modify its approach to prevent errors or damage if it encounters unexpected resistance. This kind of system gives companies flexibility that is valuable for production in dynamic environments such as manufacturing, healthcare, and logistics. Due to technological advancements and lower prices, many Danish companies see a movement in the industry towards increasing intelligence and adaptiveness.

Danrobotics: Adaptive Vision Technology Increases Efficiency

Danrobotics develops automation solutions for the manufacturing industry and is a large supplier of robotic welding. The company provides both small, standard welding stations and meter-long, specially developed welding projects. Beyond welding, Danrobotics delivers customised robotic solutions that can handle logistics tasks, assembly, and welding without human intervention. In this way, Danrobotics contributes to increasing the efficiency of their customers' production processes.

Vision technologies are central to Danrobotics, enabling them to use sensors and images to automate logistics, assembly, production, and welding. The company has been using vision cameras for many years, but a new development in the field is the integration of vision technologies with AI, making automation even more efficient. The company expects AI to continue to drive growth in the robotics industry and open new opportunities.

Predictive Maintenance

Predictive maintenance combines many of the technologies encapsulated by the term intelligent and adaptive systems. Predictive maintenance uses sensor data on the performance of robotics equipment and analyses these through machine learning algorithms to determine when the different parts of the equipment require service. This approach can substantially minimize downtime costs by anticipating equipment maintenance needs.

Rather than waiting for the robot or automation system to break down and then fixing it (with all the waiting this entails – perhaps even including ordering new components), predictive maintenance fixes the problem before it arises. Moreover, predictive maintenance can also help avoid unnecessary expenses on components that need not be replaced by providing accurate, performance-based estimates on the remaining lifetime of robotics parts.

Trend 2

Interoperability

Robotics and automation have been around for a long time. Many companies have robots from various brands and suppliers. The presence of several robot systems can create a new challenge in achieving seamless communication among the different systems. Therefore, many Danish robotics companies are noticing a shift towards greater interoperability between technological solutions. As different kinds of robots become more capable of communicating with each other, the potential benefits of automated solutions increase, and new operational possibilities emerge – for robotics companies and their customers.

Interoperability ensures that different technological solutions can integrate and communicate with existing robots, technologies, or systems. This means that systems, devices, or applications can communicate, exchange data, and utilise information coherently, which is a prerequisite for optimal fleet handling. Interoperability also entails cost reductions for some robotics companies since they do not need to develop all parts of a solution and can avoid expensive and time-consuming system adaptations by having their product easily integrated. By adopting open communication standards, robotics companies can develop more specialised solutions, offer customers the flexibility to integrate products from multiple suppliers, and ultimately expand the market.

Below, we outline some of the key components of interoperability and offer a perspective on the challenges and potential benefits of the trend.

MiR: Flexible Integration as the Future Standard

MiR (Mobile Industrial Robots) is one of Denmark's largest robotics companies. They primarily serve the industrial sector and have built a successful business by simplifying internal logistics for manufacturing companies. With their mobile robots that transport goods across factory floors, MiR has established a strong reputation by offering solutions that can be tailored to various needs and loads. Their strength lies in providing flexible platforms that do not lock customers into a single application but instead allow them the freedom to choose how they want to use the technology.

One of the technological trends MiR is focusing on is interoperability. For MiR, interoperability means that their robots can be smoothly integrated with customers' existing systems and other technological solutions. This is a huge advantage because it means that companies do not need to overhaul their entire setup to accommodate a MiR robot.

The concept of flexible integration is important not just for MiR but also has the potential to impact the entire robotics industry. In today's fast-paced world, where companies are constantly striving for efficiency, being able to adapt to new technologies without dismantling existing ones is a significant advantage. MiR is leading the way by emphasising that collaboration between systems is not just a good idea, but a necessity. This approach could very well become the standard for industry development, where increasingly, technologies need to communicate effectively to achieve success.

Open Communication Protocols

To achieve interoperability between different systems and technologies, several robot companies offer fleet systems that bridge various systems. These software layers can translate and mediate between different communication protocols, allowing for smoother interoperability without extensive hardware changes.

Some major robotic platforms are beginning to open their APIs to third-party vendors, fostering an ecosystem where different technologies can work together more efficiently. However, previous attempts to establish common operating systems for seamless communication have had limited success.

Despite challenges, open communication can be highly valuable. Effective communication protocols can make it far easier and more efficient to gain a comprehensive overview of various robots and automation technologies within a fleet or operational environment. This is particularly relevant for integrators. By adopting open communication standards, robotics companies can develop more specialised solutions, offer customers the flexibility to integrate products from multiple suppliers, and ultimately expand the market.

Capra Robotics: Mobile and Versatile Platforms

Capra Robotics is a Danish robotics company specialising in the development and production of advanced mobile robot platforms. Their core products are versatile wheeled robots primarily designed for intralogistics tasks. Capra Robotics produces three main solutions that operate effectively in both indoor and outdoor environments. The solutions are suitable for inspection, surveillance, as well as transportation of both small samples and large pallets.

Their standardised platforms serve as a foundation, enabling various specialised top modules to be developed so that the final robot is adapted to a specific need. Capra Robotics builds modular robots and leaves the customisation and implementation to integrators, who might devise various add-ons to Capra Robotics' design. By using integrators for the customisation process, the company can instead work on standardising the robot production itself and communication between robots and fleet systems.

By focusing on robust standard platforms and open interfaces, their robots are designed to be open to various industries and use cases.

Modular Robots

Modularity is increasingly the norm in the Danish robotics industry, and it supports more interoperability. By building robotics systems in modules and ensuring that these modules are compatible with key industry standards, customers or integrators can more easily modify their systems to work with systems from other suppliers. Modularity also makes it easier to upgrade, adjust, or service existing systems.

A modular robotics system could consist of a robotic arm with different "hands" designed for different tasks or a robot platform where top modules can be easily swapped according to customer needs. A robot constructed with modularity in mind should have components that are simple to replace, e.g., if a wheel breaks. This approach makes it easier for the customer to fix the system. They can just replace the broken module with a spare part rather than having to wait for service from the producer of the robot or an integrator.

With modularity, instead of replacing an entire robotic system to gain new functionalities, customers can switch or add modules that meet their current needs. In this way, robot companies can easily adapt products to custo-

mers' scaling needs by replacing or upgrading modules for a new, specific function without compromising the overall integrity of the system. This approach not only streamlines the process of adapting systems and enhances the performance of individual robots but also allows companies to respond rapidly to market changes and customer requirements.

The Importance of Connectivity

Cloud and edge computing can enhance robot performance and functionality. The technologies provide access to data analytics and machine learning models without requiring extensive local hardware. At the same time, they can improve response times and reduce dependence on central systems.

Connectivity is a crucial aspect in this context. Robots typically need continuous communication with their control systems to operate efficiently and effectively. Meanwhile, edge computing enhances the coordination and control of robot movements. By processing data closer to where a robot or autonomous vehicle operates, edge computing simplifies the expansion and scaling of systems comprising multiple units. This approach can enhance robustness, improve response times and increase energy efficiency, which is particularly beneficial for mobile or battery-powered devices.

Trend 3

Security

With societies becoming ever more based on online connectivity and growing geopolitical tension, cybersecurity has become a key theme for both societies and businesses. As late as June 2024, the Danish Centre for Cyber Security raised the national threat level for destructive cyberattacks against Denmark from low to medium[9] This imposes greater security demands on companies that deliver automation and robotics solutions. Since cybersecurity is today of central importance to both buyers and suppliers of robotics, the ability to offer high levels of security has become a key competitive factor.

Although the risk of cyberattacks is not new, the current high level of threat has made it an important trend for robotics companies. Their customers place ever greater emphasis on the security of the robotics systems they purchase and their underlying supply chain. As robotics technology advances and becomes more pervasive across different sectors, ensuring robust cybersecurity measures is increasingly vital. The following sections present some of the key themes in cybersecurity in the robotics industry today.

Documentation and Certification

Documentation of cybersecurity procedures has evolved into an important component of many companies' overall security strategy. This documentation serves as both a blueprint for current cybersecurity practices and a foundation for future improvements and audits. By recording every aspect of their cybersecurity measures, companies can ensure consistency and accountability across their operations. This approach allows for easy identification of weak points and facilitates updates to security policies as new threats emerge.

Conducting risk assessments has become a regular practice, allowing organisations to proactively identify and address potential vulnerabilities in their systems. These assessments involve evaluating both internal and external threats, considering the unique risks associated with robotic systems. By prioritising risks based on their potential impact and likelihood, companies can allocate resources more effectively, ensuring that critical systems receive the necessary protection.

Organisations also emphasise the implementation of certifications such as ISO 27001. This certification provides a comprehensive framework for managing information security risks, covering a wide range of protocols, inclu-

Upteko: Supplier Security Provides an Edge

Upteko manufactures standardised and modular drones for various businesses working with critical infrastructure, such as the police, defence, emergency services, and fire departments. The company is scaling up its production to meet increasing demand and believes that drones can eventually find applications in virtually all industries.

Upteko produces rotary drones and associated payloads, controllers, and chargers. Their drones are currently being used to inspect offshore windmill farms, which is otherwise expensive and dangerous. By using drones to inspect the windmills, the infrastructure operators can get close-up images of the mills without having to be placed on them or hanging from them.

In recent years, Upteko has experienced a growing demand from customers both domestically and internationally for drones without Chinese components. In response, Upteko has transitioned to a complete supply chain completely free of Chinese components, even where these might be cheaper. Upteko has implemented full traceability across its entire supply chain and production.

ding regular data backups, incident response strategies, and access controls. Achieving ISO 27001 certification not only demonstrates an organisation's commitment to maintaining high-security standards but also enhances its reputation and credibility in the marketplace.

Supplier Management

Supplier management is a critical aspect of cybersecurity in the robotics industry, as many security breaches today originate from subcontractors or third-party vendors.[10] These suppliers may inadvertently or maliciously introduce vulnerabilities into the supply chain, such as unauthorised software installations or hardware modifications.

To mitigate this risk, the robotics industry increasingly adopts the zero-trust model, which emphasises rigorous verification and control measures. This approach requires companies to conduct thorough inspections of hardware and software components provided by suppliers, ensuring that they align with purchase orders and meet stringent security standards. The process of managing suppliers requires substantial resources and diligence. Regular audits and assessments are conducted to ensure compliance with security standards, and any discrepancies are promptly addressed.

Legacy System Management

Legacy systems present a significant challenge in maintaining cybersecurity within the robotics industry. As equipment ages and reaches the end of its life cycle, it may no longer receive security updates, increasing its vulnerability to attacks. If not properly managed, these outdated systems can become entry points for cyber threats.

Companies must carefully evaluate their legacy systems to determine the best course of action. This might involve replacing outdated systems with newer, more secure alternatives or implementing compensating controls to mitigate vulnerabilities.

Human Factors and Employee Training

Human factors are critical in cybersecurity, as employees often unintentionally create vulnerabilities through poor password practices or by allowing unauthorised individuals into secure areas. Despite significant investments in training, companies often find that the effectiveness of these programmes is limited by employees' lack of interest or understanding of cybersecurity principles.

To address these challenges, organisations must develop continuous education and awareness programmes that engage employees and emphasise the importance of cybersecurity in their daily activities.

Emerging Threats and Advances in Cryptography

The cybersecurity threat landscape is constantly evolving, with new challenges emerging regularly. In the robotics industry, espionage, particularly from certain geopolitical regions, has become more prevalent, posing significant risks to intellectual property and sensitive data. While ransomware attacks have diminished in frequency, there is an increased focus on data exfiltration, where hackers threaten to leak sensitive information rather than encrypt it.[11] To navigate this complex threat landscape, businesses are increasingly investing in threat intelligence services, conducting regular penetration testing, and implementing advanced security technologies such as AI and machine learning to detect and respond to threats in real time.

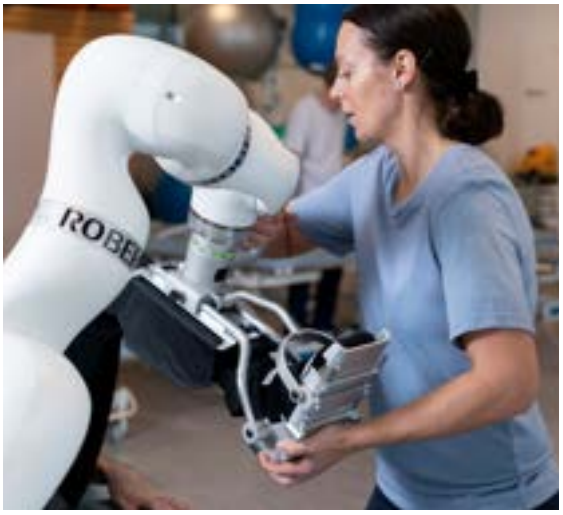
Cryptography is a crucial component of cybersecurity in the robotics industry, ensuring secure communication and data protection. However, advancements in quantum computing may make existing cryptographic standards vulnerable, necessitating continuous updates and improvements to cryptographic methods. To address this challenge, some companies are preparing for post-quantum cryptography standards, designed to withstand quantum computers' computational power.

Trend 4

Strategic Simplification

Many potential end users consider investment the primary barrier to implementing robotics in their workflows.[12] Bringing down costs in the robotics industry is thus necessary to make robotics more widely available to a broader audience and increase the market size for companies that develop robots, automation, and drones. Although technological developments of many components and sub-technologies have made robotics more available, it is complex and often costly to produce. So, how can Danish companies in the robotics industry make the technology more financially available to a broader audience without negatively impacting the business?

Strategic simplification in this context refers to a trend among robotics companies to streamline their products and operations to overcome market entry barriers and enhance profitability. This trend is about how companies address the challenges of high costs and complexity. Adopting standardisation and specialisation strategies, such as simplifying user interfaces and developing easy-to-integrate products, is a way of harnessing this trend.



This trend must be understood against a historical tendency towards highly customised robotics products. Robotics companies have often been engaged in complex development projects to design a product perfectly suited for a customer's unique needs. Unfortunately, long customisation projects may result in products that are only relevant to a single customer, leaving the robotics company with a product that is anything but scalable. To avoid this "customisation trap", robotics companies are moving towards more straightforward, off-the-shelf solutions that require as little customisation and adjustment as possible. This makes for lower unit prices and more profitable products.

Reducing the Time and Cost of Implementation

Many companies are working on reducing the complexity of the user interface. Ideally, integrating and programming robotic units should be easier or less time-consuming, ultimately reducing implementation time. Many companies see ease of implementation and plug-and-play solutions as a way of reaching a broader audience.

Standardised and easy-to-deploy robotics and automation are foreseen to increase in the industry, which is likely to bring about more

affordability to the customers. Standardisation of the products also ensures that robotic systems and components can be easily integrated, reducing the need for custom solutions and facilitating more efficient development and deployment. It helps create a cohesive ecosystem where different products and systems are interoperable.

Specialisation as a Strategy

Specialisation can give robotics companies a significant advantage by enabling them to deeply understand their customers' challenges and provide tailored solutions. By focusing on solving very specific problems rather than attempting to offer a broad range of solutions and services that may be less profitable, these companies can enhance customer satisfaction and drive innovation. This targeted approach fosters expertise and ensures that resources are directed toward areas where they can make the greatest impact.

In a standardised environment, specialisation can become a key strategy for differentiation. Companies can focus on developing expertise in specific areas rather than trying to cover a broad range of applications. This specialisation

Nordbo Robotics: Easier Programming and Automation

Nordbo Robotics is a robotics company that specialises in developing software platforms for the automation of surface processing and surface quality inspection.

With its Mimic platform, Nordbo Robotics has developed an intuitive programming platform that allows end users to record and save complex human movements that a robot can replicate (or mimic) afterwards. Implementing Mimic does not require programming experience. Instead, the end user demonstrates movements using a specific tracker or controller connected to the robotic system. In this manner, the movements demonstrated are recorded, and the Mimic software translates them into code that the robotic system needs to complete the task at hand.

The Mimic platform can now be used for a wider range of applications, such as deburring, sanding, and painting, and

together with various robotic systems. It can be combined with wireless handheld trackers to capture more organic fluid movements, for instance, when applied to painting and powder coating tasks.

By simplifying the programming process, a robot becomes more accessible for companies, considering the entry barrier too high. Thus, by strategically simplifying the setup, companies might be able to unlock new customer segments.

allows for more efficient use of resources and a stronger competitive position in niche markets.

Delivering tailor-made solutions has been the business model for many Danish robotics and automation companies for years. This strategy might have been well suited in the early days with a limited market, but for many companies, it can be worth simplifying the operations and product portfolio to make the business more profitable. The journey towards more simplicity will be different according to the specific context, but thinking in simplicity can be the way to become more profitable.

Aim Robotics: Simplified Precision

Aim Robotics has developed and refined a dispenser system for precision work over the years, designed to be mounted on a robotic arm. They have established a strong market position by simplifying complex processes in production environments. The dispenser system seamlessly interacts with the cobot it partners with, and the company focuses on ensuring that the user interface is straightforward and intuitive.

Aim Robotics focuses on delivering solutions that are easy to integrate and operate, granting customers the freedom to optimise their workflows without extensive training. By emphasising user-friendliness, operators can quickly adapt and efficiently use the technology. By minimising complexity and enhancing value through user-friendly design, robotics companies can improve their market strategy.

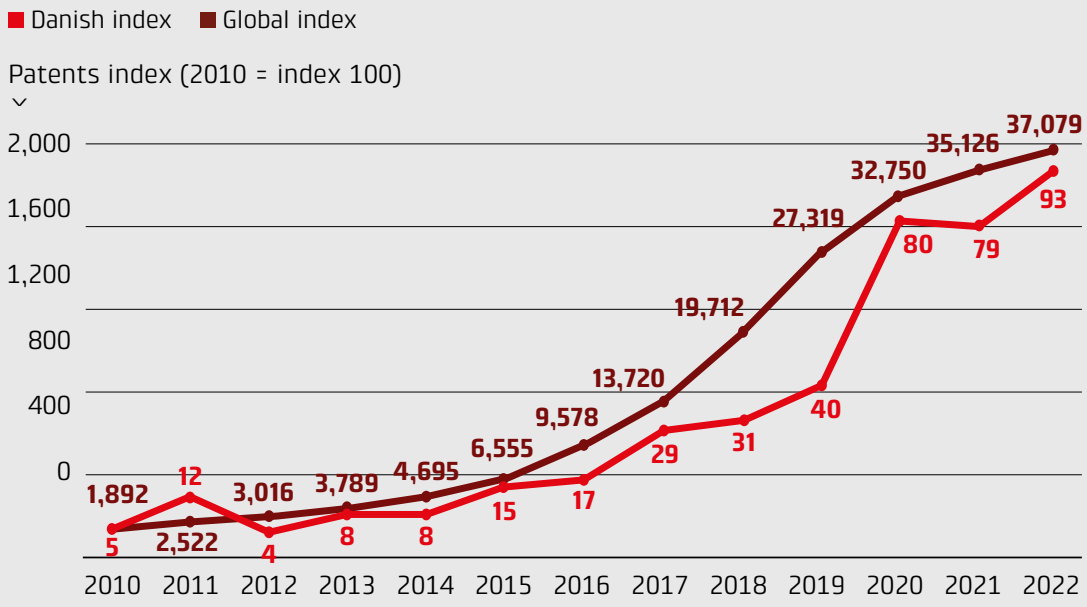
> **Simplicity can be the way to become more profitable.**

A Map of Global Robotics Innovation

Danish companies are in fierce competition with the rest of the world in the race to come up with new robotics innovations that enable the development of new products. The following pages present an analysis of robotics innovation in Denmark and internationally, based on patent data obtained via the database PatSnap and analysed by Danish Technological Institute. Patent applications can be considered an indicator of innovation activity since filing patent applications is costly in both time and money. Although not a perfect measure, it provides an idea of the overall development and the macro tendencies in Denmark and globally.

As depicted in Figure 2, the world has seen a surge in innovation activity within robotics, automation, and drones from 2010 to 2022. The number of yearly patent applications related to robotics has grown rapidly from less than

Figure 2. Robotics Innovation in Denmark and Globally, 2010-2022



Index of the evolution in the number of patent applications in robotics-related technology. The graph shows the absolute yearly numbers of new patents. 2010 = Index 100. Source: Based on 199,396 patent applications related to robotics technology, filed in 2010-2022. Data obtained via PatSnap.

2,000 applications in 2010 to more than 37,000 applications in 2022. Although the curve shows a slight decrease in innovation activity in the latter years (which may partly be attributed to COVID-19), the trend is clear. Robotics innovation is high on the global innovation agenda.

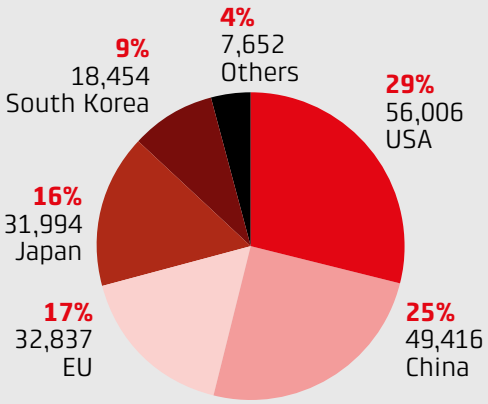
Figure 2 shows a similar story for Danish innovation activity. Danish innovation in robotics also progressed significantly from 2010 to 2022, albeit at a slightly lower rate than global development.

Geographical Distribution of Patent Activity

As depicted in Figure 3, the largest share of patent activity can be attributed to American organisations (29 %). China is the second most important country for robotics innovation, with 25 % of all robotics-related patent applications assigned to Chinese entities. European organisations take third place, representing 17 % of robotics-related patent applications worldwide.

One way of gauging a country's innovative activity is by comparing it to the size of the country's economy. The region of East Asia – with China, Japan, and South Korea – accounts for half of all the world's robotics patent applications from 2010 to 2022. This is impressive, considering that the three countries together "only" accounted for roughly 23 % of global nominal GDP in 2022.[13] In comparison, the USA accounts for a slightly larger share of global robotics innovation (29 %) compared to its share of global nominal GDP (ca. 26%) in 2022, while the EU's share of robotics innovation is roughly equal to its share of the global GDP in 2022 (17 %). In short, when the overall sizes of national economies are taken into consideration, East Asia is much more active in robotics innovation than both the USA and EU.

Figure 3. Distribution of Total Patent Applications, 2010-2022



The regions and countries are selected because of their relative strength or their strategic importance. Source: Based on 199,396 patent applications related to robotics technology, filed in 2010-2022. Data obtained via PatSnap.

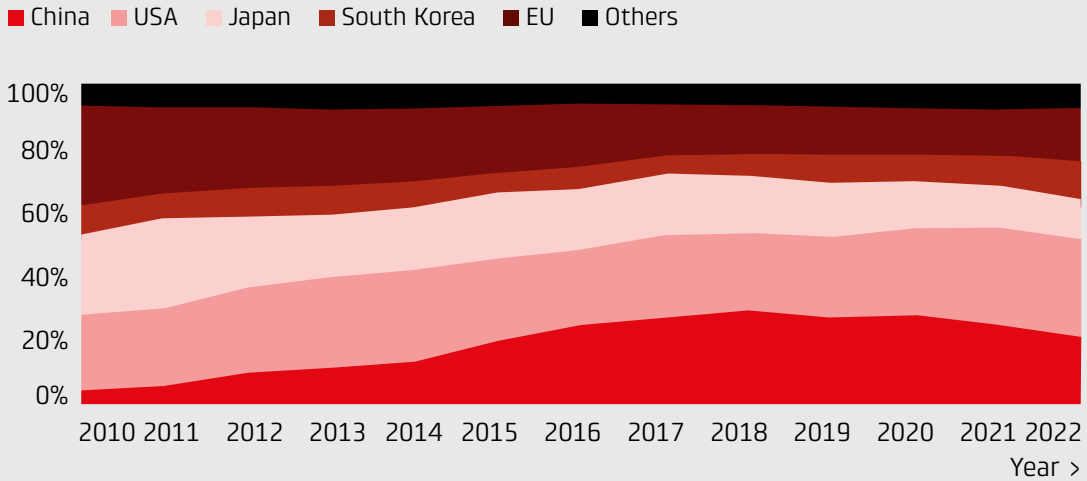
The relative innovation activity among the leading countries has also shifted since 2010. Figure 4 shows that the USA has grown its share of the total number of patent applications per year from 2010 to 2022. The same is true on a far more dramatic scale for China, even if China's share has also contracted since its peak around 2018. South Korea's share has also increased a little from 2010 to 2022. The larger shares of the USA, China, and South Korea have been at the expense of Japan and Europe, which have both experienced substantial decreases in the size of their respective shares of global patent applications related to robotics. The decline is the most dramatic for Europe, since the region has changed from being the world's leading region for robotics innovation in 2010 to filing fewer patent applications than either the USA or China.

Figures 3 and 4 both indicate how robotics innovation is dominated by relatively few countries, including the EU. Figure 5 underscores this point by providing a heat map of patent innovation activity. Based on the addresses of the organisations applying for robotics patents, the heat map shows where exactly in the world there is a concentration of innovation activity.

Figure 5 clearly shows how robotics innovation happens on the eastern and western coasts of the USA, in a few large cities in east China, around Tokyo and Osaka in Japan, Seoul in South Korea, Taipei in Taiwan, and spread out in Western Europe. However, the map also identifies smaller innovation hubs, such as Israel, Singapore, and Australia. The concentration of innovation on some Caribbean islands is likely due to several large companies having the addresses of their headquarters registered here.

Another way of assessing innovation activity is by measuring the number of patent applications per capita. This gives a measure of whether a country is innovating more or less than one might expect, given its population size. Figure 6 shows the number of patent applications per capita for the countries and

Figure 4. Development in Global Shares of Patent Applications, 2010-2022



The depicted regions and countries are selected because of their relative strength or their strategic importance. Source: Based on 199,396 patent applications related to robotics technology, filed in 2010-2022. Data obtained via PatSnap.

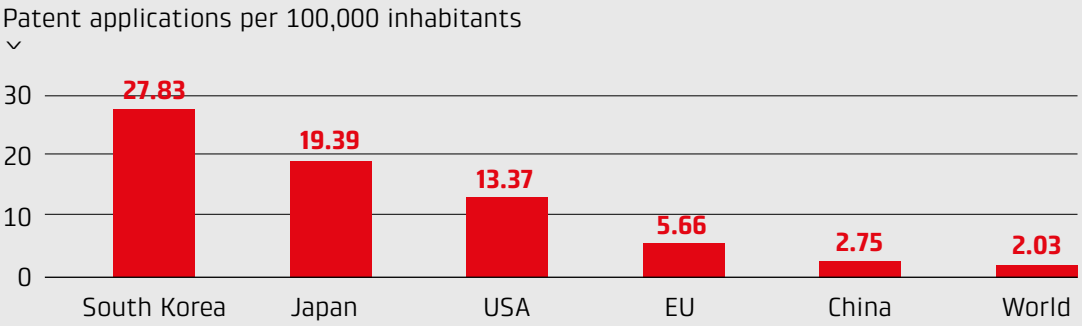
regions that file the most patent applications, the same entities examined in Figures 3 and 4. The figure clearly shows that South Korea and Japan outperform the rest, with an impressive 27.83 and 19.39 patent applications per capita, respectively. With 13.37 patent applications per capita, the USA also delivers far more patent applications than the global average of 2.03. While above the global average, both the EU and China are far behind their competitors when considering population sizes.

The national framework conditions, political environment, and patenting culture vary significantly between the examined regions and will account for some of the differences in innovation volume per capita. Therefore, it can also be difficult to compare Denmark to, for example, South Korea since companies operate under very different conditions. Consequently, it may be more beneficial to compare Denmark to the most innovative European countries rather than the global leaders. This is done in Figure 6.

Figure 5. World Map of Robotics Innovation

Based on the addresses of patent applicants related to robotics, 2010-2022. Map created with BatchGeo.

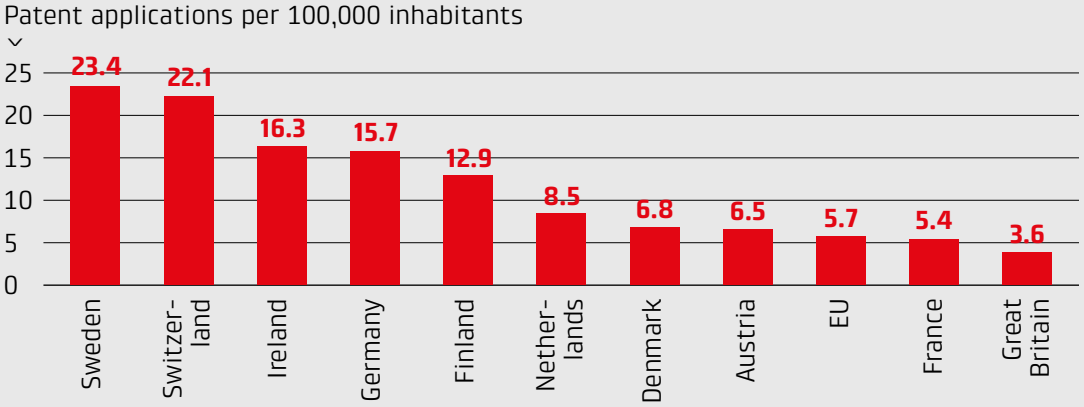
Figure 6. Patent Applications per 100,000 Inhabitants for the most Patent Applying Regions and Countries in the World, 2010-2022



The countries with the most significant overall volume of robotics patent applications globally. The world average is included for comparison. Source: Based on 199,396 patent applications related to robotics technology, filed in 2010-2022. Data obtained via PatSnap.

Denmark is the seventh most patent-applying European country when population size is considered. Although slightly ahead of the European average, Denmark is far behind the leading European countries, Sweden (23.4 patent applications per 100,000 inhabitants) and Switzerland (22.1). Ireland, Germany, Finland, and the Netherlands are also all ahead of Denmark. This indicates that Denmark might have much to learn from the countries surrounding it in terms of fostering more robotics innovation – especially from its Swedish neighbour.

Figure 7. The Ten European Countries with the Most Robotics Patent Applications per 100,000 Inhabitants, 2010-2022



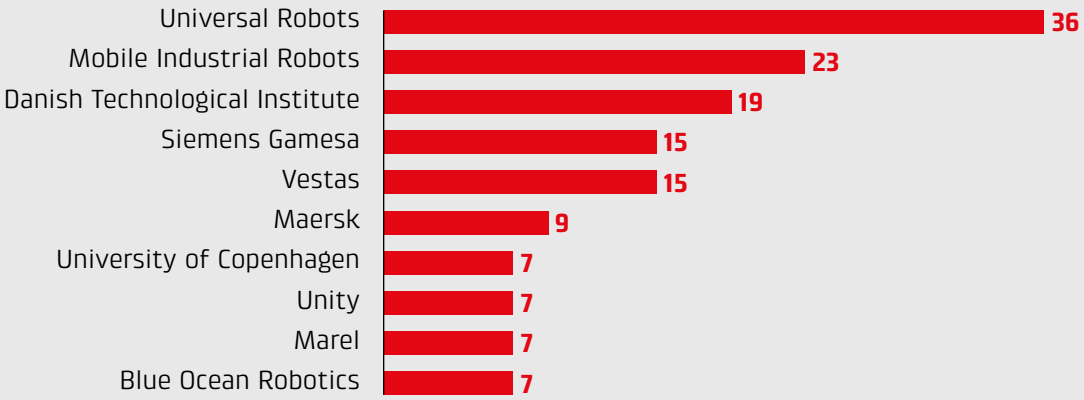
The ten countries with the highest number of patent applications per capita in Europe. Source: Based on 198,665 patent applications related to robotics technology, filed in 2010-2022. Data obtained via PatSnap.

Innovative Organisations

Figure 8 shows the diverse cast of organisations that led the robotics innovation in Denmark from 2010 to 2022. Figure 8 shows a diverse cast of organisations. Universal Robots and Mobile Industrial Robots (MiR) – two established robotics companies with large Danish and international market shares, and both owned by American Teradyne – are at the top of the list. The remaining companies on the list represent a broader set of industries. Siemens Gamesa and Vestas construct wind turbines, Mærsk is a global shipping conglomerate, Unity is a software game engine, and Marel works in food processing. Besides Universal Robots and MiR, only Blue Ocean Robotics is primarily a robotics-oriented company.

The list also includes two knowledge institutions. Danish Technological Institute is an important player in the Danish robotics landscape, with 19 patent applications. Indeed, it is rare to find a not-for-profit organisation ranking so high in patent application rankings, which are usually dominated by businesses. The University of Copenhagen has also filed seven robotics patent applications, putting it on par with several companies on the list.

Figure 8. The Ten Danish Organisations that have Applied for the Most Robotics Patents, 2010-2022



Organisations that have filed the most patent applications related to robotics, 2010-2022. Source: Based on 199,396 patent applications related to robotics technology, filed in 2010-2022. Data obtained via PatSnap.

Moving fast but falling behind

All in all, the EU holds a significant but declining position in global robotics innovation from 2010 to 2022. While its share of patent applications aligns with its contribution to global GDP, it pales compared to East Asia, where countries like China, Japan, and South Korea dominate the robotics patent landscape, producing half of the world's patents. The EU's robotics innovation performance has also decreased relative to other regions, as the USA and China have overtaken its share of patent applications. This trend underscores the need for Europe to strengthen its innovation ecosystem to remain competitive in the rapidly evolving robotics field.

These findings align with a recent study by the Danish Academy of Technical Sciences, conducted by Danish Technological Institute, which found that Europe is lagging increasingly behind the USA and China in innovation in several critical technologies, including robotics, automation, and AI.[14]

Denmark is actively competing globally in robotics innovation, with its patent activity reflecting significant growth from 2010 to 2022. While the Danish robotics innovation is moving fast, Denmark's innovation speed has been slightly lower than the global rate. Regarding patent applications per capita, Denmark ranks seventh among European nations, slightly above the European average. Despite this, Denmark is well behind countries like Sweden and Switzerland, suggesting room for improvement in fostering innovation.

Looking ahead

This report highlights important technology and business trends in Denmark's robotics industry, driven by its innovative ecosystem and collaborative efforts among industry leaders, startups, and academic institutions.

The trends identified in this study – advancements in intelligent and adaptive systems, interoperability, security, and strategic simplification – are pivotal for the continued growth of the robotics sector in Denmark. These developments emphasise the importance of sustained investment in research and development to maintain competitive advantages and drive technological progress.

The implications are significant for industries adopting robotics technology. By integrating robotics into their operations, the manufacturing, healthcare, agriculture, construction, and defence sectors can all benefit from enhanced efficiency, precision, and sustainability, especially in a time of labour shortages across many Danish industries.

The report also underscores Denmark's need to address the global competition in patent applications and innovation. While Danish companies are innovative, Denmark is falling behind several other European countries in robotics patent applications. Strengthening intellectual property strategies may be crucial to ensure Denmark's continued leadership in robotics technology.

Looking forward, the Danish robotics industry should focus on expanding its global presence by leveraging its strengths in innovation and adaptability. Embracing emerging technologies like AI and machine learning will be essential to develop solutions that meet the evolving needs of various markets. By aligning strategically with the identified trends and fostering collaboration across sectors, Denmark can play an important part in developing advanced robotics technologies and their applications across diverse industries, domestically and abroad.

Notes

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[9] Centre for Cyber Security 2024: CFCS raises threat level for destructive cyber attacks

[10] David Fox 2024: The Growing Risk of Third-Party Vendor Breaches: Due Diligence is Key

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[13] United Nations data. data.un.org. For an overview, see en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal)

[14] Danish Academy of Technical Sciences 2024: Kritiske teknologier: globale hotspots, europæiske perspektiver, danske muligheder [Critical Technologies: Global hotspots, European perspectives, Danish possibilities].

Participating Companies

The following companies were interviewed for this report:

- Aim Robotics
- Autonomous Units
- Blue Ocean Robotics
- B&R Industrial Automation
- Cabinplant
- Capra Robotics
- Cobod International
- Coalescent Mobile Robotics
- Danrobotics
- Drone Volt Scandinavia
- Ephort
- FarmDroid
- GMT Robotics
- Inrotech
- Intelligent Systems
- Mobile Industrial Robot
- MyDefence
- Nordbo Robotics
- OnRobot
- Pilz Skandinavien
- Quadsat
- ROEQ
- Technicon
- Terma
- The Gripper Company
- TinyMobileRobots
- Upteko
- UXV Technologies

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