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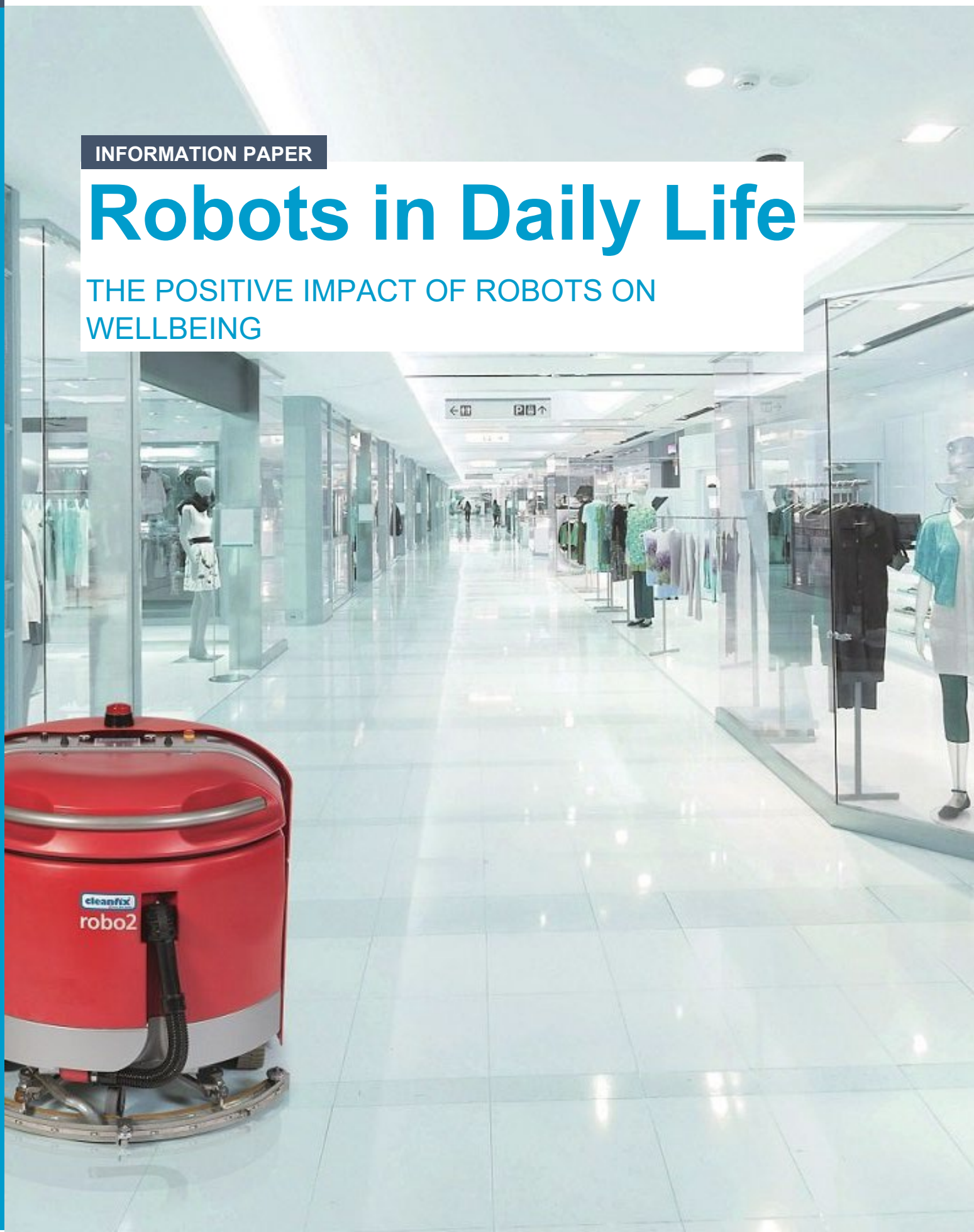
IFR International Federation of Robotics

INFORMATION PAPER

Robots in Daily Life

THE POSITIVE IMPACT OF ROBOTS ON WELLBEING



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Executive Summary

Robots are improving our daily lives in an increasing variety of ways. This IFR paper focuses on how robots improve health outcomes, the quality and sustainability of food, the quality and availability of the products and services we receive, and the reduction of carbon emissions.

Robots

- Help improve health outcomes. They improve health at work by doing the heavy lifting and other unergonomic tasks in sectors such as manufacturing, logistics, retail and healthcare. They improve efficiency in the production of the medicines and medical devices, clean and disinfect hospitals, help nurses focus on patient care by fetching and carrying linens and medication, help the elderly live independently for longer, enable patients to recover faster - and better - from conditions such as stroke, and increase mobility for people with physical disabilities.
- Improve the quality and sustainability of food by reducing pesticide use and energy consumption in farming as well as helping conserve water. Robots help us access fresher foods and support small farms to stay in business.
- Increase the range and quality of products we buy by enabling manufacturers to produce a range of products (e.g. smartphones) in large quantities as well as highly customized products (e.g. shoes) in small numbers at competitive prices and to high quality standards.
- Reduce the environmental impact of production by optimizing the production process and reducing carbon emissions in specific processes. Robots enable manufacturers in developed economies to produce closer to the customer at competitive prices, thereby minimizing energy consumption in the logistics chain. Robots reduce material waste and rejects. They are increasingly made with energy-saving features, from lightweight materials to drive technologies.

Introduction

When we think of robots, we tend to imagine large, powerful machines hammering out metal parts or mounting car doors. Industrial robots have indeed been used for over 50 years in manufacturing for these and other tasks aimed at improving productivity. However, the last ten years have seen a dramatic shift in the capabilities and uses of robots. Today, many robots are out of their

Figure 1: The SeRoDi Service Assistant Robot, image credit: Fraunhofer IPA.

cages, moving around factories, warehouses, homes, and public spaces.

For decades, industrial robots have made manufacturing safer for workers, carrying out tasks that are dangerous, dirty – or plain dull. The range of tasks robots perform in factories has expanded greatly over the past 20 years. Robot grippers are now far more dexterous, and so can handle a greater range of materials. Robots are smaller and lighter, meaning they can be used in factories that are short on space and in which robots and humans need to work alongside one another - from pharmaceutical research to food-processing, as well as in later stages of traditional manufacturing such as product assembly.

The advent of robots that can sense and respond to their environment - and in many cases move around within it – has taken robots outside of industrial settings and into public life. Whether in direct contact with people, or behind the scenes, performing tasks we rely on but never think about, robots are making our daily lives healthier, safer, and more convenient. Robots also have an increasing role to play in making our planet sustainable for a rapidly rising global population.

This paper from the International Federation of Robotics describes how robots are improving our daily lives in an increasing variety of ways - from helping paraplegics to walk again to enabling us to eat fresher foods, with lower impact on the planet's natural resources. We look at how robots improve health outcomes, the quality and sustainability of food, the quality and availability of the products we receive, and the reduction of carbon emissions.

For more detail on how robots improve our daily lives please see also World Robotics Service Robots[1].

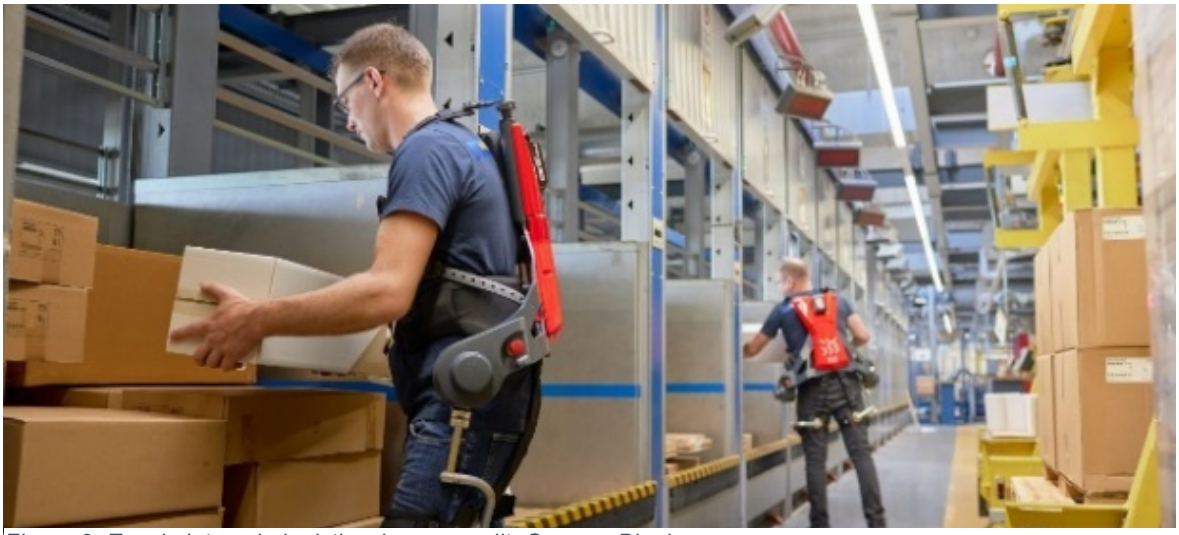


Figure 2: Exoskeletons in logistics, image credit: German Bionic

Improving health

As robots move out of factories and into daily life, one field in which they show significant impact is on our health. Behind the scenes, robots help improve health outcomes in a variety of ways. They improve efficiency in the production of the medicines and medical devices we need, make hospitals even safer, and ease the load on nurses and carers, enabling them to focus more on patients. Meanwhile, wearable robots reduce back pain

1 World Robotics 2020 – Service Robots. Available at https://ifr.org/worldrobotics/

and other acute and chronic work-related injuries for workers in many industrial sectors.

As societies age and we live longer, robots are playing a vital role in enabling us to live independently for longer, recover faster - and better - from age-related conditions such as stroke, and live higher quality lives with debilitating conditions such as arthritis. Robots are also giving hope and freedom to people of all ages who have suffered spinal cord or other neurological injuries that leave them unable to walk or move their hand and arms. Robotic wheelchairs that can open doors and climb stairs bring increased mobility to the wheelchair bound. Thanks to exoskeletons (wearable robots), people who have been wheelchair-bound for years are taking walks in the park with their families.

Improved health at work

Robots can significantly improve health at work in industry sectors that involve heavy lifting, including manufacturing, logistics healthcare and retail. Over forty percent of European employees report having to work in tiring or painful positions more than one quarter of the time, with 32% being called to lift heavy loads[2]. In the U.S musculoskeletal disorders (MSDs) accounted for 30 percent of the days off work in 2018[3] and 5.76% of GDP in 2014 (more than defense spending for that year)[4].

Video 1: A cobot assists a production worker

Robots carry out dull, repetitive and unergonomic work, fetching and carrying loads and completing tasks that often cause muscle strain. They support overall wellbeing by enabling workers – from production operators to nurses – to focus on more interesting and satisfying tasks.

Figure 3: Robotic stool, image credit: Noonee

In manufacturing, robots increasingly work directly alongside production operators as assistants. Many of these are 'cobots' – lightweight robots with specially rounded edges, able to slow or stop when a worker comes into their field of operation. They perform parts of the overall task that are the least ergonomic for the employee, while the employee completes the other tasks and ensures the process is carried out correctly. In this video, for example, the robot lifts and places heavy automotive transmission cases, and the production operator then completes assembly.

Mobile robots fetch and carry materials in manufacturing, healthcare and retail, bringing parts to assembly lines, products to workers in e-commerce who are assembling orders and linens and other items to nurses and nursing

2 Eurofound Sixth European Working Conditions Survey: 2015
3 US Bureau of Labor Statistics https://www.bls.gov/iif/oshwc/case/msds.htm
4 United States Bone and Joint Initiative https://www.boneandjointburden.org/fourth-edition/about

aids. See the IFR paper 'A Mobile Revolution - How Mobility is Reshaping Robotics' for examples of how mobile robots are assisting workers.

Exoskeletons – wearable robots – are increasingly adopted in manufacturing and logistics. They are used to provide upper-body support, for lifting and for working in unergonomic positions, for example on parts overhead. There are also wearable robotic stools which enable workers to sit when part of their work is carried out in a stationary position. These exoskeletons recognize and respond to changes in the center of gravity of the wearer. They either stabilize the wearer in the correct position or provide additional force for lifting.

At some point, nurses may wear exoskeletons for support in moving patients - but healthcare organizations typically have budget constraints which would require a lower price-point than is currently the case. However, other robotic support for lifting patients in hospital is being trialed. For example, the Patient Transfer Assist from Toyota Motor Corporation combines weight-supporting arms with a mobile platform to help caregivers transfer patients from beds to chairs or toilets and back. The caregiver operates the robot by moving its arms.

Figure 4: The Lio mobile personal robot, image credit: F&P Robotics AG.

Better patient care

Robots give healthcare workers more time to focus on patient care

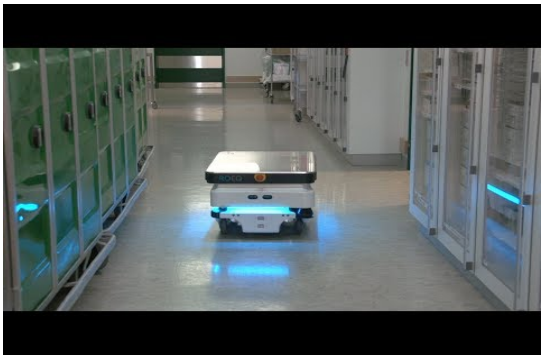
Nurses spend a significant amount of time fetching and carrying medications, linen and waste, walking at least 4 miles per day according to one study[5]. An 800-bed hospital may handle up to 27 tons of materials every day, covering a distance of about 800 km[6]. Robots can significantly reduce this, giving nurses more time to focus on patient care. Mobile robots loaded with linens and medication can find their own way around hospitals, some operating lifts and opening doors. The hospital employee loads items onto the robot, enters the destination – often through a separate tablet – and the robot uses an internal map and sensors to find its way to the destination.

5 How far do nurses walk? Medsurg Nursing 01 Aug 2006
6 See https://bluebotics.com/agvs-hospital-logistics/

Robots increasingly interact directly with patients and residents in care homes, with a number of assistance robots in trials.

For example, the Lio mobile personal robot from F&P Robotics[7] is aimed at supporting healthcare professionals in nursing and geriatric institutions and rehabilitation centers by carrying out tasks such as greeting patients, grasping and carrying objects, offering drinks, reminding patients of, and accompanying them to, upcoming appointments and providing entertainment.

Self-service robots that allow patients or care-home residents to selects drinks or snacks from a mobile vending machine are also being trialed[8] and we can expect robots to deliver meals directly to patients in the future. See the IFR paper 'A Mobile Revolution - How Mobility is Reshaping Robotics' for more examples of how mobile robots are assisting healthcare workers.



Video 2: An autonomous robot at work in a hospital

Cleaning robots reduce hospital infections

Infections caught during hospital stays account for around 37 000 deaths per year in Europe and almost 100,000 in the U.S.. The cost of treating hospital infections runs to around €7 billion in Europe and US$6.5 billion in the U.S.[9]. Cleaning and disinfection robots are widely used in hospitals to combat infections.

Figure 5: Disinfection robots, image credit: Blue Ocean Robotics

Cleaning robots scrub, sweep and vacuum floors while disinfection robots use high-frequency ultraviolet light (UV-C) or spray disinfectant to destroy microorganisms. Ultra-violet disinfection robots can destroy 99.9% of all microorganisms in a hospital room within 10 minutes. While the room must be empty during disinfection, there are no negative health effects from the UV rays. Like the mobile robots used in hospitals, described above, these robots can navigate autonomously and, on reaching their destination, activate the required function, such as spraying or cleaning. Cleaning robots use sensors to detect and avoid obstacles in their path.

The COVID-19 pandemic has rapidly accelerated the use of cleaning and disinfection robots - not only in hospitals, but also in other public spaces such as hotels and public transport. The IFR forecasts continued high growth in both categories of robots going forward. See further information and case studies on cleaning robots.

Robots help patients recover faster from stroke & neurological disorders

Robots are used extensively to help patients recover from stroke and other severe neurological disorders. The market for rehabilitation robots is expanding rapidly. The

7 See https://www.fp-robotics.com/en/care-lio/
8 See for example the SeRoDi robotic service assistant, developed by Fraunhofer IPA https://www.ipa.fraunhofer.de/en/press-media/press_releases/Service_Robotics_for_Care.html
9 https://www.who.int/gpsc/country_work/gpsc_ccisc_fact_sheet_en.pdf

Figure 6: Rehabilitation robot, image credit: Hocoma.

IFR predicts a 37% increase in annual unit sales of these robots from 2020 to 2023[10].

The advantage of robot devices over rehabilitation exercises guided only by a therapist is that the robot device ensures that the movement is repeated in exactly the same way each time, training the brain to enable muscles to carry out the movements alone. Repetitions per session are also generally higher with robot-assisted rehabilitation. Several studies[11] indicate that the ability of the robot to assist in very accurate, repetitive movements means that patients recover faster through robot-assisted therapy.

Many robotic rehabilitation devices comprise exoskeletons - robotic external skeletons adapted for a particular body part - linked to a program that transfers data from the training program to the exoskeleton and vice versa. Sensors in these exoskeletons predict and respond to the patient's intended motion, correcting and supporting to encourage the desired movement. The level of assistance, or force, provided by the robot can be adapted as the patient gains strength, and the systems come with pre-programmed routines that can be set to the patient's level of mobility. There are rehabilitation robots for both upper and lower body parts. Lower body rehabilitation robots typically combine a treadmill or harness with an exoskeleton. Robots for the upper body are used to restore gross motor skills in arms and fine motor skills in the hands. Upper-body robots generally comprise an exoskeleton arm attached to a chair and video screen. Users perform movements as directed by the training program. There are also rehabilitation gloves focused on regaining fine motor skills in the hands. See further information and case studies on rehabilitation robots.

Video 3: Robot filling vials

10 See https://ifr.org/worldrobotics/
11 See for example Kim et al. 2017 Is robot-assisted therapy effective in upper extremity recovery in early stage stroke? and Mehrholz et al. 2017 Electromechanical-assisted training for walking after stroke

Robots improve efficiency of medicines and medical devices

Robots are increasingly used across the whole pharmaceutical supply chain, from basic research to the production of medicines, quality inspection and packaging. Robots support the discovery of vital new treatments, enable faster medical tests for patients, and help pharmaceutical manufacturers to meet increasingly strict regulations for the production of medicines and maximize the efficiency of drug production.

Robots support medical researchers by carrying out repetitive tasks that must be completed in high numbers with great precision such as filling vials, handling samples[12] and placing samples on microscope slides. A robot can place 40,000 dots of DNA onto a single microscopic slide – a task impossible for humans. Researchers can focus on higher-value work with less risk of repetitive strain injury.

In pharmaceutical production, robots can work in sterile environments which are required for many products such as infusions. They are widely used in the production of medicines and medical devices, carrying out a variety of tasks such as assembling medical syringes[13], filling and labelling vials[14], and packaging medications and medical devices. Robots also improve productivity in the production of medical equipment and devices. Robots have been indispensable during the COVID-19 pandemic, supporting the production of life-saving products including personal protective equipment (PPE), disinfectants, medical diagnostic equipment and ventilators[15].

Robots also speed up medical testing – one laboratory was able to deliver more than 90% of blood test results within 1 hour despite a 20% increase in samples arriving for analysis, thanks to two robots[16]. Blood samples arrive in the lab on a conveyor. The first robot picks up a sample and places it in a barcode scanner. A vision camera photographs the color of the screw cap, and the robot is guided to place the sample in one of four different

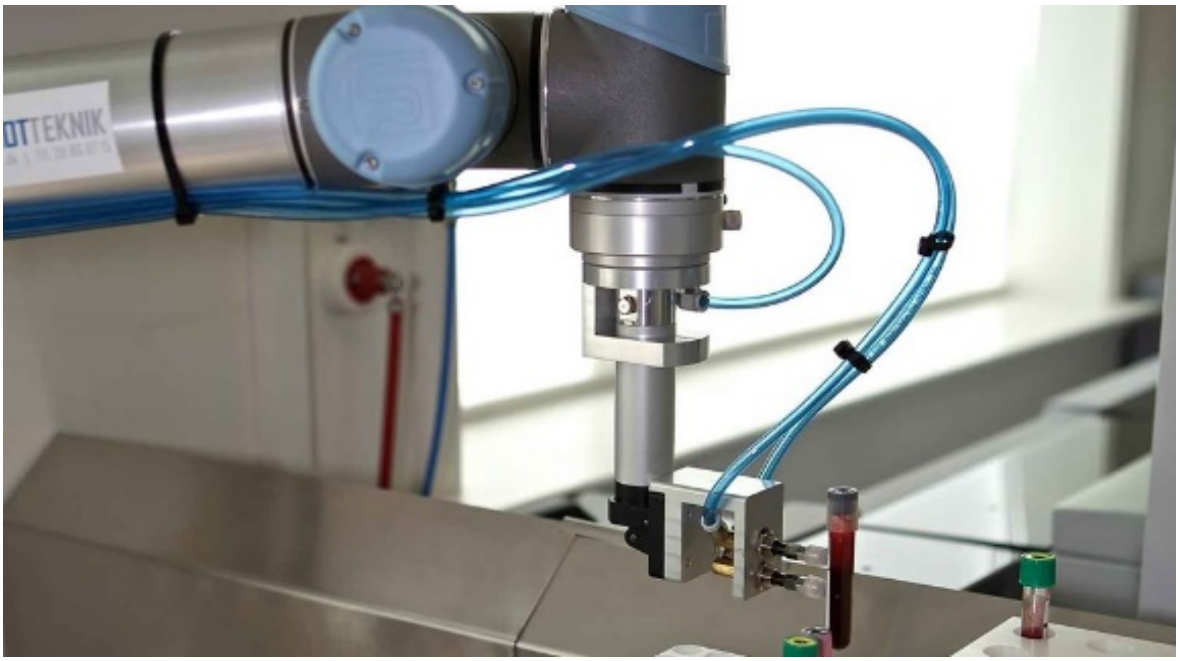


Figure 7: Robots speed up medical testing, image credit: Universal Robots.

12 See for example https://youtu.be/sCkb0Cph-3Y
13 See for example https://youtu.be/hW0Y_hBrsc8
14 See for example https://youtu.be/OK4F6W8x34Q
15 See https://ifr.org/case-studies/robots-help-fight-the-battle-against-covid-19-pandemic
16 See https://youtu.be/mnk4iT4BTg4

racks according to color. The second robot picks up the rack samples and places them in the machine feeder for centrifugation and analysis.

More independence for the elderly

Robots are helping the elderly to remain independent in assisted-living facilities or their own homes. Telepresence robots, comprising a screen mounted on a remote-controlled robot, connect an older person with their carers, friends and family.

Most of these robots are controllable from any location with a smartphone or computer and internet connection. Family members, friends, doctors, and care givers can all log into the telepresence robot, drive it, interact with others, and explore the environment with audio and video.

Video 4: Telepresence robot supports independent living

Increased mobility for people with disabilities

Robots are making a significant impact on the lives of people with physical disabilities.

Exoskeletons enable paraplegics to walk again

Wearable robots called exoskeletons enable people who were wheelchair bound to walk again. Not only does this vastly improve their mental health, it also reduces complications from sitting in a wheelchair such as obesity, cardio-metabolic problems, sores and bone deterioration. It improves digestive function and enables many patients to reduce or eliminate pain medication and its associated side-effects such as fatigue.

Figure 8: Exoskeleton, image credit: ReWalk

The exoskeletons control movement of lower limbs by sensing and responding to changes in the wearer's center of gravity. For example, a forward tilt initiates a step forward, powered by the robot. Repeated body shifting generates a sequence of steps which mimics a functional natural gait of the legs.

These robots are good news for physical therapists too, reducing physical load and improving productivity and job satisfaction though visible and measurable results. Data from the exoskeleton shows how much the patient is working and how much the machine is assisting them, so the therapist can adjust to the required level of assistance and both therapist and patient can monitor their progress. See further information and case studies on exoskeletons.

Robots support people with limited mobility in hands and arms

Robots support wheelchair-bound people who also have limited mobility in their hands and arms. There are a variety of robotic arms that can be attached to a wheelchair to enable people to open doors, pick up objects and perform a wide variety of other tasks, including feeding themselves.

In some cases, the arm is operated through the joystick or other device used to operate the

wheelchair itself[17]. In other cases[18], the robot arm is a splint into which the user lays their own arm. The robot arm senses the motion intended by the wearer and calculates the support needed.

There are a number of other robotic aids for people with restricted motion in hands and arms, such as feeding devices that comprise robotic arms that are remotely controlled by the user from another part of the body (foot or chin for example)[19].

Most electric wheelchairs use joysticks or other manually operated input devices, which makes them unusable for people unable to move their hands and arms. Autonomous wheelchairs that respond to eye movement and can map their environment to navigate autonomously and go up and down stairs are being developed[20]. Researchers at MIT in the US are working on a voice-controlled autonomous wheelchair for people who have lost mobility due to brain injury or the loss of limbs, but who retain speech[21].

Figure 9: Robot feeding device, image credit: Obi

Figure 10:Robot arm attached to a wheelchair, image credit: Kinova.

17 See for example the Jaco from Kinova https://www.kinovarobotics.com/en/assistive-technologies
18 See for example the Dowing from Focal Meditech https://www.focalmeditech.nl/dowing/
19 See for example the Obi from Obi Robot www.MeetObi.com and the Bestic feeding device from Camanio Care https://youtu.be/FLWLY5wHop8
20 See https://www.mdpi.com/2227-7080/9/1/16/htm
21 See https://www.csail.mit.edu/node/5962

Improving the quality and sustainability of food

It is widely acknowledged that feeding a global population estimated to reach 9 billion by 2050 with current agricultural methods and food supply chains is not sustainable. The 50% increase in productivity required[22] seems unlikely given that up to 40% of what is sown does not make it to market[23]. Agriculture takes a major toll on the environment, accounting for up to 30% of greenhouse gas emissions[24], and is a major contributor to deforestation which reduces the supply of a vital natural means of carbon sequestration. Agriculture also uses 70% of the world's supply of freshwater, which is already in scarce supply[25]. Fertilizer and pesticide use also contribute to greenhouse gas emissions.

At the other end of the food chain, we increasingly eat foods that have travelled vast distances and have lost valuable nutrients along the way or include additives to preserve freshness.

Robots are making their mark across the food chain and, as vision and gripping technologies improve, will become increasingly ubiquitous in commercial agriculture over the next decade. Used as part of precision agriculture systems, robots can vastly reduce the amount of fertilizer, pesticide and water needed to grow crops and eliminate weeds that threaten them and improve the productivity of farms at the same time. Smaller, lightweight robots reduce damage to soil. Meanwhile, many urban consumers already benefit from robots that prepare food freshly to order without additives, and from fresh vegetables grown in automated greenhouses that are cost-efficient to establish near urban centers.

Robots reduce pesticide use and energy consumption in farming

Robots are increasingly used in precision agriculture, which combines sensors, vision technology, GPS navigation, artificial intelligence and robots or modified traditional agricultural equipment to provide detailed information on plant location and health and to automate tasks such as planting, hoeing, weeding, watering and applying herbicides and pesticides. The use of robots in agriculture reduces the back-breaking work of planting and hoeing and enables farmers to apply exactly the right amount of nutrients,

Figure 11: Robotic greenhouse, image credit: IronOx.

22 World Bank 2017
23 Food and Agriculture Organisation: Seeking end to loss and waste of food along production chain
24 McKinsey 2019
25 Freshwater accounts for only 3% of the world's water resources. The World Wildlife Fund estimates that by 2025, two-thirds of the world's population may face water shortages.

water and pesticides to plants. This improves agricultural output, since weeds reduce major crop yields by 34% on average[26], and reduces the amount of pesticides and herbicides needed – by around 80% for some crops[27], reducing both environmental impact and costs.

Figure 12: Autonomous weeding robot, image credit: Ecorobotix

There are a number of start-up companies in precision agriculture focused on planting, weeding, watering and the targeted application of fertilizer, herbicide and pesticide. These are generally lightweight robots which have the advantage of not compacting soil, thus preserving valuable microorganisms. These lighter robots also use less energy than heavy agricultural machinery. The robots can navigate according to an internal map which they update in real-time, similar to a driverless car. Machine learning and other artificial intelligence algorithms are used to enable the robot to distinguish between weeds and plants as well as to plan the path of the robot gripper to grasp and pull out the weed. Some manufacturers offer these robots on a rental basis (so-called Robot-as-a-Service)[28].

Robots reduce the amount of water used in farming

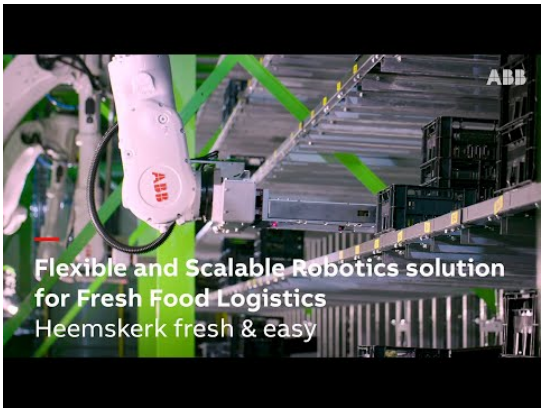
According to the World Bank, in most regions of the world, over 70 percent of freshwater is used for agriculture. By 2050, feeding a planet of 9 billion people will require a 15 percent increase in water withdrawals. A number of research projects are focused on robotic irrigation, which can significantly reduce water usage[29]. Powered by artificial intelligence algorithms which predict, from GPS, satellite and other data, exactly how much water is needed, robots can be used to directly irrigate, or to adjust smart valves in sprinkler hoses.

Automated nurseries and greenhouses that can be established near to urban centers, can also significantly reduce water use, and there are numerous start-up companies in this field. Many work on the principle of 'vertical farming' where produce is grown in vertically-stacked trays without soil, fed with water-based nutrients and artificial lighting. Some of these companies use robots to transfer plants to larger trays as they grow and to monitor plant health using robotic vision systems[30]. Some robotic nursery/greenhouse solution providers claim these hydroponic growing systems use around 90% less water than traditional farming while growing 30 times the amount of crops per acre of land[31].

Robots enable us to eat fresher foods

Robots are increasingly at work in food production, helping us access fresher foods. Many of the vegetables and fruits we buy in supermarkets travel thousands of miles to reach us, contributing to increased emissions and losing freshness by the mile.

26 Crop Losses to Pests, Orke 2009
27 Precision agriculture and the future of farming in Europe, European Parliamentary Research Service 2016
28 See for example https://www.naio-technologies.com/en/news/dinos-brand-new-mechanical-weeding-service-waas/
29 See for example 'Development of an autonomous mobile plant irrigation robot for semi structured environment' 2nd International Conference on Sustainable Materials Processing and Manufacturing (SMPM 2019) and https://nevonprojects.com/plant-irrigation-water-sprinkler-robot/
30 https://ironox.com/
31 https://ironox.com/



Video 5: Shortening supply chains for fresh food

Robots can help shorten supply chains. For example, one of the largest vegetable processing companies in Europe, which produces 3.5 million to 4 million fresh convenience products every week such as salads and pre-cut vegetables and fruit, uses robots to prepare orders according to each food retailer's needs, so that the products can be shipped directly to stores and supermarkets instead of making an intermediate stop at a distribution center. This reduces the amount of time that fresh food spends in the supply chain, resulting in extended shelf life and less wasted food.

One robot takes crates containing the orders for a particular market and places them on a conveyor belt. Others pick them up and place them in a location designated for that market. Two more robots consolidate the orders in stable stacks. The crates are then picked up by another robot and placed on dollies to be transported directly to the supermarket. The system can process an endless variety of orders and ensures that 75 percent of the products processed today are on store shelves the following day[32].

Robots are also enabling local production of fresh vegetables. Automated nurseries (see above) can be set up near cities and are also resource efficient. Meanwhile, robot bread-making units are making their way into supermarkets and mobile automated kitchens, enabling customers to enjoy freshly made food, with less additives. In the Breadbot example shown in the video below, employees fill the robotic unit with ingredients and the robot does the rest, preparing the mix for a specific type of bread, kneading, proofing and baking. Customers can select, through a touchscreen, the type of bread they want and specify whether it should be sliced or still warm.

Cow-milking robots keep small farms in business

Dairy farming is a risky business, particularly for small farms which struggle to remain competitive. According to the US Department of Agriculture, for example, the number of licensed U.S. dairy herds fell by more than half between 2002 and 2019[33]. The COVID-19 pandemic has exacerbated challenges for dairy farmers all over the world.

Cow-milking robots help farmers remain competitive, smoothing out labor demand

Figure 14: The Breadbot

Figure 13: Cow-milking robot

32 See https://youtu.be/I-rbncpOzxo
33 USDA: Consolidation in U.S. Dairy Farming, July 2020

cycles and enabling farm workers to focus on other activities, such as improving animal health, vaccination and improving reproduction. The cow walks of its own accord into the milking robot unit. A transponder around the cow's neck is read by the robot, enabling a range of herd management tasks such as monitoring the control of the milk yield, the milk flow, and the milk quality. The milking robot executes the whole milking process, beginning with teat cleaning and ending with the removal of the last teat cup and spraying of the teats.

One of the main advantages of the robot vs. traditional milking machines is that the cow decides when to be milked. The other advantage is the data which is gathered by the robot which can be used, for example, to adjust the type and amount of food concentrates an individual cow receives. Finally, the robot also improves quality of life for farmers by relieving them of very early or late milking schedules.

Improving the range and quality of products we buy at competitive prices

Gone are the days when, in the words of Henry Ford, "You can have any color as long as it's black"! As consumers, we enjoy a continuously increasing range of products, and product options. Without industrial robots,

Figure 15: Cobots enable high mix/low volume production

we would not be able to buy a new smartphone every few years. Robots enable manufacturers to produce an increasing range of products in small volumes (known as high mix/ low volume production), often at short notice, without passing on substantial price increases to customers.

'Cobots' - collaborative robots that work alongside production operators - shorten production times, carry out unergonomic and boring tasks, and can be easily switched from one production line and task to another, giving manufacturers the flexibility they need to remain competitive. Cobots help keep many small-to-medium-sized manufacturers in

Figure 16: Human-robot collaboration at BMW, image credit: BMW.

Figure 17: Pixel Paint robot, image credit: ABB.

business, and in some cases enable manufacturers to keep production - and jobs – local, rather than outsourcing to countries with cheaper labor costs. The US high mix/ low volume manufacturer in this video, for example, mounted two cobots on mobile pedestals so they could be quickly assigned to new tasks based on orders for that day and placed next to workers in the designated production line. The robots were generally given tedious, unergonomic tasks such as cutting 16.000 wires a day, which would put employees at risk of carpal tunnel syndrome. These employees were assigned to other tasks. Using the robots optimized production by 20% and enabled the company to bring some of the production it had outsourced abroad back to the US.

Robots are also used to inspect products for quality. Equipped with cameras and machine vision, these robots can detect flaws that the human eye can't spot. They also keep industrial plants safe by inspecting the status of machines, particularly in inhospitable environments such as underwater or in high-temperature settings.

Reducing the environmental impact of production

Robots contribute to lowering the overall carbon footprint of manufacturing by increasing efficiency, minimizing material waste and enabling manufacturers to optimize space – and thus the energy associated with lighting and heating. Robots can operate without heating or air conditioning, and in very high or low temperatures that are uncomfortable or dangerous for employees.

Robots reduce waste and energy-consumption by improving the efficiency of production and packaging processes. One food manufacturer was able to reduce packaging waste for fresh convenience food by 25% using robots instead of traditional machines[34].

Robots enable manufacturers to better match production to demand, which reduces inventory for parts and materials, and over-production of end-products. Moreover, production processes can be optimized with robots. For example, ABB's pixel-painting robot enables a customized paint job to be carried out in a single pass, reducing cycle times by around 50 percent. The robot paints directly on to the target surface using a printing nozzle head instead of spraying with a conventional atomizer. This reduces waste to zero and eliminates the need for masking or de-masking. Emissions are reduced because less paint is required, avoiding the CO_2 normally emitted during production. Robots are also used to detect emissions, and to inspect machinery to ensure it is running optimally, reducing heat generation and energy consumption.

Robots are themselves increasingly energy-efficient, made from lighter, composite materials and using energy-efficient engines and gears with reduced frictional losses. Many

34 See https://www.universal-robots.com/case-stories/atria/

have energy-saving modes when in stand-by, as well as energy-efficient control and drive technologies. Thanks to sensors and analytic algorithms, their speed can be optimized to enable up to 25% savings in energy. Some robots that work outdoors even run off solar power.

Finally, and as mentioned above, robots enable manufacturers in developed economies to produce closer to the customer at competitive prices, thereby minimizing energy consumption in the logistics chain.

Future directions

Robots are already vacuuming our houses and mowing our lawns. While we are still far away from the multifunctional household robot that frees us from all our chores, we can expect an increasing number of (usually single task) robot assistants in our homes in the coming years. In the future, robots will work as kitchen assistants, fetching and carrying ingredients and even preparing food. They will assist the elderly in fetching and carrying objects around the house and supporting mobility.

Robots that come into contact with us will be able to respond better thanks to improved language processing, and a greater understanding of the properties of the person (or object) in front of them – a child versus an elderly person, for example.

Improvements in robot grippers mean robots are able to pick up an increasing variety of objects that are flexible or have uneven and delicate shapes – such as fruit and vegetables – further improving the efficiency of manufacturing and food production, enabling us to enjoy fresh food at competitive prices.

Robots will also help in efforts to reduce climate emissions. Robots are already at work in areas such as recycling and ocean-clean-up and we can expect to see their use in these areas expand significantly.

Conclusion

The examples in this paper are only some of the ways in which robots are improving our daily lives[35]. They illustrate how robots contribute to our well-being in more ways than we typically realize:

- improving our health and quality of life, even as we age,
- reducing heavy lifting in a variety of jobs,
- improving the quality and sustainability of the food we eat,
- positively contributing to the quality and variety of products on offer, and
- contributing to sustainability by making production more energy and resource efficient.

In many cases, we are not aware of the robots at work in these fields, but increasingly, robots are at our sides, serving as assistants and even as wearable aids.

Strict standards that apply to the manufacture and use of robots ensure these applications are safe.

As robot technologies advance rapidly, we can look forward to many other improvements in our daily lives over the next decades thanks to robot helpers.

Case studies and videos

Improving health

Case studies

- Cleaning and disinfection robots https://ifr.org/case-studies/cleaning-robots-reduce-infections
- Rehabilitation robots https://ifr.org/case-studies/robots-help-patients-recover-faster-from-stroke
- Supporting the production of medical devices and equipment https://ifr.org/case-studies/robots-help-fight-the-battle-against-covid-19-pandemic
- Medical testing https://youtu.be/mnk4iT4BTg4

35 https://sustainabilityreport.abb.com/2020/leading-technology/robotics-discrete-automation.html

- Exoskeletons https://ifr.org/case-studies/exoskeletons-enable-paraplegics-to-walk-again

Videos

- A cobot assists a production worker https://youtu.be/02TzqIvWiso
- Exoskeletons at BMW https://youtu.be/cMdjeua8Gqc
- An autonomous robot at work in a hospital https://youtu.be/mVreTUNKxa8
- A rehabilitation robot https://youtu.be/qic2nvvGsEw
- Assembling medical syringes https://youtu.be/hW0Y_hBrsc8
- Filling and labelling vials https://youtu.be/OK4F6W8x34Q
- Robotic arm attached to a wheelchair https://youtu.be/n16RImbHUbs
- Autonomous wheelchair https://youtu.be/_MB6y-2X2Qs
- Feeding device https://youtu.be/FLWLY5wHop8
- Telepresence robot supports independent living https://youtu.be/NfYqQ1TmjNw
- Exoskeleton personal testimonial https://youtu.be/aNgf8sPAer8
- Robot arm attached to a wheelchair: https://youtu.be/n16RImbHUbs

Improving the quality and Sustainability of Food

Videos

- Agricultural robot hoeing https://youtu.be/9LdXvkvcSxM
- Shortening supply chains for fresh food https://youtu.be/I-rbncpOzxo
- Robotic greenhouse: https://youtu.be/m_RXm119XPM
- The Breadbot: https://youtu.be/ypOojO8TILI
- Cow-milking robot https://youtu.be/o515XdtU7NM

Improving the range and quality of products we buy at competitive prices

Videos

- Cobots enable high mix /low volume production https://youtu.be/ZdjN9AHwzqs

Reducing the environmental impact of production

Case studies:

- Reducing packaging waste https://www.universal-robots.com/case-stories/atria/

Videos

- PixelPaint robots help reduce emissions https://youtu.be/XfWsdem6gw8