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Artificial Intelligences in Industrial Robots: A Framework Based on Gardner's Multiple Intelligences

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Abstract. Industrial robots, both in manufacturing and non-manufacturing sectors, are evolving rapidly, driven by advancements in artificial intelligence (AI). This paper presents a comprehensive survey of industrial robots, framed through the lens of Howard Gardner's theory of multiple intelligences. By categorising various AI capabilities in industrial robots—such as visual recognition, decision-making, and collaborative interaction—based on Gardner's intelligence framework, we provide a novel taxonomy that bridges human cognitive abilities and artificial systems. The survey explores the historical development of industrial robots, the current state of AI implementation, and future trends in robotics. Additionally, we discuss the implications of these advancements for industries and their workforce, as well as the ethical considerations surrounding the growing autonomy of AI systems. This paper aims to serve as a reference point for researchers and professionals seeking to understand the intersection of cognitive science and industrial AI, highlighting the potential and challenges of integrating AI into robotic systems.
Keywords: Industrial Robots, Services Robots, Industrial Artificial Intelligence, Healthcare Robots, Avatars.

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1 History of the Industrial Robots

Karel Čapek et al. (1920), a Czech science fiction writer, was the first to propose the term robot in 1920. IBM introduced its system for the design of industrial automation (CAD/CAM) in 1979 and presented its first industrial robots in 1984 (IBM 7535 Manufacturing System, 7540, 7545, 7565). In 1955, the IEEE Robotics and Automation Society was established. Whitney (1987) described the historical lineage and the state of the art of robot force control, including continuous and logic branching strategies, impedance strategies, and hybrid methods. Song and Waldron (1989) introduced the term "statically terrain adaptive" to indicate the ability to move the body in a fully controllable manner in the vertical direction, as well as to rotate it about the horizontal pitch and roll axes (legged locomotion machines). Engelberger (1989) defines a service robot as a robot that operates in an automatic or semi-automatic manner to perform useful services for the welfare of humans or their equipment, excluding manufacturing operations.

Khatib et al. (1996) present the basic models and methodologies for their analysis and control of mobile manipulation systems. These include the Operational Space Formulation for task-oriented robot motion and force control; the Dextrous Dynamic Coordination of Macro/Mini structures for increased mechanical bandwidth of robot systems; the Augmented Object Model for the manipulation of objects in a robot system with multiple arms; and the Virtual Linkage Model for the characterisation and control of internal forces in a multi-arm system. Zeng and Hemami (1997) conducted a review of 75 papers on robot force control algorithms, force control techniques, stability analysis, robust control, and learning control strategies. Eriksson and Papanikotopoulos (1997) describe a system for detecting driver fatigue by monitoring the driver's face with a small camera inside the car and observing eye movements. Asada and Christensen (1999) note that the first RoboCup (Robot Soccer Cup) took place during the International Joint Conference on Artificial Intelligence in 1997. In the year 2000, the Technical Committee on Service Robots defined the areas of application for service robots: non-manufacturing sectors (construction, agriculture, naval, mining, energy, space, and medicine) and service sectors (personal care, cleaning, surveillance, education, and entertainment) (Aracil et al., 2008; Engelberger, 1989).

Bruyninckx (2001) introduces the Open Robot Control Software package (OROCOS) project, which serves as a general-purpose open-source robot control software. In 2001, work was conducted on Internet-based teleoperated robots (Sanfeliu et al., 2008). Aracil et al. (2002) focused on a telerobotic application for the maintenance of electrical live-power lines, called ROBTET.

Ballantyne and Moll (2003) discuss the Da Vinci Telerobotic Surgical System, a prototype demonstrating the basic ability to perform remote surgical telemanipulation, developed by SRI International, Phil Green, and his colleagues.

Armada et al. (2003) present an overview of the investigations carried out by the CLAWAR network, showcasing various implementations that illustrate how to overcome the barriers to exploiting this innovative class of robotic systems.

In 2004, the term Networked Robots (NR) was created for the IEEE Society of Robotics and Automation's Technical Committee (Sanfeliu et al., 2008). A networked robot is a robotic device (teleoperated or autonomous, visible robot, virtual robot, or unconscious robot) connected to a communications network such as the Internet or a local area network (LAN).

Zinn et al. (2004) present a new actuation concept for human-friendly robot design, specifically the DM^2 - a two-degree-of-freedom prototype robot arm. Molfino and Zoppi (2005) describe the EUROShoeE (Extended User-Oriented Shoe Enterprise) Project and a prototype of a robotic device for handling limp materials. Balaguer et al. (2005) present a non-conventional climbing robot featuring a locomotion system of arms and legs designed for navigating complex 3D structures.

Salichs et al. (2006) introduce a human-robot social interaction system named Maggie, which performs medical care for older adults, assists individuals with motor or cognitive disabilities, and provides educational entertainment and personal assistance, among other functions.

Garcia et al. (2007) survey the evolution of robotics research over the last half-century, highlighting its response to changing human social needs. This evolution ranges from industrial robots that relieve human operators from dangerous or risky tasks to the recent surge in field and service robotics aimed at assisting humans.

In 2007, Stanford University developed several robotics software programs, including the STanford Artificial Intelligence Robot (STAIR) and the Personal Robotics (PR) programme. Aracil et al. (2007) introduce the telerobotic system as an architecture that facilitates interaction between a human operator and a robot performing tasks in a remote environment.

A Network Robot System, proposed by the European study group "Research Atelier on Network Robot Systems," consists of a group of Mobile Artificial Autonomous Systems (robotics, sensor systems, artificial intelligence) that utilise wireless communications (ubiquitous computing and network communications) for navigation, cooperative environment perception, cooperative map building, task allocation, cooperative task execution, human-robot interaction, and network teleoperation (Sanfeliu et al., 2008). Cobano et al. (2008) present the results obtained from field tests of a new system for the detection and location of anti-personnel landmines.

Bostelman and Albus (2008) describe a novel home lift, positioning, and rehabilitation chair designed to provide independent patient mobility, including tasks such as placing a person on a toilet or bed and providing lift assistance.

Quigley et al. (2009) propose the Robot Operating System (ROS), which comprises tools and libraries for robot behaviour across various robotic platforms. Stahl and Coeckelbergh (2016) discuss the ethical analysis, classic technology assessment, and philosophical speculation surrounding healthcare robotics.

2 A Framework Based on Gardner's Multiple Intelligences

A robot is a reprogrammable and multifunctional manipulator designed to move loads, parts, tools, or special devices according to varied trajectories, programmed to perform different jobs (Aracil et al., 2008). A robot is linked to the existence of a digital control device that will manage the movements of a mechanical system through the implementation of a programme stored in memory. There is a definition of service robots, which are those robots that carry out activities under the sea, planetary exploration, recovery and repair of satellites, assembly and disassembly of explosive units, and activities in radioactive environments (Todd, 2012).

The application of Gardner's Multiple Intelligences (MI) theory provides a framework for understanding and enhancing the capabilities of artificial intelligences (AIs) in industrial robots. Gardner's theory posits that intelligence is not a single entity but rather a collection of distinct types of intelligences that individuals possess in varying degrees. This perspective can be instrumental in designing AI systems for industrial robots that can better adapt to diverse tasks and environments by leveraging different intelligences. There are eight types of human intelligence as proposed by Gardner (2005). In this article, we define various types of artificial intelligence in robots, based on Howard's intelligence framework:

- Industrial Artificial Intelligence: This refers to the ability to execute activities within the industrial sector. Examples include deductive reasoning, solving mathematical problems, artistic graphical abilities, management of vehicles and industrial machinery, as well as applications in sex robots, combat robots, household robots, military robots, underwater activities, and others.
- Healthcare Artificial Intelligence: This encompasses the ability to perform activities related to health care. Examples include transferring a patient from a wheelchair to a bed, administering vaccinations, applying ointments to the human body, providing massages, and conducting clinical studies, among others.
- Agricultural Artificial Intelligence: This pertains to the ability to coordinate actions related to agriculture, livestock, and fisheries. Examples include feeding animals, watering plants, harvesting fruits, and milking cows, among other activities.
- Bodily-Kinesthetic Artificial Intelligence: This refers to the ability to coordinate bodily movements for activities such as dancing, acting, or engaging in sports. Robots with high bodily-kinesthetic intelligence are generally adept at physical activities, including sports, dance, and craftsmanship.
- Musical Artificial Intelligence: This involves the ability of robots to produce, compose, or play various musical instruments, encompassing musical-rhythmic and harmonic intelligence.
- Linguistic-Verbal Artificial Intelligence: Robots exhibiting high verbal-linguistic intelligence demonstrate a proficiency with words and languages. They typically excel at reading, writing, storytelling, and memorising words and dates. For example, they may master written or spoken language, such as in the case of translation robots.
- Logical-Mathematical Artificial Intelligence: This type of intelligence enables robots to engage in logical reasoning, abstraction, numerical analysis, and critical thinking. Examples include deductive reasoning, solving mathematical problems, and demonstrating artistic graphical abilities.

An Industrial Robot is a service robot that has Industrial Artificial Intelligence. This paper aims at being a guide to understanding Industrial Robots by presenting a survey of the characteristics, the taxonomy, the history of Industrial Robots. Section 2 presents the History of the Industrial Robots, Section 3 the Industrial Robots and the Future Trends, and the last section presents the conclusions.

3 Industrial Robots and the Future Trends

In this section, we propose the following taxonomy related to industrial robots (both manufacturing and non-manufacturing): domestic robots, construction robots, agricultural robots, naval robots, mining robots, personal care robots, cleaning robots, educational robots, surveillance robots, entertainment robots, healthcare robots, robots in libraries and museums, and avatars.

3.1. Robots in the automotive industry

The automotive industry has experienced a major transformation with the incorporation of robotics, leading to increased productivity, precision, and flexibility within manufacturing processes.

The adoption of industrial robots has been pivotal in automating various tasks, including welding, painting, assembly, and quality inspection. This shift towards automation is largely driven by the need for increased efficiency and the ability to meet the growing demand for customized vehicles in a competitive market (Pisková, 2024; Karabegović & Husak, 2018).

The implementation of industrial robots has been crucial in automating a range of tasks, such as welding, painting, assembly, and quality inspection. This shift towards automation is largely driven by the need for increased efficiency and the ability to meet the growing demand for customized vehicles in a competitive market (Pisková, 2024; Karabegović & Husak, 2018).

A key application of robotics in the automotive industry is within the welding process. Robots are widely employed for both spot welding and arc welding, which are essential for the assembly of vehicle body structures. The implementation of robotic welding systems has led to improvements in weld quality and consistency, as well as reductions in cycle times (Karabegović, 2018). Furthermore, the use of robots in painting processes has minimized human exposure to hazardous materials while ensuring a uniform application of coatings, thereby enhancing the overall quality of the finished product (Karabegović, 2018).

Technologies such as laser scanning and non-contact measurement systems have emerged as essential tools for ensuring dimensional accuracy in automotive assembly lines. These systems allow for real-time monitoring and quality control, which are crucial for maintaining high standards in production (Kiraci et al., 2016; Kiraci et al., 2016). The ability to conduct in-process inspections not only reduces the likelihood of defects but also streamlines the manufacturing process by identifying issues early on (Qiao & Weiss, 2017).

The influence of robotics on labour dynamics within the automotive industry is significant as well. Although there are concerns about job displacement caused by automation, research indicates that the introduction of robots can, in some cases, result in a rise in overall employment. For example, the need for skilled workers to manage and maintain robotic systems has increased, indicating that automation can enhance rather than fully replace human labour (Pisková, 2024; Moniz et al., 2022). Moreover, the use of robots has enabled the advancement of more intricate manufacturing processes, which demand greater expertise and specialised training (Karabegović et al., 2021).

The emergence of Industry 4.0 has hastened the integration of robotics in the automotive industry. The combination of digital technologies, like the Internet of Things (IoT) and artificial intelligence (AI), with robotic systems has enabled more intelligent manufacturing processes. These innovations allow for better data collection and analysis, resulting in enhanced decision-making and increased operational efficiency (Karabegović & Husak, 2018; Karabegović et al., 2021). As automotive manufacturers increasingly adopt these technologies, robotics is set to play a larger role, fostering innovation and boosting the industry's competitiveness.

The Unmanned Robot Applied to Automotive Test (URAT) can be classified as an industrial robot (robot driver, robotic driver) designed to achieve autonomous driving under dangerous conditions and harsh environments. The electromagnetic URAT consists of a mechanical throttle leg, mechanical brake leg, clutch mechanical leg, shift mechanical arm, and their drive unit (EMLM).

Fairchild (2013) discussed the challenges faced by the manufacturing industry regarding robots used for painting, particularly issues associated with human errors such as the over- or underutilisation of paint on the vehicle body. In this article, the author presented several robot developers involved in painting activities.

Gang Chen et al. (2013) proposed a control system based on a Fuzzy Neural Network to address the deficiencies of proportional-integral-derivative (PID) control for the unmanned robot applied to automotive testing (URAT), which requires a priori manual retuning, exhibits large speed fluctuations, and is difficult to adjust in terms of control parameters.

Gang Chen and Wei-gong Zhang (2015) proposed a digital prototyping design for the electromagnetic URAT based on the linear electromagnetic motor (EMLM).

Gang Chen and Wei-gong Zhang (2015b) introduced a control method for the electromagnetic URAT that improves the Smith predictor compensator with time delay and adopts pulse width modulation (PWM) control. This method achieves accurate tracking of the target vehicle's speed and reduces the mileage deviation of autonomous driving, thereby meeting national test standards.

Gang Chen and Wei-gong Zhang (2015c) presented a prototype simulation system for evaluating the performance of an unmanned electromagnetic robot applied to URAT, enabling online debugging of the control programme and facilitating the rapid acquisition of test vehicle dynamic performance.

Chen and Zhang (2016) proposed an application of URAT to optimise time and costs while improving the accuracy of tests. The authors developed a hierarchical coordinated control method based on fuzzy logic theory to ensure coordinated control and accurate speed tracking during the driving test cycle. This control method is based on the Sardis hierarchical architecture to coordinate multiple robot manipulator systems within the automotive test system.

3.2. Robots in the Healthcare industry

The incorporation of robotics into the healthcare industry has become a game-changer, improving patient care, boosting operational efficiency, and helping to address workforce challenges. Robots are now employed in diverse roles, including surgical assistance, rehabilitation, telemedicine, and logistics, each contributing to improved healthcare delivery (Defi et al., 2022; Morgan et al., 2022; Animesh, 2024).

One of the most notable uses of robotics in healthcare is in surgical procedures. Robotic systems, like the da Vinci Surgical System, enable minimally invasive surgeries with greater precision and control, resulting in shorter recovery times and better patient outcomes (Kyrarini et al., 2021; Mitzner et al., 2013). These technologies allow surgeons to perform intricate procedures with enhanced accuracy, reducing complications often associated with traditional methods. Additionally, the application of robots in rehabilitation has shown potential in aiding patients with mobility issues by providing personalised therapy that adapts to individual needs (Vijayakumar & Suresh, 2022; Ribeiro et al., 2021).

Telepresence robots have become increasingly popular, especially for remote consultations and patient monitoring. These robots enable effective communication between healthcare providers and patients, ensuring continuous care even in difficult situations (Lee et al., 2019; Morgan et al., 2022). The capacity to conduct virtual consultations via robotic systems not only improves access to healthcare services but also helps ease the strain on healthcare facilities by decreasing the need for in-person visits (Lee et al., 2019).

The technological breakthroughs in robotics since its inception have enabled a growth in their fields of application, which initially began in industrial settings. Robots, originally built to assist and perform specific tasks by hand, now represent a new way of helping individuals with disabilities.

By utilising various branches of technology, such as control systems, mechanics, electronics, and computer science, robotics can address and provide support for the challenges posed by physical impairments. We can draw a comparison between humans and robots based on their functional components: the brain corresponds to the microprocessor; the body to the structure; muscles to motors; and senses to sensors. This analogy allows us to design support systems for individuals with physical disabilities or tools that can be controlled by the user. The use of robots simplifies the daily activities of people with visual, motor, or cognitive impairments (Casals, 1999).

There are several types of Healthcare Robots:

- Robotic Surgery: This type of surgery enables surgeons to perform procedures with greater precision through a connection that does not require them to be physically present to operate. Instead, the surgeon can control the robot from a cabin, allowing for remote operations. The success of these surgeries has led to a new form of surgical practice, with the first significant challenge occurring in Iraq, where surgeons in Washington operated on wounded soldiers using robots. Unfortunately, variations in signal transmission due to long distances made these surgical interventions partially unsafe. Additionally, during robotic surgery, the surgeon lacks haptic sensation, which is present in open surgery, where the tactile feedback from organic tissues and fluids is felt. Robotic surgery is considered the future of surgical procedures and currently encompasses eight medical subspecialties: gynaecology, general surgery, bariatric surgery, urology, cardiovascular surgery, oncology, oncological urology, and onco-gynaecology. The robot that revolutionised robotic surgery and is the only one approved by the United States Food and Drug Administration (FDA) is the Da Vinci Surgical System. This system represents a convenient and practical solution for physicians, minimising fatigue as the robot performs much of the work.

- Robotic Assistance: Robotic assistance is designed for individuals who have lost limbs or have total immobility that prevents them from performing certain tasks autonomously. The aim is to improve their quality of life through robotic mechanisms. Traditional rehabilitation has focused on replacing missing anatomical members or enhancing those that are diminished, primarily through the provision of myoelectric prostheses (a combination of electronics and mechanics controlled by muscle signals) to replace missing limbs. Furthermore, systems are being developed to assist quadriplegics in managing their environment and controlling equipment for locomotion, thereby providing some autonomy in daily activities.
- Robotic Diagnosis: Currently, algorithms exist that can assess health through interpreters that translate medical imaging, analyse heart sounds, and interpret diagnostic tests. These advancements suggest that there are algorithms capable of diagnosing conditions more effectively than human medical professionals.

A robot that assists in orthopedic surgical procedures is the Arthrobot (1983), a small robot used for restorative surgery on joints. It was designed to provide precision in drilling during hip surgery and can be programmed with the location and path of the cavity to create implants. Another example of a robot that aids in surgical operations is the Da Vinci Surgical System (1997). This robot is designed for remote operation, with the goal of helping to save lives, although it is not a substitute for the surgeon, who retains the legal obligation for the operation.

There is also a robot named RIBA-II, an electrical lifting system designed to reduce injuries in hospitals and public health centres. This robot, which features a bear-like face, raises patients from the floor to a bed or chair, ensuring their safety. Sensors measure the weight and balance of the patients and calculate the correct position of the lift arms to ensure comfort.

Countless examples of robots that support health services exist, and research and applications in this area are extensive and exciting. The future trends of medical robots go beyond science fiction, as they can perform various activities such as scouting, guiding, assisting, and providing companionship. Additionally, robots are used to diagnose, monitor, and care for patients. This technology is designed for specific tasks, enabling future generations of doctors and nurses (and all teams involved in operations) to perform more complicated surgeries and improve treatment outcomes. Furthermore, the integration of artificial intelligence may allow for the prediction of potential medical accidents that could occur during and after surgery. The presence of robots in medicine is growing considerably, and artificial intelligence is part of a promising future in the development of these robotic machines worldwide. Medical robots are already a reality in some countries.

3.3. Robots in the aerospace industry

The incorporation of robotics within the aerospace sector has profoundly reshaped manufacturing practices, boosting efficiency, accuracy, and overall quality.

As the aerospace industry progresses towards Industry 4.0, the use of automation technologies, particularly in the manufacturing of composite materials, has become increasingly widespread. Automated Fiber Placement (AFP) and Automated Tape Placement (ATP) are two pivotal technologies that have transformed the production of composite components, which are vital for modern aircraft like the Boeing 787 and Airbus A350, where over 50% of the structure is composed of composite materials (Gambardella et al., 2022; Gambardella, 2023; Yin et al., 2023).

Robotic systems are extensively utilised in various manufacturing operations, including drilling, assembly, and inspection. Liu et al. emphasise the application of kinematic models to improve the performance of wing root drilling processes, which are critical for ensuring the structural integrity of aircraft (Liu et al., 2022). The introduction of parallel kinematic machines (PKMs) has proven effective in enhancing both operational speed and precision, meeting the stringent demands of aerospace manufacturing (Liu et al., 2022). Additionally, developments in deep learning and machine learning have enabled real-time defect detection and process optimisation, which are essential for maintaining high-quality standards in aerospace production (Shafi et al., 2023).

However, the challenges of achieving robotic precision in aerospace applications remain significant. The strict accuracy requirements, such as a drilling tolerance of 0.5° perpendicularity, necessitate advanced calibration techniques and compliance models to ensure that robotic systems adhere to industry standards (Morsi, 2023). Research has shown that standard industrial robots often struggle to meet the required accuracy due to mechanical constraints, such as structural flexibilities and dynamic errors (Newman et al., 2020). Therefore, advancements in robotic design and control systems are crucial to improving the performance of these machines in precision applications (Newman et al., 2020).

Robots and robotic equipment are applied in the space area for exploration to Mars exploration to the Moon, explore other bodies or planets, the orbit of the Earth or planetary exploration applications. The European Space Agency believes it has worked with two types of robots in the missions to Mars: small rovers and big rovers. The Robotics part, can be implemented from internal or external equipment, spacecraft, exploration or service.

Robonaut 1 is a robot designed by the Robot Systems Technology Branch at Johnson Space Center of NASA for the international space station. It was designed as equivalent to astronauts with extra-vehicular activity, being manipulated remotely by humans (Wilson, 2010). Robonaut 2 (Diftler et al., 2011) presents the incorporation of a manipulated set of scale amounting to his legs with more computing power and better sensors. Dextre is robot maintenance, and repairs to the international space station have two arms that can replace the observation team or change batteries, allowing to reduce the time of the spacewalks. This robot is manipulated remotely in Space Center Johnson of NASA in Houston as the headquarters of the Canadian Space Agency in Saint-Hubert.

The Philae robot spacecraft Rosetta, developed by the European Space Agency, is the first robot designed for landing, analyze and orbitrar in the comet 67 p/Churyumov-Gerasimenko. Spirit (MERB-A) and Opportunity (MERB-B) are two robotic exploration vehicles sent by NASA as part of the exploration program to Mars, to explore the Earth's surface. His arms have tools such as spectrometers, microscopes and magnets that support the collection and collection of particles. Cassini is a robotic spacecraft that rotates and studying around Saturn, which is accompanied by the Huygens space probe. NASA develops the Cassini project, the European Space Agency (ESA) and the Italian Space Agency (AgenziaSpazialeItaliana - ASI).

Eurobot is robotic support to move and navigate autonomously or cooperating with the astronauts on Earth. He has robotic arms, sensors and a 3d camera that allows the exchange of tools. Which is developed by the European Space Agency and can be handled using a lever or remotely from the Agency.

3.4. Robots in industry Lifesaving

Robotics has been applied to different areas and industries. An important area is the area of rescue and assistance to the population. United States Navy developed a robot's support for rescuers in boats with problems at sea. The robot is called the Emergency Integrated Lifesaving Lanyard (EMILY). EMILY is a 1.5 m-long remotely controlled buoy used to rescue swimmers in distress. The buoy can race across the ocean at 39 km/h, enabling swift rescues. It has been advanced with sonar-detection tech which helps it to find and identify distressed swimmers on its own. Once EMILY has reached the swimmer, they can either hang on to the buoy and await a lifeguard, or the buoy can tow them ashore itself.

Creatures like squid and starfish inspire soft robot starfish robot. Capable of complex movements with very little mechanisation, this sort of bot could be used in search-and-rescue operations following earthquakes. The multi-gait robot is tethered to a bottle of pressurised air, which pulses through the hollow-bodied robot to generate simple motion.

3.5. Robots in the Humanitarian industry

The integration of robotics in the humanitarian sector has become a crucial advancement, improving the efficiency and effectiveness of disaster response and recovery operations. Robots are increasingly being utilised in various roles, such as search and rescue, logistics support, and environmental monitoring, playing a key part in reducing the impact of disasters and humanitarian crises (Delmerico et al., 2019; Cubber et al., 2013; Murphy, 2014).

A particularly important application of robotics in humanitarian efforts is within search and rescue missions. The development of specialised robotic systems, including unmanned aerial vehicles (UAVs) and ground robots, has proven essential in locating survivors in disaster-affected regions. For example, the ICARUS project focuses on developing integrated robotic tools to support search and rescue teams in locating human survivors in difficult environments (Cubber et al., 2013). These robots are equipped with advanced sensors and communication technology, allowing them to traverse hazardous areas and relay critical information back to rescue teams (Balta et al., 2016). Additionally, the use of drones for aerial reconnaissance enables a swift evaluation of disaster zones, supporting timely decision-making and resource allocation (Delmerico et al., 2019).

Beyond search and rescue, robotics plays a vital role in logistics and supply chain management during humanitarian crises. Drones and autonomous ground vehicles are increasingly used to deliver essential supplies, such as food, water, and medical aid, to remote or hard-to-reach areas. This capability is especially valuable in situations where conventional transportation is obstructed by damaged infrastructure or ongoing conflict. The ability of robots to operate in such environments not only accelerates aid delivery but also minimises risks to human responders (Murphy, 2014).

Additionally, robotics is applied in environmental monitoring and assessment during disasters. Robots equipped with sensors can gather data on hazardous materials, evaluate structural safety, and monitor environmental conditions, offering crucial insights to inform response strategies (Delmerico et al., 2019). This data-driven approach improves situational awareness and enables humanitarian organisations to respond more effectively to the changing needs of affected populations.

There are some experiments related to human-robotic applications, where the main area is the humanitarian demining. Li, et al. (2015) presented a robotic manipulator using a stereo camera with a precise kinematic transformation calibration between the manipulator and the camera coordinate frames, and the hand-eye calibration, to achieve high-accuracy end-effector positioning. This proposal performs simultaneous joint angle and hand-eye calibration; this method considers an additional joint angle constraint is improving the calibration accuracy. Kato y Hirose (2012) proposed a quadruped walking robot controlled by teleoperation oriented to humanitarian mine detection and removal. Estremera et al. (2010) presented a crab and turning gaits for hexapod robots to contain uneven ground and forbidden zones.

Garcia and Gonzalez de Santos (2004) proposed two usages for the mobile-robot applications that require the complete coverage of an unstructured environment: floor-cleaning and humanitarian demining tasks. The used algorithm generates a path-planning technique allowing the robot to pass overall points in the environment.

Wiredgov (2018) proposed autonomous drones and unmanned ground robots to deliver orders with the capability to provide timely answers to the challenges of access for humanitarian aid and disaster relief. Some examples are autonomous hoverbikes, powered paragliders unmanned air vehicles and operating alongside self-driving ground vehicles.

Tmcnet (2014) mentioned the pizza delivery using drones. This idea became the start-up Matternet (network for transporting matter) oriented to help the one billion people who do not have access to roads. The system proposed by Raptopoulos eight-propeller UAVs can be used to transport small items (max 2kg) establishing a life-saving connection. The medical goods system delivery has three stages: the UAVs to drop and transfer the packages; the software and battery system.

De Cubber Balta Haris and Lietart (2014) presented a ground robotic system to rough outdoor conditions. In this case, this robot is used for Humanitarian Demining (specialized multichannel metal detector and unmanned aerial system supports to locate mines), and search and rescue (human victim detection sensors and a 3D camera). Cobano et al. (2010) focused on the track of predefined trajectories with hexapod robots walking on natural terrain with forbidden zones.

3.6. Robots that restore or repair the cultural heritage

Ceccarelli et al. (2015) designed a robot to support restoration activities, allowing analysis, surveying and restoration of frescos, therefore considered a cost low for the user and the restoration of cultural heritage. The HeritageBot project shows a robotic platform as a framework for the preservation of cultural heritage, technology and entrepreneurship-oriented goods (Ceccarelli et al., 2017).

Casili et al. (2017) proposed a project based on the cloud that combines elements of virtual reality, 3D models and a robotic system for the digitization of exploration for bows, restoration and maintenance of zones archaeological. The robotic system is design to any surface indoor or underground where the complicated human access.

An industrial robot, combined with a 3D modeller system and a laser tracker is used for the reconstruction of various objects, tests were evaluated objects of domestic, industrial, and cultural heritage (Kriegel, Rink, Bodenmüller, & Suppa, 2015).

4 Conclusions

We can say that robots cannot replace people 100%, but we must make it clear that all this change is no longer an experiment, but it is a reality where robots and people can coexist at the same time for the benefit of a human. The incorporation of AI into industrial robots offers a diverse range of opportunities to improve manufacturing processes through various types of intelligence, as described by Gardner. By utilising logical-mathematical, interpersonal, spatial, existential, and naturalistic intelligences, industrial robots can become more efficient, flexible, and ethically aligned with the demands of contemporary manufacturing environments. As the field progresses, continued research will be crucial to understanding the effects of these advancements on workforce dynamics and operational efficiency.

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