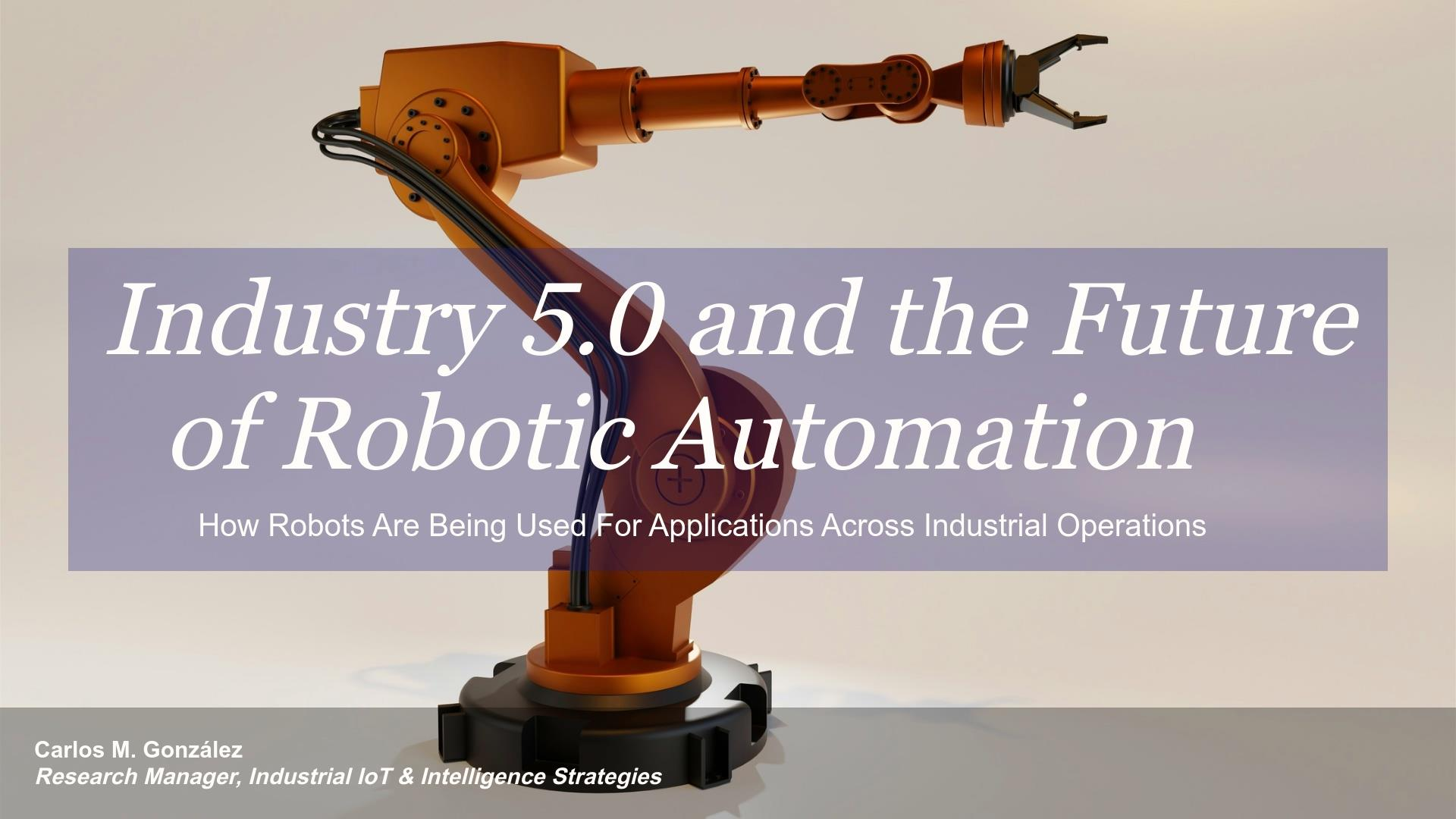


Industry 5.0 and the Future of Robotic Automation

How Robots Are Being Used For Applications Across Industrial Operations

Carlos M. González
Research Manager, Industrial IoT & Intelligence Strategies

Today’s Agenda

- Introduction to IDC’s Research Focus and Strategy
- The Status of Industry 4.0
- What is Industry 5.0?
- How are AI and robotic advancements driving innovation?
- Final Takeaway Thoughts

My Background

Journey from Engineering to Research

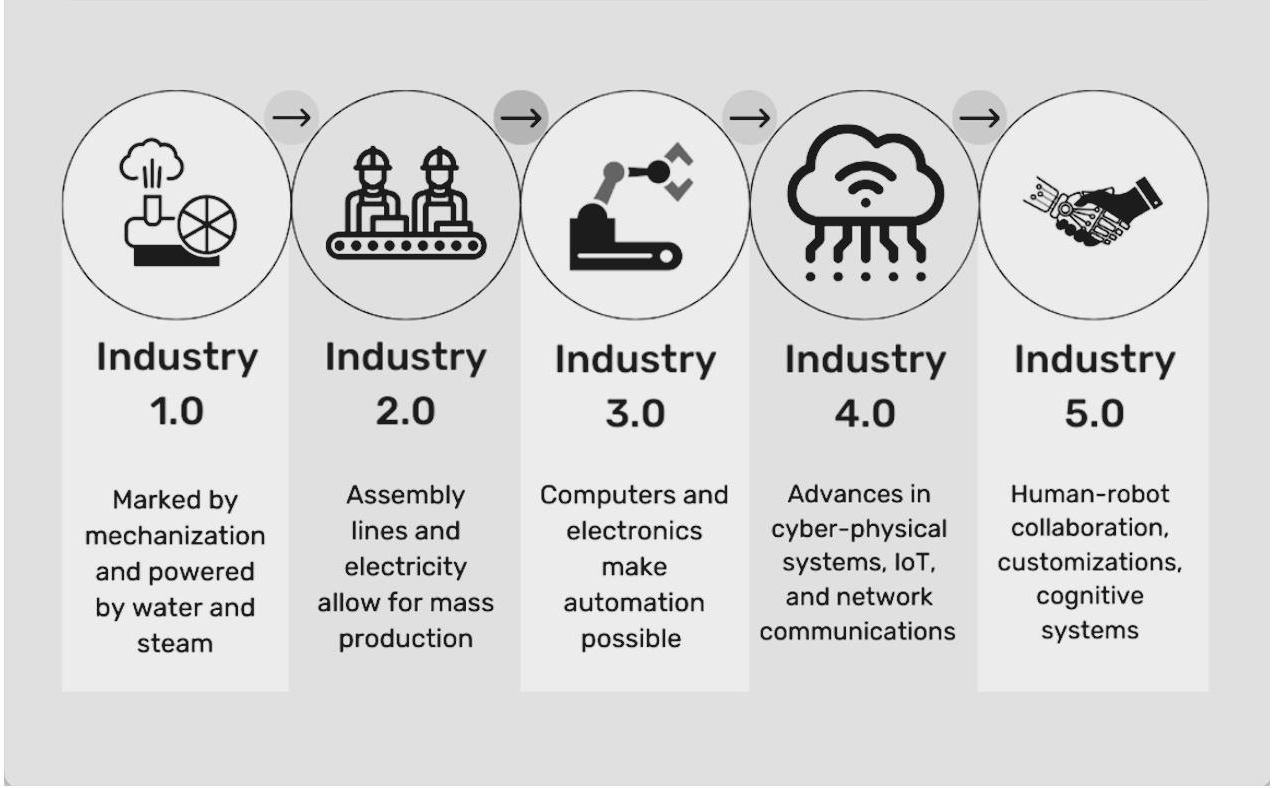
- B.S. in Mechanical Engineering, Manhattan College, 2007
- M.S. in Mechanical Engineering, Columbia University, 2010
- Sikorsky Aircraft, 2007 -2014
  - Engineering design team for the UH-60MU, S76-D, & CH-53K
- Engineering Journalist, 2015-2022
  - Machine Design
  - Hydraulics & Pneumatics
  - ASME's Mechanical Engineering Magazine
- IDC Research Analyst, 2022-Present
  - Operational Technology
  - Industrial IoT & Intelligence Strategies

IDC’s Research Focus and Strategy

IDC’s Industrial IoT & Intelligence Strategies research objective is to gauge how industrial operations are evolving/changing with increasing digital technology innovation and adoption. This includes the impacts on organizational structure and decision-making.

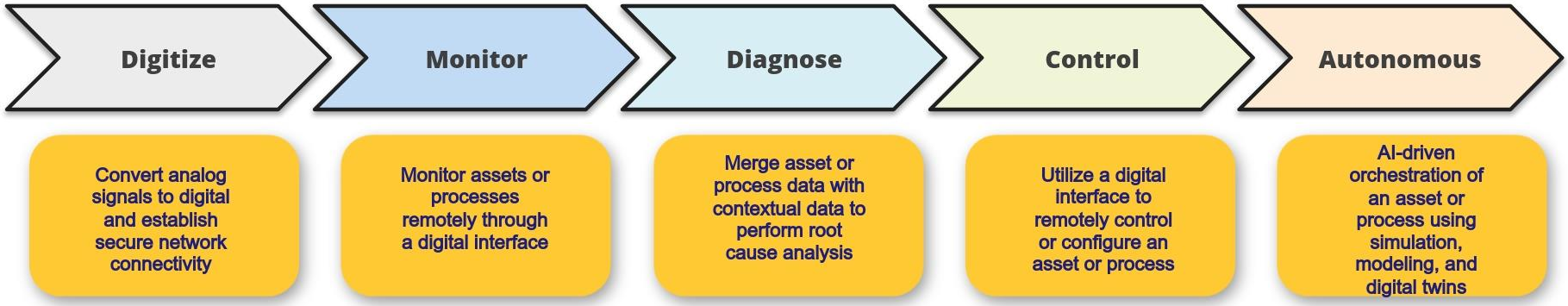
- Understanding operational challenges and how digital technology helps to address them.
- Determine the correlation between the use of data and performance.
- Gauge the adoption of AI and its impact on IoT operations.
- Assess the maturity of automation and data-driven operations.
- Evaluate the role of leadership and the evolution of workforce.

The Industrial Journey



The Phases of Digital Transformation

Convert analog signals to digital and establish secure network connectivity



The Transition from Industry 4.0 to Industry 5.0

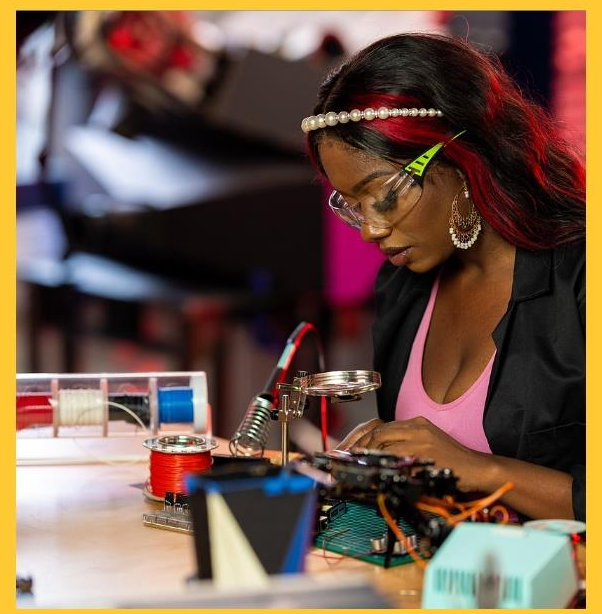
Industry 4.0 driven by data collection and insights

Emergence of Industry 5.0

AI as a transformative technology

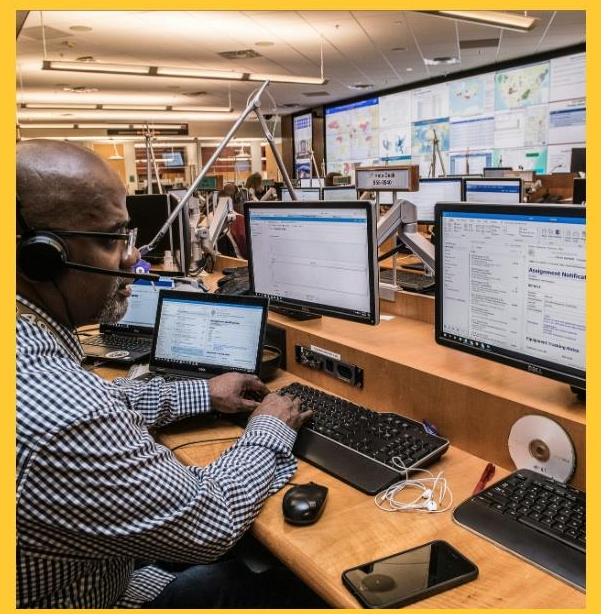
The transition from Industry 4.0 to Industry 5.0 represents a shift towards a more human-centric, sustainable, and resilient approach to manufacturing, enabled by the integration of advanced technologies like AI, robotics, and automation.

Key Themes of Industry 5.0

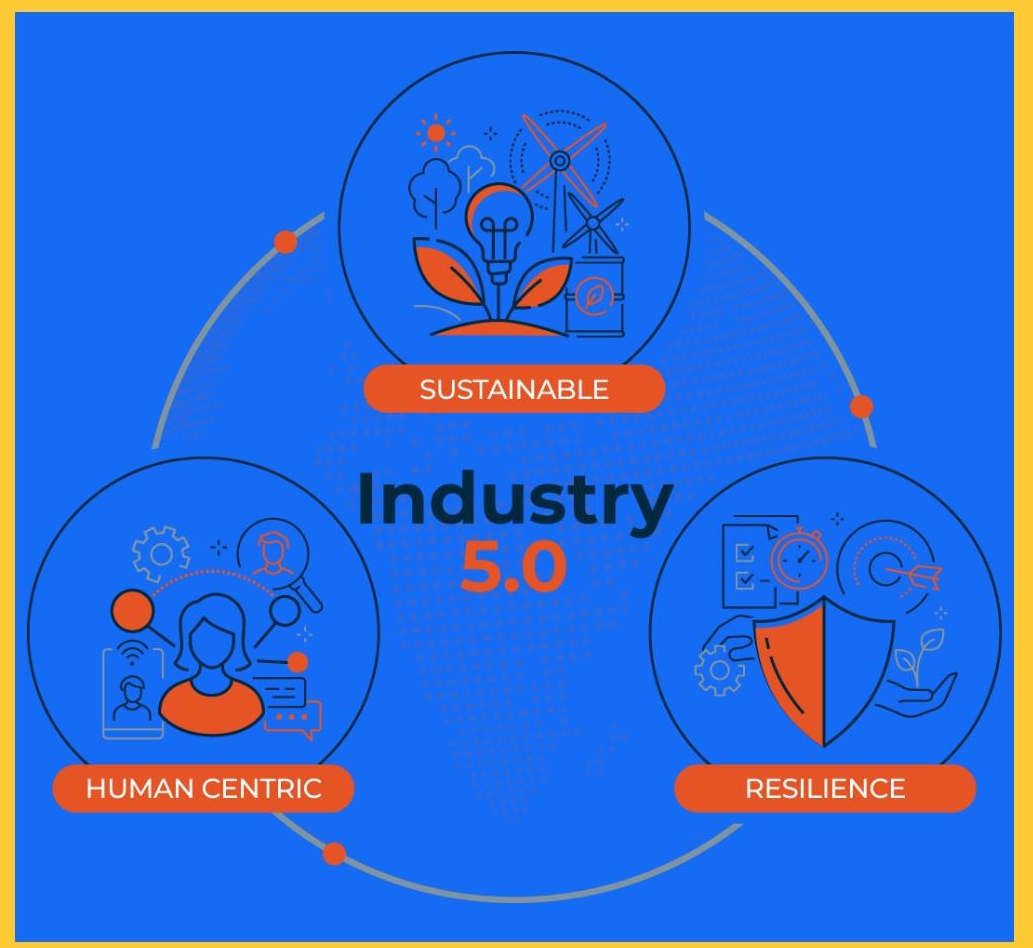


Human-Centric Focus

Sustainability Initiatives



Reliable and Resilient Operations



The Role of AI and Automation

The Impact of AI on Manufacturing

- Industrial organizations have a mix of legacy and new equipment which are being pushed onto IoT networks.
  - These devices will have conflicting communication languages and exist in data silos.
- Agentic AI will enhance real-time manufacturing adjustments.
- Device OEMs and technology vendors are increasing their adoption of open-source protocols and communication languages such as OPC-UA and MQTT.

Companies should explore options to expand their data infrastructure. Organized and streamlined data is key for autonomous manufacturing.

Industry 5.0 and the Role of Robots in Digital Transformation

Robotic Capabilities in Industry 5.0

1. **AI-Powered Decision-Making**
2. **Adaptive Learning**
3. **Seamless Human-Robot Interaction**
4. **Advanced Sensory Perception**
5. **Predictive Maintenance**
6. **Flexibility and Customization**

TOP 5 Global Robotics Trends in 2025

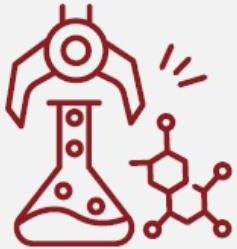
IFR International Federation of Robotics

Physical, Analytic & Generative AI

Single Pupose Humanoids

Sustainability and Energy Consumption

New Fields of Business and Customer Segments



Robots Addressing Labor Shortage

Annual Installations of Industrial Robots - World

Source: International Federation of Robotics - 2025 Preliminary Results

Robot Density in Manufacturing

Country	Robot Density (per 10,000 employees)
South Korea	1,012
China	470
Germany	429
Singapore	399
Japan	366
United States	295
Sweden	274
Denmark	254
Taiwan	246
Italy	237

*International Federation of Robotics (IFR), World Robotics Report 2023

OT Operations Will Evolve Thanks to Robotic Precision

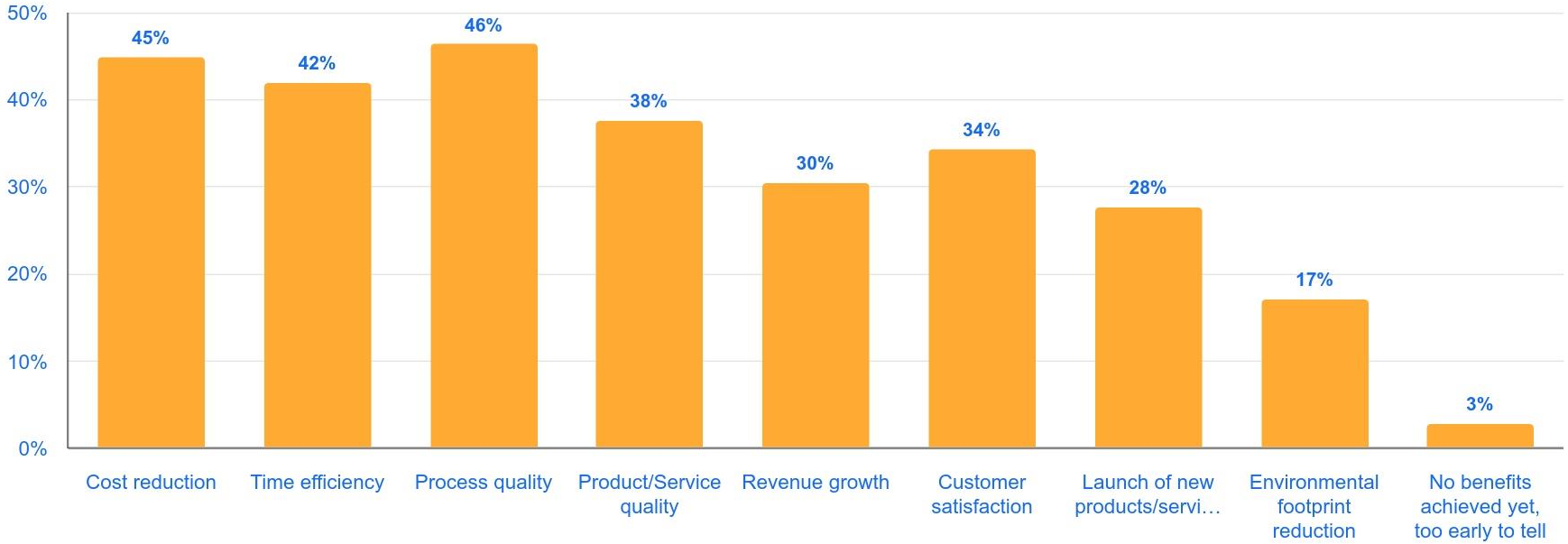
- Robot use outside of automotive and manufacturing increases.
- Collaborative robots have changed the robotic landscape.
- Robots to combat labor shortages.
- Inspection and maintenance robots for hazardous environments.

Robotic adoption is becoming easier. However, deployment and integration are still a barrier. Companies should research the best way to integrate robots into their facilities, what layout changes may occur, and which tasks will benefit employees most by becoming automated.

Robots Addressing Labor Shortage

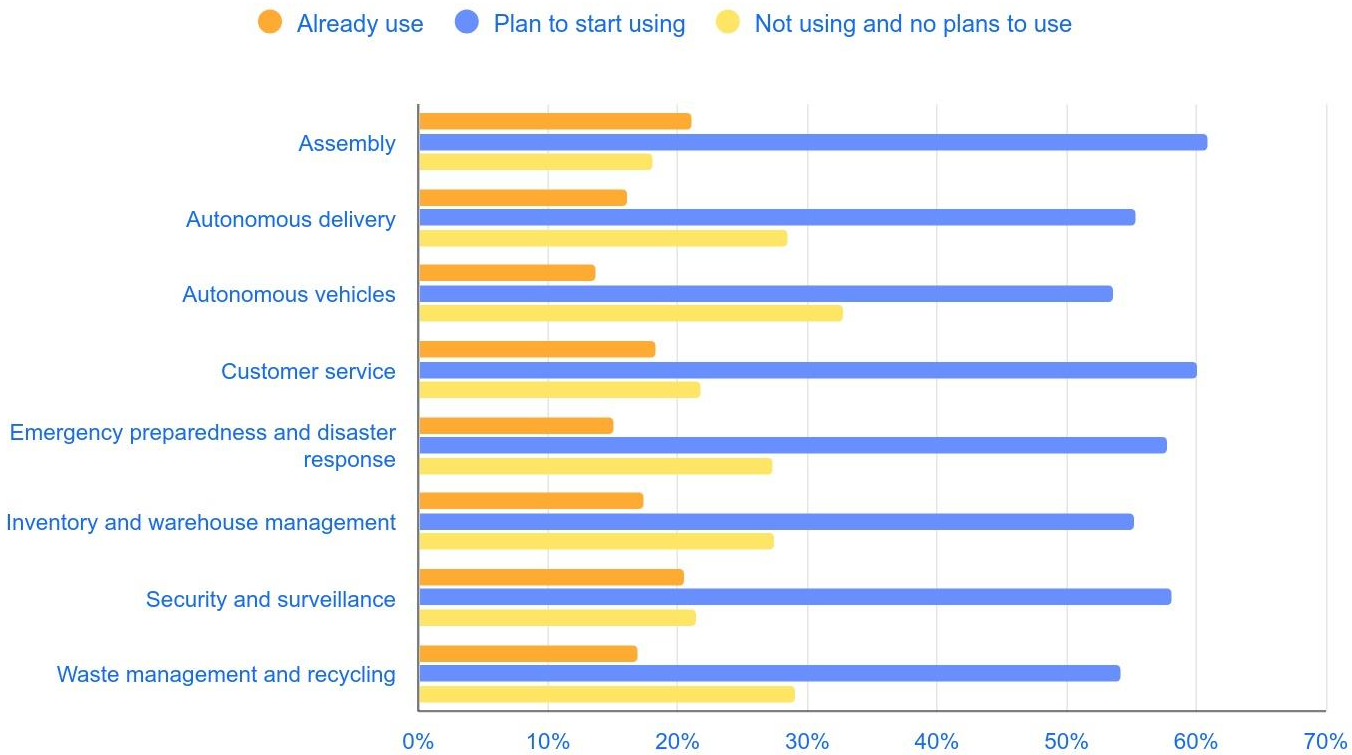
1. **Shortage of competences and skills on shopfloor workers**
2. **Augmenting Human Productivity**
3. **Democratization through ease of use**
4. **Flexible applications to fill gaps when and where needed**
5. **Increased Mobility**

Measurable Results Achieved via Advanced Robotics



IDC Syndicated Survey 2024: Emerging Techs 2024

Areas of Industry Deploying Advanced Robotics Over the Next Two Years



IDC Syndicated Survey 2024: Emerging Techs 2024

The New Robots on the Block

Cobots: Human-Robot Collaboration

Cobots, equipped with safety features, automate diverse industries by seamlessly collaborating with workers, boosting productivity.

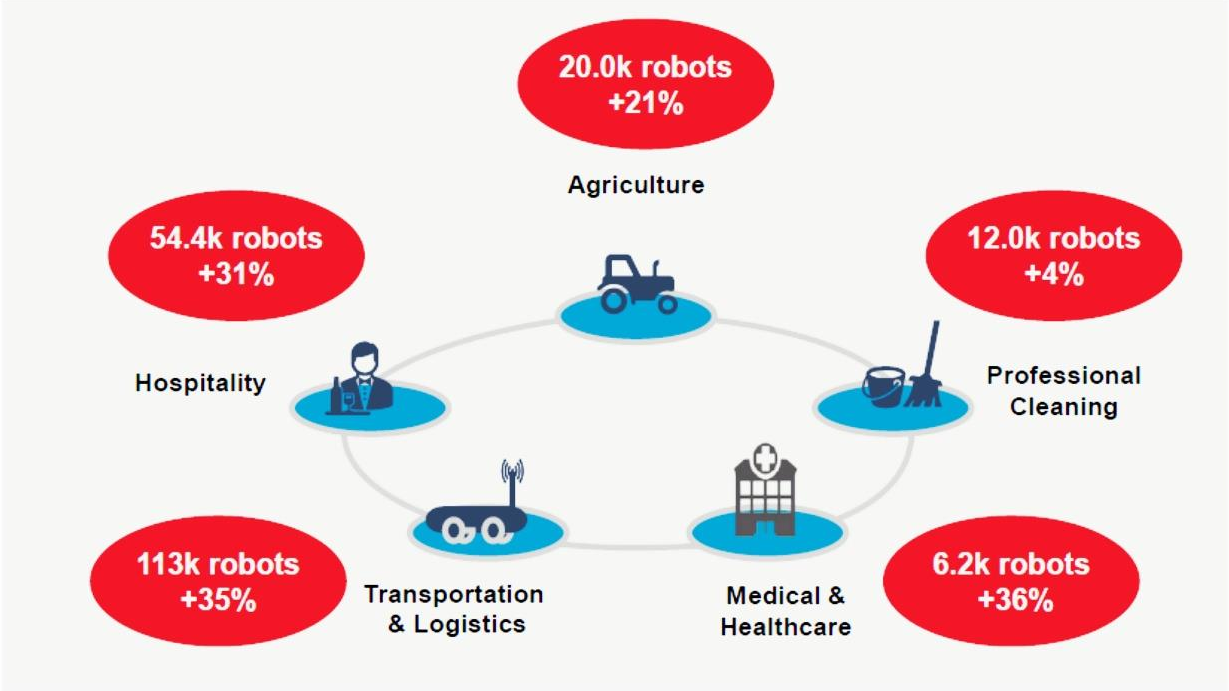
AMRs: Navigating Autonomously

Autonomous mobile robots have progressed, utilizing sensors and AI to navigate without infrastructure. Improved simulations optimize paths, enhancing automation's efficiency and flexibility.

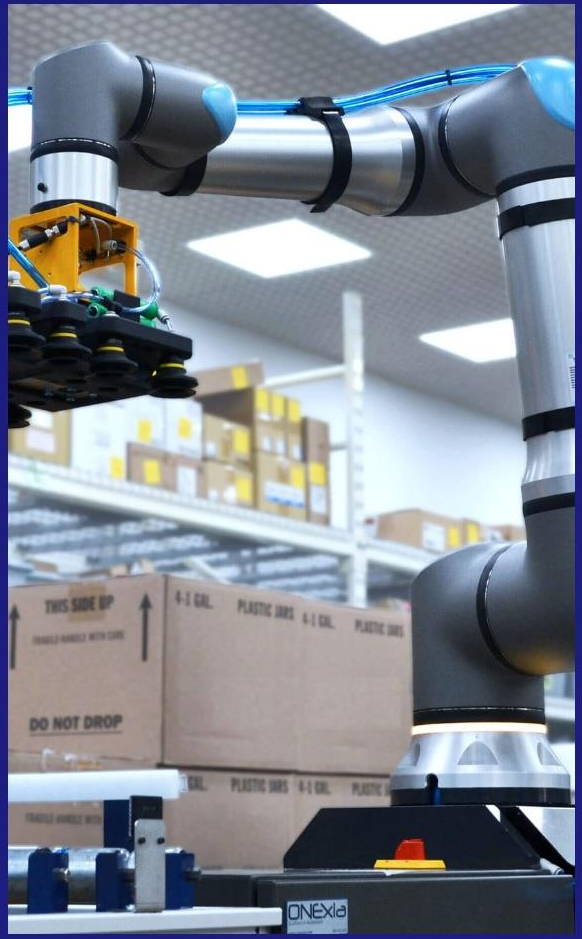
Humanoid Robots: An Extra Set of Hands

Humanoid robots will transform automation, allowing seamless human-robot collaboration through mimicry of movement and AI-powered capabilities, boosting productivity and innovation.

Top Application of Service Robots



Source: International Federation Robotics - 2024 Results



The Rise of Collaborative Robots

Collaborative Robots: Enhancing Human-Machine Collaboration

What are Collaborative Robots?

Key Features

Applications

Benefits

Collaborative robots offer a promising future where humans and machines work together harmoniously to drive innovation and productivity.

End Effectors

- End effectors are more sophisticated able to handle delicate items.
- Switching end effectors on the same robotic arm creates new applications and use cases.
- End effector market has become universal and democratize.

- Image Credit: OnRobot

Advanced Machine Vision

- Today’s advanced machine vision cameras are used for inspection, inventory control, and production management.
- Paired with robotic arms and automation, machine vision systems provide eyes to a mechanical process.
- Allows for a higher level of interaction between automated systems and production.

- Image Credit: OnRobot

The Future of Robot Mobility

Industry Development of AMRs

Rapid Growth in Professional Service Robots

Focus on Transportation and Logistics Sector

Adoption of AMRs in Warehouses

The rapid growth in the sales of professional service robots, including AMRs, with a strong focus on the transportation and logistics sector, demonstrates the increasing adoption of these advanced robotic systems in industrial operations.

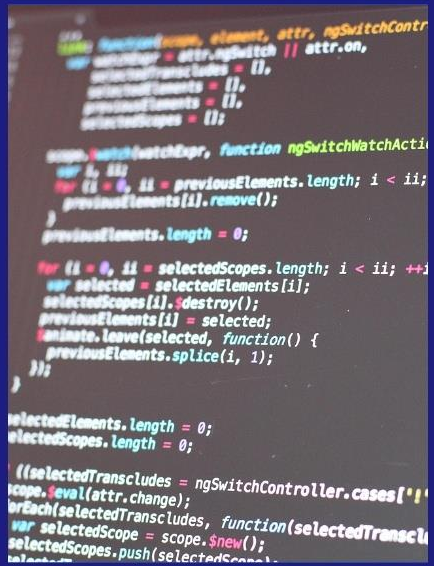
Innovations for AMRs

- Navigation without infrastructure
- Integration with IoT software platforms
- Dynamic Decision Making
- Companies leading the chage
  - OTTO Motors
  - MiR
  - VisionNav
  - ABB

Innovations for Quadrupedal Robots

- Flexiblilty for physical obstacles
- Advanced Sensing Capabilities
- Tools for building digital twins and simulation
- Companies leading the charge:
  - Boston Dynamics
  - ANYbotics
  - Unitree
  - DEEP Robotics

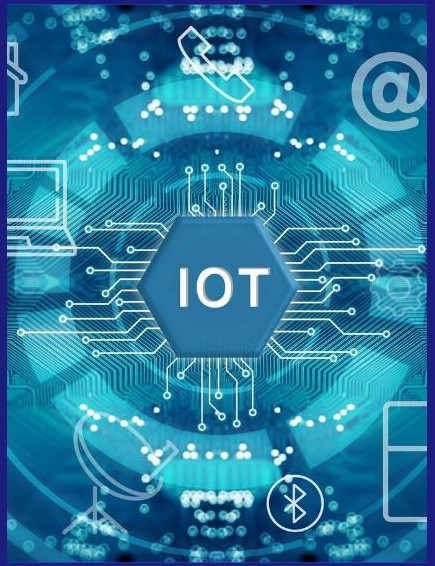
Robots Growing Data Infrastructure



AMRs as New IoT Data Points

Data Volume Increase

On-Premises, Cloud, or Hybrid Data Infrastructure



Enabling Data-Driven Insights


HD Atlas
Boston Dynamics
Figure
01
Phoenix
Sanctuary AI
Digit
Agility
Atlas
Boston Dynamics
H1
Unitree
Optimus Gen 2
Tesla
150cm / 4'11"
167cm / 5'6"
170cm / 5'7"
175cm / 5'9"
175cm / 5'9"
180cm / 5'11"
180cm / 5'11"
Retired
6.0'
5.0'
4.0'
3.0'
2.0'
1.0'
Humanoid Robots on the Horizon

Introduction to Humanoid Robots

Defining Humanoid Robots

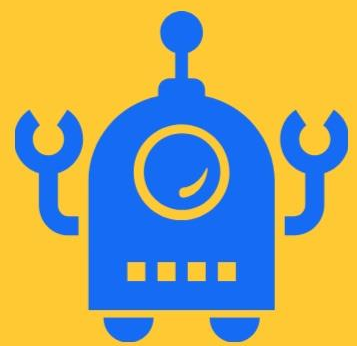
Anthropomorphic Design

Advanced Sensors and Actuators

Intelligent Control Systems

Humanoid robots represent a significant advancement in robotics, blending human-like form and function to tackle a wide range of industrial applications and revolutionize the way we approach automation and human-robot collaboration.

The Possibility of Humanoid Robots



Redefining Automation with Humanoid Robots

Automotive Industry Leads the Way

Enhancing Human-Centric Automation

Democratizing Advanced Robotics

Capabilities of Humanoid Robots

Advanced Sensory Perception

Dexterous Manipulation

Adaptable Mobility

Autonomous Decision-Making

Natural Interaction

Industrial Applications of Humanoid Robots

Humanoid Robot in Automotive Assembly

Humanoid Robot in Healthcare Sector

Humanoid Robot in Disaster Response

Humanoid Robot in Customer Service

Challenges and Limitations

- **High Initial Cost**

  Humanoid robots often require significant upfront investment, which can be a barrier for smaller businesses.

- **Maintenance and Upkeep**

  Humanoid robots require regular maintenance, repairs, and software updates, adding to the ongoing operational costs.

- **Adaptation to Existing Environments**

  Humanoid robots may struggle to seamlessly integrate into existing industrial environments, requiring infrastructure modifications.

- **Safety Concerns**

  The presence of humanoid robots in close proximity to human workers raises safety concerns and requires robust safety protocols.

- **Limited Dexterity**

  While advanced, humanoid robots may still have limitations in terms of fine motor skills and dexterity compared to human workers.

Embracing Industry 5.0: A Call to Action

Assess Readiness

Evaluate your organization's capabilities and infrastructure

Pilot Implementations

Test and refine Industry 5.0 strategies and technologies

Upskill Workforce

Train employees to effectively collaborate with robots

Adopt Flexible Processes

Implement agile and customizable production methods

For Additional Information

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