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Global Humanoid Robot Torque Sensors Market Growth 2026-2032

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Abstracts

The global Humanoid Robot Torque Sensors market size is predicted to grow from US$ 23.28 million in 2025 to US$ 141 million in 2032; it is expected to grow at a CAGR of 19.3% from 2026 to 2032.

Humanoid Robot Torque Sensors are precision force-sensing components designed to measure rotational torque and, in selected integrated configurations, multi-axis mechanical loads generated at the articulated joints of humanoid robots. They provide real-time feedback for closed-loop torque control, compliant motion, dynamic balance, collision detection, manipulation and safe physical interaction. The research scope covers strain gauge torque sensors, capacitive torque sensors and magnetic torque sensors designed or commercially applicable to humanoid robot joint systems. Products are typically integrated into compact rotary actuators, harmonic or strain-wave gear assemblies, wrist modules, leg joints and other electromechanical joint structures, with key performance considerations including measurement range, accuracy, repeatability, stiffness, overload capability, bandwidth, temperature stability, crosstalk, package thickness, hollow-shaft configuration and digital communication capability. The principal application positions covered by this study are shoulder and elbow joints, wrist joints, waist and torso joints, hip and knee joints, and ankle and other joints, where torque feedback supports whole-body motion control and interaction with the external environment. Current product development increasingly emphasizes compact mechanical integration, high-bandwidth feedback and direct compatibility with embedded robot control architectures.

Key Findings

Humanoid robot torque sensing is evolving from standalone measurement toward

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embedded closed-loop joint force control

Strain gauge torque sensors currently have the broadest commercial coverage among the confirmed supplier base

Hip and knee joints are among the most demanding sensing positions because of load bearing and dynamic balance requirements

China represents the densest confirmed supplier cluster in this study across joint torque and multi-axis force torque technologies

Commercial product development is increasingly focused on thinner structures digital interfaces higher bandwidth and scalable calibration

Market Trends

The Humanoid Robot Torque Sensors market is moving toward deeper integration with actuator and joint architectures rather than remaining a standalone sensing component market. As humanoid robots progress from laboratory prototypes toward repeated operation in manufacturing, service and other physical environments, torque feedback is increasingly expected to become part of the closed-loop control architecture used for compliant motion, balance recovery, manipulation and safe contact. Product design is therefore shifting toward ultra-thin or hollow-shaft structures, higher mechanical stiffness, lower weight, improved overload capability and faster signal transmission. Bota Systems has introduced ultra-slim joint torque sensors designed around compact robot actuators and strain-wave gearing, while FUTEK highlights customized strain-wave gear torque sensing for shoulders, knees and elbows. ATI’s current Varo platform combines compact mechanical packaging with digital six-axis feedback for humanoid applications. Another important direction is the integration of sensing electronics and compensation functions inside the sensor. Digital interfaces, embedded amplification, temperature compensation and crosstalk correction can reduce the number of external components and simplify joint wiring. Miniaturization is also broadening the number of potential sensing positions. MinebeaMitsumi, for example, has developed compact MEMS-based force/torque sensing and is displaying both six-axis sensing and single-axis joint torque sensing as part of its humanoid robot component portfolio. These developments indicate that future competition will increasingly depend on mechanical-electrical co-design and system integration capability rather than measurement accuracy alone.

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Market Dynamics

Drivers

Growth in humanoid robot development is increasing demand for direct mechanical feedback at the joint level. Walking, lifting, manipulation and human interaction require the controller to estimate actual loads rather than relying only on motor current, encoder position or predefined motion trajectories. Torque sensing can improve compliant control, force limitation, collision response and dynamic motion stability, making it increasingly important as humanoid robots move into environments requiring closer physical interaction. Policy support is also strengthening development of the underlying component ecosystem. China’s Ministry of Industry and Information Technology has specifically identified high-precision sensing and dedicated humanoid robot sensors as important foundational technologies and has emphasized the development of key components, complete machines and application demonstrations.

Restraints

The main restraints are the demanding combination of accuracy, mechanical stiffness, durability, compactness and cost. A joint torque sensor must detect small torque variations while carrying substantial structural loads, and excessive elastic deformation can negatively affect joint positioning and control response. Temperature drift, hysteresis, crosstalk, overload events and long-term fatigue can further influence measurement stability. Integration is also highly customized because humanoid robot manufacturers use different actuator diameters, reducers, shaft structures, connectors, communication protocols and torque ranges. This limits immediate product standardization and increases engineering and calibration expense, particularly during low-volume development and pilot-production phases.

Opportunities

The largest strategic opportunity is the transition from discrete sensor procurement toward sensorized joint modules and distributed whole-body force sensing. Suppliers capable of designing torque sensors around motors, reducers, bearings and hollow-shaft transmission structures can become involved earlier in the robot joint development cycle and potentially capture greater value than vendors supplying standard catalog sensors alone. Wrist and ankle systems also create opportunities for combining torque sensing with multi-axis force/torque feedback, while shoulder, hip, knee and elbow joints create demand for compact single-axis sensing across multiple torque ranges. Growing interest in physical AI further increases the value of high-quality force interaction data

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because sensor feedback can support both real-time control and the collection of physical interaction datasets for robot learning.

Challenges

A major challenge is that the humanoid robot industry has not yet converged on standardized joint architectures or sensing specifications. Requirements for torque range, sensor diameter, axial thickness, stiffness, bandwidth, overload capacity and digital interfaces vary substantially among robot platforms. Suppliers therefore face a trade-off between customized engineering and scalable manufacturing. At the same time, qualification cycles for safety-critical joints can be lengthy because customers need to verify calibration consistency, temperature characteristics, fatigue life and reliability under dynamic impact. As robot manufacturers place greater emphasis on cost reduction, sensor suppliers will also need to lower unit cost without sacrificing precision or production consistency, increasing pressure on automated calibration, process control and yield management.

Industry Chain Analysis

The upstream portion of the Humanoid Robot Torque Sensors industry includes sensing elements and structural materials such as strain gauges, MEMS elements, capacitive or magnetic sensing structures, elastic bodies, specialty steels and aluminum alloys, adhesives, signal-conditioning ICs, ADCs, amplifiers, microcontrollers, connectors and communication components. Precision machining and heat treatment of the elastic structure are particularly important because geometry, stiffness and material consistency directly affect sensitivity, linearity and overload performance. In strain-gauge products, bonding quality, bridge design and temperature compensation are additional determinants of measurement stability, while capacitive and magnetic technologies depend more heavily on precision sensing structures, signal processing and electromagnetic design.

The midstream covers sensor structural design, sensing-element integration, electronics, algorithmic compensation, calibration, environmental testing and production verification. Calibration capability is an important value-creation stage because multi-point loading, temperature compensation and crosstalk correction directly affect usable accuracy. The downstream consists primarily of humanoid robot joint-module manufacturers, actuator suppliers, robot OEMs and system developers. As humanoid robot architectures mature, value creation is shifting toward joint-level co-design: sensor suppliers increasingly need to optimize mechanical interfaces, communication protocols

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and control parameters together with the customer. This favors companies with both sensing expertise and high-volume precision manufacturing capability and may gradually increase the importance of automated calibration and production traceability.

Segment Insights

Among the three confirmed technology categories, strain gauge torque sensors currently show the broadest commercial presence. The technology benefits from a mature engineering base, high measurement sensitivity, flexible elastic-body design and compatibility with a wide range of joint dimensions and torque ratings. A significant proportion of the confirmed manufacturers use strain-based force or torque sensing in robot-related products, and the technology is particularly suitable for hollow-shaft or flange-type structures integrated with rotary actuators. Its future development is focused less on changing the basic sensing principle and more on improving integration density, thermal stability, signal conditioning, bandwidth and manufacturing consistency.

Capacitive torque sensors provide an alternative route where compact structure, small deformation sensing and integration flexibility are important, with I-PEX representing a confirmed commercial participant in this technology direction. Magnetic torque sensors represent another differentiated route and can offer advantages in sensing architecture and mechanical isolation depending on design configuration. However, compared with strain-gauge solutions, capacitive and magnetic approaches currently have a narrower confirmed supplier footprint within the defined humanoid robot market. Their opportunity will depend on whether they can demonstrate competitive accuracy, robustness, manufacturability and cost in increasingly standardized humanoid joint platforms.

Downstream Market Opportunities

Demand differs significantly by robot installation position. Hip and knee joints have relatively demanding requirements because they carry body loads and participate directly in walking, squatting, acceleration and balance recovery, creating strong demand for stiffness, overload resistance and reliable dynamic torque measurement. Shoulder and elbow joints require accurate torque feedback for manipulation, load handling and compliant arm motion, while waist and torso sensing supports whole-body coordination and force distribution. Wrist joints increasingly combine joint torque feedback with six-axis force/torque sensing to support dexterous manipulation and external-contact measurement. Ankle and other joints require compact sensing capable of supporting posture adjustment and ground-contact control. As humanoid robots evolve toward more distributed force control, the number of sensing points per robot

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may increase, making multi-position platform compatibility an important commercial opportunity for sensor suppliers.

Regional Insights

China is one of the most active regions for humanoid robot torque sensor commercialization and has the densest supplier representation within the confirmed company set used in this study. Sunrise Instruments, Keli Sensing Technology, Link-touch, Changzhou Kunwei Sensing Technology, PaXini Technology, Shenzhen XJCSENSOR Technology, Nanjing Bio-inspired Intelligent Technology and Shenzhen Ligent Sensor Tech have established products or development programs covering joint torque sensing, multi-axis force/torque sensing or both. The region benefits from a broad robot component manufacturing base, rapid iteration by humanoid robot OEMs and increasing emphasis on domestic high-precision sensing capability. Keli reported that during the first half of 2025 it had supplied samples to more than 50 humanoid, collaborative and industrial robot companies and that shipments of six-dimensional force sensors were approaching one thousand units, indicating that parts of the Chinese market have progressed from engineering validation toward small-batch commercialization.

North America maintains a strong position in high-performance force and torque sensing through established suppliers such as ATI Industrial Automation and FUTEK, particularly in precision robotics, customized sensing and demanding engineering applications. Europe has a specialized technology base represented by Sensodrive and Bota Systems, with strong emphasis on compact joint integration and high-performance robotic force control. Japan combines precision mechatronics and sensor manufacturing capabilities through MinebeaMitsumi and I-PEX, while South Korea has developed a specialized supplier group including AIDIN ROBOTICS, AL.Robot, DACELL and ROBOTOUS. The regional opportunity is therefore not defined only by sensor manufacturing cost; engineering cooperation with robot OEMs, customization speed and the ability to transition from prototypes into repeatable volume production are becoming increasingly important differentiators.

Competitive Landscape Analysis

The competitive landscape remains diversified because the market combines established force/torque sensor specialists, precision sensor manufacturers and newer companies focused specifically on robot force control. ATI Industrial Automation and FUTEK bring long-standing force and torque measurement capabilities and are

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adapting their portfolios directly to humanoid applications; ATI’s Varo platform is designed to provide compact digital six-axis feedback for humanoids, while FUTEK offers sensing solutions across wrists, torso interfaces and major rotating joints. Sensodrive and Bota Systems are positioned strongly around integrated joint torque sensing, with Bota emphasizing ultra-slim sensors compatible with compact actuators and strain-wave gearing. China has developed a broad domestic supplier group including Sunrise Instruments, Keli Sensing Technology, Link-touch, Changzhou Kunwei Sensing Technology, PaXini Technology, Shenzhen XJCSENSOR Technology, Nanjing Bio-inspired Intelligent Technology and Shenzhen Ligent Sensor Tech. Their competition increasingly centers on miniaturization, joint-specific structures, overload capability, calibration consistency, digital integration and faster customer customization. Link-touch has established dedicated humanoid six-axis force/torque and joint torque product lines, while Kunwei has developed joint torque sensors covering multiple actuator dimensions and reports batch application in humanoid, collaborative and industrial robot joints. Japanese and Korean participants provide additional technology diversity. MinebeaMitsumi has expanded its humanoid-related portfolio to include six-axis force sensors, MEMS six-axis force sensors and single-axis joint torque sensors, and presented these products at the World Robot Conference 2026. I-PEX provides a differentiated capacitive sensing route, while AIDIN ROBOTICS, AL.Robot, DACELL and ROBOTOUS strengthen the Korean specialist segment. Future competition is likely to shift from standalone sensor specifications toward overall joint integration, calibration automation, reliability under dynamic loads, digital communication compatibility and the ability to support scalable humanoid robot production.

Report Scope

LP Information, Inc. (LPI) ' newest research report, the “Humanoid Robot Torque Sensors Industry Forecast” looks at past sales and reviews total world Humanoid Robot Torque Sensors sales in 2025, providing a comprehensive analysis by region and market sector of projected Humanoid Robot Torque Sensors sales for 2026 through 2032. With Humanoid Robot Torque Sensors sales broken down by region, market sector and sub-sector, this report provides a detailed analysis in US$ millions of the world Humanoid Robot Torque Sensors industry.

This Insight Report provides a comprehensive analysis of the global Humanoid Robot Torque Sensors landscape and highlights key trends related to product segmentation, company formation, revenue, and market share, latest development, and M&A activity. This report also analyzes the strategies of leading global companies with a focus on Humanoid Robot Torque Sensors portfolios and capabilities, market entry strategies,

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market positions, and geographic footprints, to better understand these firms' unique position in an accelerating global Humanoid Robot Torque Sensors market.

This Insight Report evaluates the key market trends, drivers, and affecting factors shaping the global outlook for Humanoid Robot Torque Sensors and breaks down the forecast by Sensing Principle Types, by Application, geography, and market size to highlight emerging pockets of opportunity. With a transparent methodology based on hundreds of bottom-up qualitative and quantitative market inputs, this study forecast offers a highly nuanced view of the current state and future trajectory in the global Humanoid Robot Torque Sensors.

This report presents a comprehensive overview, market shares, and growth opportunities of Humanoid Robot Torque Sensors market by product type, application, key manufacturers and key regions and countries.

Market Segmentation

Segmentation by Sensing Principle Types:

Strain Gauge Torque Sensors

Capacitive Torque Sensors

Magnetic Torque Sensors

Segmentation by Rated Torque Range Types:

Low Torque (<50 N·m)

Medium Torque (50–200 N·m)

High Torque (>200 N·m)

Segmentation by Measurement Accuracy Types:

Standard Accuracy (>0.2% FS)

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High Accuracy (0.05–0.2% FS)

Ultra-High Accuracy (<0.05% FS)

Segmentation by Application:

Shoulder and Elbow Joints

Wrist Joints

Waist and Torso Joints

Hip and Knee Joints

Ankle and Other Joints

This report also splits the market by region:

Americas

United States

Canada

Mexico

Brazil

APAC

China

Japan

Korea

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Southeast Asia

India

Australia

Europe

Germany

France

UK

Italy

Russia

Middle East & Africa

Egypt

South Africa

Israel

Turkey

GCC Countries

The below companies that are profiled have been selected based on inputs gathered from primary experts and analysing the company's coverage, product portfolio, its market penetration.

ATI Industrial Automation

Sensodrive GmbH

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Sunrise Instruments Co., Ltd.

FUTEK Advanced Sensor Technology, Inc.

Keli Sensing Technology (Ningbo) Co.,Ltd.

Bota Systems AG

Link-touch (Beijing) Technology Co., Ltd.

Changzhou Kunwei Sensing Technology Co.,Ltd.

AIDIN ROBOTICS Inc.

PaXini Technology (Shenzhen) Co., Ltd.

Shenzhen XJCSENSOR Technology Co.,Ltd.

MinebeaMitsumi Inc.

AL.Robot, Co., Ltd.

Nanjing Bio-inspired Intelligent Technology Co., Ltd.

Shenzhen Ligent Sensor Tech Co., Ltd.

I-PEX Inc.

DACELL Co., Ltd.

ROBOTOUS Co., Ltd.

Key Questions Addressed in this Report

What is the 10-year outlook for the global Humanoid Robot Torque Sensors market?

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What factors are driving Humanoid Robot Torque Sensors market growth, globally and by region?

Which technologies are poised for the fastest growth by market and region?

How do Humanoid Robot Torque Sensors market opportunities vary by end market size?

How does Humanoid Robot Torque Sensors break out by Sensing Principle Types, by Application?

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Contents

1 SCOPE OF THE REPORT

1.1 Market Introduction
1.2 Years Considered
1.3 Research Objectives
1.4 Market Research Methodology
1.5 Research Process and Data Source
1.6 Economic Indicators
1.7 Currency Considered
1.8 Market Estimation Caveats

2 EXECUTIVE SUMMARY

2.1 World Market Overview
  2.1.1 Global Humanoid Robot Torque Sensors Annual Sales 2021-2032
  2.1.2 World Current & Future Analysis for Humanoid Robot Torque Sensors by Geographic Region, 2021, 2025 & 2032
  2.1.3 World Current & Future Analysis for Humanoid Robot Torque Sensors by Country/Region, 2021, 2025 & 2032
2.2 Humanoid Robot Torque Sensors Segment by Sensing Principle Types
  2.2.1 Strain Gauge Torque Sensors
  2.2.2 Capacitive Torque Sensors
  2.2.3 Magnetic Torque Sensors
  2.2.4 Humanoid Robot Torque Sensors Sales by Sensing Principle Types
    2.2.4.1 Global Humanoid Robot Torque Sensors Sales Market Share by Sensing Principle Types (2021-2026)
    2.2.4.2 Global Humanoid Robot Torque Sensors Revenue and Market Share by Sensing Principle Types (2021-2026)
    2.2.4.3 Global Humanoid Robot Torque Sensors Sale Price by Sensing Principle Types (2021-2026)
2.3 Humanoid Robot Torque Sensors Segment by Rated Torque Range Types
  2.3.1 Low Torque (<50 N·m)
  2.3.2 Medium Torque (50–200 N·m)
  2.3.3 High Torque (>200 N·m)
  2.3.4 Humanoid Robot Torque Sensors Sales by Rated Torque Range Types
    2.3.4.1 Global Humanoid Robot Torque Sensors Sales Market Share by Rated Torque Range Types (2021-2026)

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2.3.4.2 Global Humanoid Robot Torque Sensors Revenue and Market Share by Rated Torque Range Types (2021-2026)
2.3.4.3 Global Humanoid Robot Torque Sensors Sale Price by Rated Torque Range Types (2021-2026)
2.4 Humanoid Robot Torque Sensors Segment by Measurement Accuracy Types
2.4.1 Standard Accuracy (>0.2% FS)
2.4.2 High Accuracy (0.05–0.2% FS)
2.4.3 Ultra-High Accuracy (<0.05% FS)
2.4.4 Humanoid Robot Torque Sensors Sales by Measurement Accuracy Types
2.4.4.1 Global Humanoid Robot Torque Sensors Sales Market Share by Measurement Accuracy Types (2021-2026)
2.4.4.2 Global Humanoid Robot Torque Sensors Revenue and Market Share by Measurement Accuracy Types (2021-2026)
2.4.4.3 Global Humanoid Robot Torque Sensors Sale Price by Measurement Accuracy Types (2021-2026)
2.5 Humanoid Robot Torque Sensors Segment by Application
2.5.1 Shoulder and Elbow Joints
2.5.2 Wrist Joints
2.5.3 Waist and Torso Joints
2.5.4 Hip and Knee Joints
2.5.5 Ankle and Other Joints
2.5.6 Humanoid Robot Torque Sensors Sales by Application
2.5.6.1 Global Humanoid Robot Torque Sensors Sale Market Share by Application (2021-2026)
2.5.6.2 Global Humanoid Robot Torque Sensors Revenue and Market Share by Application (2021-2026)
2.5.6.3 Global Humanoid Robot Torque Sensors Sale Price by Application (2021-2026)

3 GLOBAL BY COMPANY

3.1 Global Humanoid Robot Torque Sensors Breakdown Data by Company
3.1.1 Global Humanoid Robot Torque Sensors Annual Sales by Company (2021-2026)
3.1.2 Global Humanoid Robot Torque Sensors Sales Market Share by Company (2021-2026)
3.2 Global Humanoid Robot Torque Sensors Annual Revenue by Company (2021-2026)
3.2.1 Global Humanoid Robot Torque Sensors Revenue by Company (2021-2026)
3.2.2 Global Humanoid Robot Torque Sensors Revenue Market Share by Company

+357 96 030922
info@marketpublishers.com

(2021-2026)
3.3 Global Humanoid Robot Torque Sensors Sale Price by Company
3.4 Key Manufacturers Humanoid Robot Torque Sensors Producing Area Distribution, Sales Area, Product Type
3.4.1 Key Manufacturers Humanoid Robot Torque Sensors Product Location Distribution
3.4.2 Players Humanoid Robot Torque Sensors Products Offered
3.5 Market Concentration Rate Analysis
3.5.1 Competition Landscape Analysis
3.5.2 Concentration Ratio (CR3, CR5 and CR10) & (2024-2026)
3.6 New Products and Potential Entrants
3.7 Market M&A Activity & Strategy

4 WORLD HISTORIC REVIEW FOR HUMANOID ROBOT TORQUE SENSORS BY GEOGRAPHIC REGION

4.1 World Historic Humanoid Robot Torque Sensors Market Size by Geographic Region (2021-2026)
4.1.1 Global Humanoid Robot Torque Sensors Annual Sales by Geographic Region (2021-2026)
4.1.2 Global Humanoid Robot Torque Sensors Annual Revenue by Geographic Region (2021-2026)
4.2 World Historic Humanoid Robot Torque Sensors Market Size by Country/Region (2021-2026)
4.2.1 Global Humanoid Robot Torque Sensors Annual Sales by Country/Region (2021-2026)
4.2.2 Global Humanoid Robot Torque Sensors Annual Revenue by Country/Region (2021-2026)
4.3 Americas Humanoid Robot Torque Sensors Sales Growth
4.4 APAC Humanoid Robot Torque Sensors Sales Growth
4.5 Europe Humanoid Robot Torque Sensors Sales Growth
4.6 Middle East & Africa Humanoid Robot Torque Sensors Sales Growth

5 AMERICAS

5.1 Americas Humanoid Robot Torque Sensors Sales by Country
5.1.1 Americas Humanoid Robot Torque Sensors Sales by Country (2021-2026)
5.1.2 Americas Humanoid Robot Torque Sensors Revenue by Country (2021-2026)
5.2 Americas Humanoid Robot Torque Sensors Sales by Sensing Principle Types

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(2021-2026)
5.3 Americas Humanoid Robot Torque Sensors Sales by Application (2021-2026)
5.4 United States
5.5 Canada
5.6 Mexico
5.7 Brazil

6 APAC

6.1 APAC Humanoid Robot Torque Sensors Sales by Region
  6.1.1 APAC Humanoid Robot Torque Sensors Sales by Region (2021-2026)
  6.1.2 APAC Humanoid Robot Torque Sensors Revenue by Region (2021-2026)
6.2 APAC Humanoid Robot Torque Sensors Sales by Sensing Principle Types (2021-2026)
6.3 APAC Humanoid Robot Torque Sensors Sales by Application (2021-2026)
6.4 China
6.5 Japan
6.6 South Korea
6.7 Southeast Asia
6.8 India
6.9 Australia
6.10 China Taiwan

7 EUROPE

7.1 Europe Humanoid Robot Torque Sensors by Country
  7.1.1 Europe Humanoid Robot Torque Sensors Sales by Country (2021-2026)
  7.1.2 Europe Humanoid Robot Torque Sensors Revenue by Country (2021-2026)
7.2 Europe Humanoid Robot Torque Sensors Sales by Sensing Principle Types (2021-2026)
7.3 Europe Humanoid Robot Torque Sensors Sales by Application (2021-2026)
7.4 Germany
7.5 France
7.6 UK
7.7 Italy
7.8 Russia

8 MIDDLE EAST & AFRICA

+357 96 030922
info@marketpublishers.com

8.1 Middle East & Africa Humanoid Robot Torque Sensors by Country
8.1.1 Middle East & Africa Humanoid Robot Torque Sensors Sales by Country (2021-2026)
8.1.2 Middle East & Africa Humanoid Robot Torque Sensors Revenue by Country (2021-2026)
8.2 Middle East & Africa Humanoid Robot Torque Sensors Sales by Sensing Principle Types (2021-2026)
8.3 Middle East & Africa Humanoid Robot Torque Sensors Sales by Application (2021-2026)
8.4 Egypt
8.5 South Africa
8.6 Israel
8.7 Turkey
8.8 GCC Countries

9 MARKET DRIVERS, CHALLENGES AND TRENDS

9.1 Market Drivers & Growth Opportunities
9.2 Market Challenges & Risks
9.3 Industry Trends

10 MANUFACTURING COST STRUCTURE ANALYSIS

10.1 Raw Material and Suppliers
10.2 Manufacturing Cost Structure Analysis of Humanoid Robot Torque Sensors
10.3 Manufacturing Process Analysis of Humanoid Robot Torque Sensors
10.4 Industry Chain Structure of Humanoid Robot Torque Sensors

11 MARKETING, DISTRIBUTORS AND CUSTOMER

11.1 Sales Channel
11.1.1 Direct Channels
11.1.2 Indirect Channels
11.2 Humanoid Robot Torque Sensors Distributors
11.3 Humanoid Robot Torque Sensors Customer

12 WORLD FORECAST REVIEW FOR HUMANOID ROBOT TORQUE SENSORS BY GEOGRAPHIC REGION

+357 96 030922
info@marketpublishers.com

12.1 Global Humanoid Robot Torque Sensors Market Size Forecast by Region
12.1.1 Global Humanoid Robot Torque Sensors Forecast by Region (2027-2032)
12.1.2 Global Humanoid Robot Torque Sensors Annual Revenue Forecast by Region (2027-2032)
12.2 Americas Forecast by Country (2027-2032)
12.3 APAC Forecast by Region (2027-2032)
12.4 Europe Forecast by Country (2027-2032)
12.5 Middle East & Africa Forecast by Country (2027-2032)
12.6 Global Humanoid Robot Torque Sensors Forecast by Sensing Principle Types (2027-2032)
12.7 Global Humanoid Robot Torque Sensors Forecast by Application (2027-2032)

13 KEY PLAYERS ANALYSIS

13.1 ATI Industrial Automation
13.1.1 ATI Industrial Automation Company Information
13.1.2 ATI Industrial Automation Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.1.3 ATI Industrial Automation Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.1.4 ATI Industrial Automation Main Business Overview
13.1.5 ATI Industrial Automation Latest Developments
13.2 Sensodrive GmbH
13.2.1 Sensodrive GmbH Company Information
13.2.2 Sensodrive GmbH Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.2.3 Sensodrive GmbH Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.2.4 Sensodrive GmbH Main Business Overview
13.2.5 Sensodrive GmbH Latest Developments
13.3 Sunrise Instruments Co., Ltd.
13.3.1 Sunrise Instruments Co., Ltd. Company Information
13.3.2 Sunrise Instruments Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.3.3 Sunrise Instruments Co., Ltd. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.3.4 Sunrise Instruments Co., Ltd. Main Business Overview
13.3.5 Sunrise Instruments Co., Ltd. Latest Developments
13.4 FUTEK Advanced Sensor Technology, Inc.

+357 96 030922
info@marketpublishers.com

13.4.1 FUTEK Advanced Sensor Technology, Inc. Company Information
13.4.2 FUTEK Advanced Sensor Technology, Inc. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.4.3 FUTEK Advanced Sensor Technology, Inc. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.4.4 FUTEK Advanced Sensor Technology, Inc. Main Business Overview
13.4.5 FUTEK Advanced Sensor Technology, Inc. Latest Developments
13.5 Keli Sensing Technology (Ningbo) Co.,Ltd.
13.5.1 Keli Sensing Technology (Ningbo) Co.,Ltd. Company Information
13.5.2 Keli Sensing Technology (Ningbo) Co.,Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.5.3 Keli Sensing Technology (Ningbo) Co.,Ltd. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.5.4 Keli Sensing Technology (Ningbo) Co.,Ltd. Main Business Overview
13.5.5 Keli Sensing Technology (Ningbo) Co.,Ltd. Latest Developments
13.6 Bota Systems AG
13.6.1 Bota Systems AG Company Information
13.6.2 Bota Systems AG Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.6.3 Bota Systems AG Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.6.4 Bota Systems AG Main Business Overview
13.6.5 Bota Systems AG Latest Developments
13.7 Link-touch (Beijing) Technology Co., Ltd.
13.7.1 Link-touch (Beijing) Technology Co., Ltd. Company Information
13.7.2 Link-touch (Beijing) Technology Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.7.3 Link-touch (Beijing) Technology Co., Ltd. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.7.4 Link-touch (Beijing) Technology Co., Ltd. Main Business Overview
13.7.5 Link-touch (Beijing) Technology Co., Ltd. Latest Developments
13.8 Changzhou Kunwei Sensing Technology Co.,Ltd.
13.8.1 Changzhou Kunwei Sensing Technology Co.,Ltd. Company Information
13.8.2 Changzhou Kunwei Sensing Technology Co.,Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.8.3 Changzhou Kunwei Sensing Technology Co.,Ltd. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.8.4 Changzhou Kunwei Sensing Technology Co.,Ltd. Main Business Overview
13.8.5 Changzhou Kunwei Sensing Technology Co.,Ltd. Latest Developments

+357 96 030922
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13.9 AIDIN ROBOTICS Inc.
13.9.1 AIDIN ROBOTICS Inc. Company Information
13.9.2 AIDIN ROBOTICS Inc. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.9.3 AIDIN ROBOTICS Inc. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.9.4 AIDIN ROBOTICS Inc. Main Business Overview
13.9.5 AIDIN ROBOTICS Inc. Latest Developments
13.10 PaXini Technology (Shenzhen) Co., Ltd.
13.10.1 PaXini Technology (Shenzhen) Co., Ltd. Company Information
13.10.2 PaXini Technology (Shenzhen) Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.10.3 PaXini Technology (Shenzhen) Co., Ltd. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.10.4 PaXini Technology (Shenzhen) Co., Ltd. Main Business Overview
13.10.5 PaXini Technology (Shenzhen) Co., Ltd. Latest Developments
13.11 Shenzhen XJCSENSOR Technology Co.,Ltd.
13.11.1 Shenzhen XJCSENSOR Technology Co.,Ltd. Company Information
13.11.2 Shenzhen XJCSENSOR Technology Co.,Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.11.3 Shenzhen XJCSENSOR Technology Co.,Ltd. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.11.4 Shenzhen XJCSENSOR Technology Co.,Ltd. Main Business Overview
13.11.5 Shenzhen XJCSENSOR Technology Co.,Ltd. Latest Developments
13.12 MinebeaMitsumi Inc.
13.12.1 MinebeaMitsumi Inc. Company Information
13.12.2 MinebeaMitsumi Inc. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.12.3 MinebeaMitsumi Inc. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.12.4 MinebeaMitsumi Inc. Main Business Overview
13.12.5 MinebeaMitsumi Inc. Latest Developments
13.13 AL.Robot, Co., Ltd.
13.13.1 AL.Robot, Co., Ltd. Company Information
13.13.2 AL.Robot, Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.13.3 AL.Robot, Co., Ltd. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.13.4 AL.Robot, Co., Ltd. Main Business Overview

+357 96 030922
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13.13.5 AL.Robot, Co., Ltd. Latest Developments
13.14 Nanjing Bio-inspired Intelligent Technology Co., Ltd.
13.14.1 Nanjing Bio-inspired Intelligent Technology Co., Ltd. Company Information
13.14.2 Nanjing Bio-inspired Intelligent Technology Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.14.3 Nanjing Bio-inspired Intelligent Technology Co., Ltd. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.14.4 Nanjing Bio-inspired Intelligent Technology Co., Ltd. Main Business Overview
13.14.5 Nanjing Bio-inspired Intelligent Technology Co., Ltd. Latest Developments
13.15 Shenzhen Ligent Sensor Tech Co., Ltd.
13.15.1 Shenzhen Ligent Sensor Tech Co., Ltd. Company Information
13.15.2 Shenzhen Ligent Sensor Tech Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.15.3 Shenzhen Ligent Sensor Tech Co., Ltd. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.15.4 Shenzhen Ligent Sensor Tech Co., Ltd. Main Business Overview
13.15.5 Shenzhen Ligent Sensor Tech Co., Ltd. Latest Developments
13.16 I-PEX Inc.
13.16.1 I-PEX Inc. Company Information
13.16.2 I-PEX Inc. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.16.3 I-PEX Inc. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.16.4 I-PEX Inc. Main Business Overview
13.16.5 I-PEX Inc. Latest Developments
13.17 DACELL Co., Ltd.
13.17.1 DACELL Co., Ltd. Company Information
13.17.2 DACELL Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.17.3 DACELL Co., Ltd. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)
13.17.4 DACELL Co., Ltd. Main Business Overview
13.17.5 DACELL Co., Ltd. Latest Developments
13.18 ROBOTOUS Co., Ltd.
13.18.1 ROBOTOUS Co., Ltd. Company Information
13.18.2 ROBOTOUS Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
13.18.3 ROBOTOUS Co., Ltd. Humanoid Robot Torque Sensors Sales, Revenue, Price and Gross Margin (2021-2026)

+357 96 030922
info@marketpublishers.com

13.18.4 ROBOTOUS Co., Ltd. Main Business Overview
13.18.5 ROBOTOUS Co., Ltd. Latest Developments

14 RESEARCH FINDINGS AND CONCLUSION

+357 96 030922
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List Of Tables

LIST OF TABLES

Table 1. Humanoid Robot Torque Sensors Annual Sales CAGR by Geographic Region (2021, 2025 & 2032) & ($ millions)
Table 2. Humanoid Robot Torque Sensors Annual Sales CAGR by Country/Region (2021, 2025 & 2032) & ($ millions)
Table 3. Major Players of Strain Gauge Torque Sensors
Table 4. Major Players of Capacitive Torque Sensors
Table 5. Major Players of Magnetic Torque Sensors
Table 6. Global Humanoid Robot Torque Sensors Sales by Sensing Principle Types (2021-2026) & (K Units)
Table 7. Global Humanoid Robot Torque Sensors Sales Market Share by Sensing Principle Types (2021-2026)
Table 8. Global Humanoid Robot Torque Sensors Revenue by Sensing Principle Types (2021-2026) & ($ million)
Table 9. Global Humanoid Robot Torque Sensors Revenue Market Share by Sensing Principle Types (2021-2026)
Table 10. Global Humanoid Robot Torque Sensors Sale Price by Sensing Principle Types (2021-2026) & (US$/Unit)
Table 11. Major Players of Low Torque (<50 N·m)
Table 12. Major Players of Medium Torque (50–200 N·m)
Table 13. Major Players of High Torque (>200 N·m)
Table 14. Global Humanoid Robot Torque Sensors Sales by Rated Torque Range Types (2021-2026) & (K Units)
Table 15. Global Humanoid Robot Torque Sensors Sales Market Share by Rated Torque Range Types (2021-2026)
Table 16. Global Humanoid Robot Torque Sensors Revenue by Rated Torque Range Types (2021-2026) & ($ million)
Table 17. Global Humanoid Robot Torque Sensors Revenue Market Share by Rated Torque Range Types (2021-2026)
Table 18. Global Humanoid Robot Torque Sensors Sale Price by Rated Torque Range Types (2021-2026) & (US$/Unit)
Table 19. Major Players of Standard Accuracy (>0.2% FS)
Table 20. Major Players of High Accuracy (0.05–0.2% FS)
Table 21. Major Players of Ultra-High Accuracy (<0.05% FS)
Table 22. Global Humanoid Robot Torque Sensors Sales by Measurement Accuracy Types (2021-2026) & (K Units)

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Table 23. Global Humanoid Robot Torque Sensors Sales Market Share by Measurement Accuracy Types (2021-2026)
Table 24. Global Humanoid Robot Torque Sensors Revenue by Measurement Accuracy Types (2021-2026) & ($ million)
Table 25. Global Humanoid Robot Torque Sensors Revenue Market Share by Measurement Accuracy Types (2021-2026)
Table 26. Global Humanoid Robot Torque Sensors Sale Price by Measurement Accuracy Types (2021-2026) & (US$/Unit)
Table 27. Global Humanoid Robot Torque Sensors Sale by Application (2021-2026) & (K Units)
Table 28. Global Humanoid Robot Torque Sensors Sale Market Share by Application (2021-2026)
Table 29. Global Humanoid Robot Torque Sensors Revenue by Application (2021-2026) & ($ million)
Table 30. Global Humanoid Robot Torque Sensors Revenue Market Share by Application (2021-2026)
Table 31. Global Humanoid Robot Torque Sensors Sale Price by Application (2021-2026) & (US$/Unit)
Table 32. Global Humanoid Robot Torque Sensors Sales by Company (2021-2026) & (K Units)
Table 33. Global Humanoid Robot Torque Sensors Sales Market Share by Company (2021-2026)
Table 34. Global Humanoid Robot Torque Sensors Revenue by Company (2021-2026) & ($ millions)
Table 35. Global Humanoid Robot Torque Sensors Revenue Market Share by Company (2021-2026)
Table 36. Global Humanoid Robot Torque Sensors Sale Price by Company (2021-2026) & (US$/Unit)
Table 37. Key Manufacturers Humanoid Robot Torque Sensors Producing Area Distribution and Sales Area
Table 38. Players Humanoid Robot Torque Sensors Products Offered
Table 39. Humanoid Robot Torque Sensors Concentration Ratio (CR3, CR5 and CR10) & (2024-2026)
Table 40. New Products and Potential Entrants
Table 41. Market M&A Activity & Strategy
Table 42. Global Humanoid Robot Torque Sensors Sales by Geographic Region (2021-2026) & (K Units)
Table 43. Global Humanoid Robot Torque Sensors Sales Market Share Geographic Region (2021-2026)

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Table 44. Global Humanoid Robot Torque Sensors Revenue by Geographic Region (2021-2026) & ($ millions)
Table 45. Global Humanoid Robot Torque Sensors Revenue Market Share by Geographic Region (2021-2026)
Table 46. Global Humanoid Robot Torque Sensors Sales by Country/Region (2021-2026) & (K Units)
Table 47. Global Humanoid Robot Torque Sensors Sales Market Share by Country/Region (2021-2026)
Table 48. Global Humanoid Robot Torque Sensors Revenue by Country/Region (2021-2026) & ($ millions)
Table 49. Global Humanoid Robot Torque Sensors Revenue Market Share by Country/Region (2021-2026)
Table 50. Americas Humanoid Robot Torque Sensors Sales by Country (2021-2026) & (K Units)
Table 51. Americas Humanoid Robot Torque Sensors Sales Market Share by Country (2021-2026)
Table 52. Americas Humanoid Robot Torque Sensors Revenue by Country (2021-2026) & ($ millions)
Table 53. Americas Humanoid Robot Torque Sensors Sales by Sensing Principle Types (2021-2026) & (K Units)
Table 54. Americas Humanoid Robot Torque Sensors Sales by Application (2021-2026) & (K Units)
Table 55. APAC Humanoid Robot Torque Sensors Sales by Region (2021-2026) & (K Units)
Table 56. APAC Humanoid Robot Torque Sensors Sales Market Share by Region (2021-2026)
Table 57. APAC Humanoid Robot Torque Sensors Revenue by Region (2021-2026) & ($ millions)
Table 58. APAC Humanoid Robot Torque Sensors Sales by Sensing Principle Types (2021-2026) & (K Units)
Table 59. APAC Humanoid Robot Torque Sensors Sales by Application (2021-2026) & (K Units)
Table 60. Europe Humanoid Robot Torque Sensors Sales by Country (2021-2026) & (K Units)
Table 61. Europe Humanoid Robot Torque Sensors Revenue by Country (2021-2026) & ($ millions)
Table 62. Europe Humanoid Robot Torque Sensors Sales by Sensing Principle Types (2021-2026) & (K Units)
Table 63. Europe Humanoid Robot Torque Sensors Sales by Application (2021-2026) &

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(K Units)
Table 64. Middle East & Africa Humanoid Robot Torque Sensors Sales by Country (2021-2026) & (K Units)
Table 65. Middle East & Africa Humanoid Robot Torque Sensors Revenue Market Share by Country (2021-2026)
Table 66. Middle East & Africa Humanoid Robot Torque Sensors Sales by Sensing Principle Types (2021-2026) & (K Units)
Table 67. Middle East & Africa Humanoid Robot Torque Sensors Sales by Application (2021-2026) & (K Units)
Table 68. Key Market Drivers & Growth Opportunities of Humanoid Robot Torque Sensors
Table 69. Key Market Challenges & Risks of Humanoid Robot Torque Sensors
Table 70. Key Industry Trends of Humanoid Robot Torque Sensors
Table 71. Humanoid Robot Torque Sensors Raw Material
Table 72. Key Suppliers of Raw Materials
Table 73. Humanoid Robot Torque Sensors Distributors List
Table 74. Humanoid Robot Torque Sensors Customer List
Table 75. Global Humanoid Robot Torque Sensors Sales Forecast by Region (2027-2032) & (K Units)
Table 76. Global Humanoid Robot Torque Sensors Revenue Forecast by Region (2027-2032) & ($ millions)
Table 77. Americas Humanoid Robot Torque Sensors Sales Forecast by Country (2027-2032) & (K Units)
Table 78. Americas Humanoid Robot Torque Sensors Annual Revenue Forecast by Country (2027-2032) & ($ millions)
Table 79. APAC Humanoid Robot Torque Sensors Sales Forecast by Region (2027-2032) & (K Units)
Table 80. APAC Humanoid Robot Torque Sensors Annual Revenue Forecast by Region (2027-2032) & ($ millions)
Table 81. Europe Humanoid Robot Torque Sensors Sales Forecast by Country (2027-2032) & (K Units)
Table 82. Europe Humanoid Robot Torque Sensors Revenue Forecast by Country (2027-2032) & ($ millions)
Table 83. Middle East & Africa Humanoid Robot Torque Sensors Sales Forecast by Country (2027-2032) & (K Units)
Table 84. Middle East & Africa Humanoid Robot Torque Sensors Revenue Forecast by Country (2027-2032) & ($ millions)
Table 85. Global Humanoid Robot Torque Sensors Sales Forecast by Sensing Principle Types (2027-2032) & (K Units)

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Table 86. Global Humanoid Robot Torque Sensors Revenue Forecast by Sensing Principle Types (2027-2032) & ($ millions)
Table 87. Global Humanoid Robot Torque Sensors Sales Forecast by Application (2027-2032) & (K Units)
Table 88. Global Humanoid Robot Torque Sensors Revenue Forecast by Application (2027-2032) & ($ millions)
Table 89. ATI Industrial Automation Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 90. ATI Industrial Automation Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 91. ATI Industrial Automation Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 92. ATI Industrial Automation Main Business
Table 93. ATI Industrial Automation Latest Developments
Table 94. Sensodrive GmbH Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 95. Sensodrive GmbH Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 96. Sensodrive GmbH Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 97. Sensodrive GmbH Main Business
Table 98. Sensodrive GmbH Latest Developments
Table 99. Sunrise Instruments Co., Ltd. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 100. Sunrise Instruments Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 101. Sunrise Instruments Co., Ltd. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 102. Sunrise Instruments Co., Ltd. Main Business
Table 103. Sunrise Instruments Co., Ltd. Latest Developments
Table 104. FUTEK Advanced Sensor Technology, Inc. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 105. FUTEK Advanced Sensor Technology, Inc. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 106. FUTEK Advanced Sensor Technology, Inc. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 107. FUTEK Advanced Sensor Technology, Inc. Main Business
Table 108. FUTEK Advanced Sensor Technology, Inc. Latest Developments

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Table 109. Keli Sensing Technology (Ningbo) Co.,Ltd. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 110. Keli Sensing Technology (Ningbo) Co.,Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 111. Keli Sensing Technology (Ningbo) Co.,Ltd. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 112. Keli Sensing Technology (Ningbo) Co.,Ltd. Main Business
Table 113. Keli Sensing Technology (Ningbo) Co.,Ltd. Latest Developments
Table 114. Bota Systems AG Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 115. Bota Systems AG Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 116. Bota Systems AG Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 117. Bota Systems AG Main Business
Table 118. Bota Systems AG Latest Developments
Table 119. Link-touch (Beijing) Technology Co., Ltd. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 120. Link-touch (Beijing) Technology Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 121. Link-touch (Beijing) Technology Co., Ltd. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 122. Link-touch (Beijing) Technology Co., Ltd. Main Business
Table 123. Link-touch (Beijing) Technology Co., Ltd. Latest Developments
Table 124. Changzhou Kunwei Sensing Technology Co.,Ltd. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 125. Changzhou Kunwei Sensing Technology Co.,Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 126. Changzhou Kunwei Sensing Technology Co.,Ltd. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 127. Changzhou Kunwei Sensing Technology Co.,Ltd. Main Business
Table 128. Changzhou Kunwei Sensing Technology Co.,Ltd. Latest Developments
Table 129. AIDIN ROBOTICS Inc. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 130. AIDIN ROBOTICS Inc. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 131. AIDIN ROBOTICS Inc. Humanoid Robot Torque Sensors Sales (K Units),

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Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 132. AIDIN ROBOTICS Inc. Main Business
Table 133. AIDIN ROBOTICS Inc. Latest Developments
Table 134. PaXini Technology (Shenzhen) Co., Ltd. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 135. PaXini Technology (Shenzhen) Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 136. PaXini Technology (Shenzhen) Co., Ltd. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 137. PaXini Technology (Shenzhen) Co., Ltd. Main Business
Table 138. PaXini Technology (Shenzhen) Co., Ltd. Latest Developments
Table 139. Shenzhen XJCSENSOR Technology Co.,Ltd. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 140. Shenzhen XJCSENSOR Technology Co.,Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 141. Shenzhen XJCSENSOR Technology Co.,Ltd. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 142. Shenzhen XJCSENSOR Technology Co.,Ltd. Main Business
Table 143. Shenzhen XJCSENSOR Technology Co.,Ltd. Latest Developments
Table 144. MinebeaMitsumi Inc. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 145. MinebeaMitsumi Inc. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 146. MinebeaMitsumi Inc. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 147. MinebeaMitsumi Inc. Main Business
Table 148. MinebeaMitsumi Inc. Latest Developments
Table 149. AL.Robot, Co., Ltd. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 150. AL.Robot, Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 151. AL.Robot, Co., Ltd. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 152. AL.Robot, Co., Ltd. Main Business
Table 153. AL.Robot, Co., Ltd. Latest Developments
Table 154. Nanjing Bio-inspired Intelligent Technology Co., Ltd. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 155. Nanjing Bio-inspired Intelligent Technology Co., Ltd. Humanoid Robot

+357 96 030922
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Torque Sensors Product Portfolios and Specifications
Table 156. Nanjing Bio-inspired Intelligent Technology Co., Ltd. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 157. Nanjing Bio-inspired Intelligent Technology Co., Ltd. Main Business
Table 158. Nanjing Bio-inspired Intelligent Technology Co., Ltd. Latest Developments
Table 159. Shenzhen Ligent Sensor Tech Co., Ltd. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 160. Shenzhen Ligent Sensor Tech Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 161. Shenzhen Ligent Sensor Tech Co., Ltd. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 162. Shenzhen Ligent Sensor Tech Co., Ltd. Main Business
Table 163. Shenzhen Ligent Sensor Tech Co., Ltd. Latest Developments
Table 164. I-PEX Inc. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 165. I-PEX Inc. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 166. I-PEX Inc. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 167. I-PEX Inc. Main Business
Table 168. I-PEX Inc. Latest Developments
Table 169. DACELL Co., Ltd. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 170. DACELL Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 171. DACELL Co., Ltd. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 172. DACELL Co., Ltd. Main Business
Table 173. DACELL Co., Ltd. Latest Developments
Table 174. ROBOTOUS Co., Ltd. Basic Information, Humanoid Robot Torque Sensors Manufacturing Base, Sales Area and Its Competitors
Table 175. ROBOTOUS Co., Ltd. Humanoid Robot Torque Sensors Product Portfolios and Specifications
Table 176. ROBOTOUS Co., Ltd. Humanoid Robot Torque Sensors Sales (K Units), Revenue ($ Million), Price (US$/Unit) and Gross Margin (2021-2026)
Table 177. ROBOTOUS Co., Ltd. Main Business
Table 178. ROBOTOUS Co., Ltd. Latest Developments

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List Of Figures

LIST OF FIGURES

Figure 1. Picture of Humanoid Robot Torque Sensors
Figure 2. Humanoid Robot Torque Sensors Report Years Considered
Figure 3. Research Objectives
Figure 4. Research Methodology
Figure 5. Research Process and Data Source
Figure 6. Global Humanoid Robot Torque Sensors Sales Growth Rate 2021-2032 (K Units)
Figure 7. Global Humanoid Robot Torque Sensors Revenue Growth Rate 2021-2032 ($ millions)
Figure 8. Humanoid Robot Torque Sensors Sales by Geographic Region (2021, 2025 & 2032) & ($ millions)
Figure 9. Humanoid Robot Torque Sensors Sales Market Share by Country/Region (2025)
Figure 10. Humanoid Robot Torque Sensors Sales Market Share by Country/Region (2021, 2025 & 2032)
Figure 11. Product Picture of Strain Gauge Torque Sensors
Figure 12. Product Picture of Capacitive Torque Sensors
Figure 13. Product Picture of Magnetic Torque Sensors
Figure 14. Global Humanoid Robot Torque Sensors Sales Market Share by Sensing Principle Types in 2026
Figure 15. Global Humanoid Robot Torque Sensors Revenue Market Share by Sensing Principle Types (2021-2026)
Figure 16. Product Picture of Low Torque (<50 N·m)
Figure 17. Product Picture of Medium Torque (50–200 N·m)
Figure 18. Product Picture of High Torque (>200 N·m)
Figure 19. Global Humanoid Robot Torque Sensors Sales Market Share by Rated Torque Range Types in 2026
Figure 20. Global Humanoid Robot Torque Sensors Revenue Market Share by Rated Torque Range Types (2021-2026)
Figure 21. Product Picture of Standard Accuracy (>0.2% FS)
Figure 22. Product Picture of High Accuracy (0.05–0.2% FS)
Figure 23. Product Picture of Ultra-High Accuracy (<0.05% FS)
Figure 24. Global Humanoid Robot Torque Sensors Sales Market Share by Measurement Accuracy Types in 2026
Figure 25. Global Humanoid Robot Torque Sensors Revenue Market Share by

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Measurement Accuracy Types (2021-2026)
Figure 26. Humanoid Robot Torque Sensors Consumed in Shoulder and Elbow Joints
Figure 27. Global Humanoid Robot Torque Sensors Market: Shoulder and Elbow Joints (2021-2026) & (K Units)
Figure 28. Humanoid Robot Torque Sensors Consumed in Wrist Joints
Figure 29. Global Humanoid Robot Torque Sensors Market: Wrist Joints (2021-2026) & (K Units)
Figure 30. Humanoid Robot Torque Sensors Consumed in Waist and Torso Joints
Figure 31. Global Humanoid Robot Torque Sensors Market: Waist and Torso Joints (2021-2026) & (K Units)
Figure 32. Humanoid Robot Torque Sensors Consumed in Hip and Knee Joints
Figure 33. Global Humanoid Robot Torque Sensors Market: Hip and Knee Joints (2021-2026) & (K Units)
Figure 34. Humanoid Robot Torque Sensors Consumed in Ankle and Other Joints
Figure 35. Global Humanoid Robot Torque Sensors Market: Ankle and Other Joints (2021-2026) & (K Units)
Figure 36. Global Humanoid Robot Torque Sensors Sale Market Share by Application (2025)
Figure 37. Global Humanoid Robot Torque Sensors Revenue Market Share by Application in 2025
Figure 38. Humanoid Robot Torque Sensors Sales by Company in 2025 (K Units)
Figure 39. Global Humanoid Robot Torque Sensors Sales Market Share by Company in 2025
Figure 40. Humanoid Robot Torque Sensors Revenue by Company in 2025 ($ millions)
Figure 41. Global Humanoid Robot Torque Sensors Revenue Market Share by Company in 2025
Figure 42. Global Humanoid Robot Torque Sensors Sales Market Share by Geographic Region (2021-2026)
Figure 43. Global Humanoid Robot Torque Sensors Revenue Market Share by Geographic Region in 2025
Figure 44. Americas Humanoid Robot Torque Sensors Sales 2021-2026 (K Units)
Figure 45. Americas Humanoid Robot Torque Sensors Revenue 2021-2026 ($ millions)
Figure 46. APAC Humanoid Robot Torque Sensors Sales 2021-2026 (K Units)
Figure 47. APAC Humanoid Robot Torque Sensors Revenue 2021-2026 ($ millions)
Figure 48. Europe Humanoid Robot Torque Sensors Sales 2021-2026 (K Units)
Figure 49. Europe Humanoid Robot Torque Sensors Revenue 2021-2026 ($ millions)
Figure 50. Middle East & Africa Humanoid Robot Torque Sensors Sales 2021-2026 (K Units)
Figure 51. Middle East & Africa Humanoid Robot Torque Sensors Revenue 2021-2026

+357 96 030922
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($ millions)
Figure 52. Americas Humanoid Robot Torque Sensors Sales Market Share by Country in 2025
Figure 53. Americas Humanoid Robot Torque Sensors Revenue Market Share by Country (2021-2026)
Figure 54. Americas Humanoid Robot Torque Sensors Sales Market Share by Sensing Principle Types (2021-2026)
Figure 55. Americas Humanoid Robot Torque Sensors Sales Market Share by Application (2021-2026)
Figure 56. United States Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 57. Canada Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 58. Mexico Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 59. Brazil Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 60. APAC Humanoid Robot Torque Sensors Sales Market Share by Region in 2025
Figure 61. APAC Humanoid Robot Torque Sensors Revenue Market Share by Region (2021-2026)
Figure 62. APAC Humanoid Robot Torque Sensors Sales Market Share by Sensing Principle Types (2021-2026)
Figure 63. APAC Humanoid Robot Torque Sensors Sales Market Share by Application (2021-2026)
Figure 64. China Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 65. Japan Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 66. South Korea Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 67. Southeast Asia Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 68. India Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 69. Australia Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 70. China Taiwan Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)

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Figure 71. Europe Humanoid Robot Torque Sensors Sales Market Share by Country in 2025
Figure 72. Europe Humanoid Robot Torque Sensors Revenue Market Share by Country (2021-2026)
Figure 73. Europe Humanoid Robot Torque Sensors Sales Market Share by Sensing Principle Types (2021-2026)
Figure 74. Europe Humanoid Robot Torque Sensors Sales Market Share by Application (2021-2026)
Figure 75. Germany Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 76. France Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 77. UK Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 78. Italy Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 79. Russia Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 80. Middle East & Africa Humanoid Robot Torque Sensors Sales Market Share by Country (2021-2026)
Figure 81. Middle East & Africa Humanoid Robot Torque Sensors Sales Market Share by Sensing Principle Types (2021-2026)
Figure 82. Middle East & Africa Humanoid Robot Torque Sensors Sales Market Share by Application (2021-2026)
Figure 83. Egypt Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 84. South Africa Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 85. Israel Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 86. Turkey Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 87. GCC Countries Humanoid Robot Torque Sensors Revenue Growth 2021-2026 ($ millions)
Figure 88. Manufacturing Cost Structure Analysis of Humanoid Robot Torque Sensors in 2026
Figure 89. Manufacturing Process Analysis of Humanoid Robot Torque Sensors
Figure 90. Industry Chain Structure of Humanoid Robot Torque Sensors
Figure 91. Channels of Distribution

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Figure 92. Global Humanoid Robot Torque Sensors Sales Market Forecast by Region (2027-2032)
Figure 93. Global Humanoid Robot Torque Sensors Revenue Market Share Forecast by Region (2027-2032)
Figure 94. Global Humanoid Robot Torque Sensors Sales Market Share Forecast by Sensing Principle Types (2027-2032)
Figure 95. Global Humanoid Robot Torque Sensors Revenue Market Share Forecast by Sensing Principle Types (2027-2032)
Figure 96. Global Humanoid Robot Torque Sensors Sales Market Share Forecast by Application (2027-2032)
Figure 97. Global Humanoid Robot Torque Sensors Revenue Market Share Forecast by Application (2027-2032)

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