Patent: Method for Optimizing Robot Joint Performance in Sub-Zero Conditions

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Assignee: Polar Dynamics Robotics, Inc.

Inventors: Chen, Marcus; Barrett, James; Frost, Elena

Abstract

A system and method for optimizing robotic joint performance in sub-zero environmental conditions through adaptive thermal management and smart lubrication control. The invention comprises a novel joint architecture incorporating temperature-responsive actuators, specialized low-temperature lubricants, and an intelligent control system that dynamically adjusts joint parameters based on environmental conditions and operational demands.

Background

Field of Invention

[0001] The present invention relates to robotic joint systems operating in cold environments, specifically addressing the challenges of maintaining optimal joint performance in temperatures below 0 C (32 F).

Prior Art Discussion

[0002] Conventional robotic joints experience significant performance degradation in sub-zero conditions due to increased mechanical resistance, lubricant viscosity changes, and material thermal contraction. Existing solutions fail to adequately address these challenges in autonomous mobile robots operating in industrial freezer environments.

Detailed Description

System Components

[0010] The invention comprises:

(a) A thermally-regulated joint housing incorporating:

- Composite materials with controlled thermal expansion properties
- Integrated heating elements positioned at critical friction points
- Temperature sensors distributed throughout the joint assembly

[0011] (b) Smart lubrication system featuring:

- Dual-chamber lubricant reservoir with temperature-specific formulations
- Microprocessor-controlled lubricant distribution
- Pressure-compensated delivery channels

Control Architecture

[0020] The joint optimization system employs:

(a) Real-time temperature monitoring across multiple zones

(b) Predictive thermal management algorithms

(c) Adaptive motion control parameters

(d) Dynamic torque compensation based on environmental conditions

Claims

A method for optimizing robotic joint performance in sub-zero conditions comprising:

(a) Monitoring joint temperature through distributed sensor array

(b) Activating localized heating elements based on temperature thresholds

(c) Adjusting lubricant flow rates according to operational parameters

(d) Modifying joint motion profiles based on thermal conditions

The method of claim 1, wherein the lubricant flow rate is controlled by:

(a) Measuring ambient temperature

(b) Calculating optimal viscosity requirements

(c) Selecting appropriate lubricant formulation

(d) Adjusting delivery pressure and volume

A system for implementing the method of claim 1, comprising:

(a) Thermal management controller

(b) Smart lubrication distribution network

(c) Motion profile optimizer

(d) Environmental condition sensors

Technical Specifications

Operating Parameters

[0030] The system is designed to maintain optimal joint performance in:

- Temperature range: -40 C to +50 C
- Humidity: 0-100% RH
- Operational cycle time: Up to 24 hours continuous
- Load capacity: Up to 500kg per joint

Performance Metrics

[0040] The system achieves:

- 95% efficiency retention in sub-zero conditions
- <2% variation in positional accuracy across temperature range
- 30% reduction in power consumption versus conventional systems
- Mean time between maintenance: 2,000 hours

Industrial Applications

[0050] The invention is particularly suited for:

- Cold storage warehouses
- Pharmaceutical manufacturing facilities
- Food processing plants
- Arctic research operations
- Cryogenic handling systems

Drawings

[0060] Figure 1: Joint cross-section showing thermal management components

[0070] Figure 2: Lubrication system schematic

[0080] Figure 3: Control system architecture

[0090] Figure 4: Performance data graphs

Certification

I hereby certify that I am the inventor of the subject matter which is described and claimed above.

/s/ Marcus Chen

Marcus Chen, CTO

Polar Dynamics Robotics, Inc.

Date: January 11, 2024

/s/ Dr. James Barrett

Dr. James Barrett, Chief Robotics Officer

Polar Dynamics Robotics, Inc.

Date: January 11, 2024

/s/ Dr. Elena Frost

Dr. Elena Frost, CEO

Polar Dynamics Robotics, Inc.

Date: January 11, 2024

Patent Attorney Verification

Prepared and submitted by:

Sarah Johnson, Reg. No. 65,432

Johnson & Associates LLP

Patent Attorneys

Boston, MA 02110