PriMera Scientific Engineering
Volume 7 Issue 3 September 2025
ISSN: 2834-2550

PriMera Scientific Publications

Utilizing Biomimicry in Dynamic Positioning Systems for Drill-ship

Type: Short Communication
Received: May 18,2025
Published: September 03, 2025

Citation:
Prashob PS. "Utilizing Biomimicry in Dynamic Positioning Systems for Drill-ship". PriMera Scientific Engineering 7.3 (2025): 34-36.

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Keywords: Biomimicry; Dynamic Positioning System; Drillship

Introduction

In the recent decades, offshore oil and gas exploration is exploring deeper waters and more challenging environments. Drill-ship, fitted with sophisticated Dynamic Positioning Systems (DPS), helps in maintaining positional accuracy during drilling in deep waters. Many modifications were done in the conventional DPS which rely on GPS data, thrusters, gyroscopes, and wind sensors. Some of the drawbacks includes high energy consumption and complex failures due to its technical usage to rapid environmental changes, requiring a better configuration.

Biomimicry, helps in the design and production of systems, and structures using nature inspiration. This technique offers a promising idea for enhancing DPS capabilities. Marine/land organisms which inspires remarkable positioning and maneuvering strategies which are energy-efficient, adaptive, and robust. By focusing these nature inspired design, engineers can create solutions for many problems where DPS can be redesigned to respond intelligently to environmental disturbances.

Inspirations from Nature for DPS Enhancement

Fish Schooling and Swarm Intelligence

Adapting the movement of fish in sea is a typical example of decentralized control with lateral line sensing. Incorporating this behavior to DPS design can lead to swarm-intelligent thruster like natural phenomenon of how birds interact locally, where each thruster helps in the local flow conditions seamlessly achieving global station-keeping.

Cephalopod Jet Propulsion

Cephalopod or scientifically known as cephalopoda, such as squids and octopuses, which are characterized by bilateral symmetric body helps in the multi-directional propulsion. Their highly flexible limbs helps to achieve omnidirectional movement which inspires omnidirectional thruster control. This helps in the idea of soft actuators or variable-pitch propellers which can respond to the flow patterns around the drill-ship.

Bird Flight and Environmental Sensing

Birds can adjust their wing shape in different angles and orientation in response to the flow of wind, using the natural sensory input from their feathers. In DPS, this technique can be implemented to high-fidelity environmental sensors that can detect minor variations or changes in the environment conditions such as wave, wind or current, enabling adjustments in the sensors.

Jellyfish Locomotion and Energy Efficiency

Jellyfish exhibit an excellent locomotion of propulsion by pulsating their bell structures, where they contract the muscles in the bell to expel water and then propel themselves up. This technique can be used in the thruster management of DPS which regulates thrust in pulses to conserve energy, mainly in steady-state position.

Bioinspired Design Strategies

Swarm-Based Control Algorithms

The idea inspired by natural swarms like beekeeping, uses decentralized control architectures for the DPS which can help decision-making across multiple actuators. Each thruster behaves like a bee in their natural group, makes local adjustments based on real-time sensor inputs available which helps in stable positioning.

Bio-Inspired Sensor Arrays

The lateral line system in fish, where sensor arrays are embedded along the hull to detect wave celerity, turbulence, and pressure differences. This helps in the hydrodynamic situational awareness, by improving its response time and thereby accuracy.

Adaptive Learning and Feedback Systems

Similiar to the maintaining of internal conditions in a human body (homeostasis), adaptive algorithms can be used to allow DPS to maintain stability in various environmental loads. These systems can learn from previous station-keeping events encountered in the past and adjust its control responses accordingly.

Conventional versus Biomimetic DPS

Feature	*Conventional DPS*	*Biomimetic DPS*
Control Logic	Centralized PID	Decentralized Swarm
Energy Efficiency	Moderate to Low	High
Environmental Response	Reactive	Predictive & Adaptive
Fault Tolerance	Redundant Systems	Self-regulating Network
Sensor Coverage	Standard GPS, gyro	Bio-inspired distributed sensors

Table 1: Comparison - Features of Conventional and Biomimetic DPS.

Challenges and Implementation Considerations

Some of the challenges include:

- Understanding these bio-inspired algorithms and its complexity and applying in real-time systems.
- Integration with the existing marine control systems like SCADA .
- Monitoring of sensor arrays in harsh ocean environments.
- To satisfy the regulatory and classification societies rules for conventional control methodologies.

To overcome these, collaboration across multi disciplines are essential. Additionally, real-time simulation environments, digital twin platforms can accelerate the design and testing of such systems before implementing.

Conclusion and Future Work

Biomimicry represents a transformative approach to enhancing Dynamic Positioning Systems on drillships. By mimicking from nature such as movement of jelly fish, adaptation, bioinspired DPS can potentially achieve greater efficiency. There are plenty of future research areas one should focus on in the development of DPS, and its experimental validation through models and field trials.