ALGORITHMIC AND INFORMATION PROVISION OF AUTONOMOUS UNDERWATER VEHICLE WITH RADIO BUOYS

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I. Purpose and scope of AUV with radio buoys.

Autonomous Underwater Vehicles (AUVs) equipped with radio buoys are advanced marine systems designed for a wide range of underwater missions. The primary purpose of such systems is to enable autonomous data collection, transmission, and real-time communication in underwater environments. The radio buoy serves as a critical interface between the AUV and surface or remote operators, facilitating data relay and operational control.

Main areas of applications:

– Oceanographic research: Collecting data on temperature, salinity, currents and marine life;

– Environmental monitoring: Detecting pollutants, tracking oil spills, and monitoring underwater ecosystems;

– Military and defense: Surveillance, reconnaissance, and mine detection and their destruction;

– Humanitarian demining of contaminated areas.

– Industrial applications: Inspecting underwater infrastructure, such as pipelines, cables and sub-sea installations;

– Shipping and commercials applications: Vessels underwater inspections in anchorage, vessel pre-arrival inspection by authority before entering in ports.

– Search and rescue: Locating submerged objects or assisting in underwater recovery operations.

– Performing instrumental and manipulative underwater technical works.

The integration of a radio beacon expands the operational capabilities of the AUV, providing real-time data transmission and remote control even in remote underwater environments.

II. General technical and operational characteristics of AUV with radio buoy AUV Specifications:

– Dimensions: Typically, 2-5 meters in length, depending on the mission profile.

– Weight: 100-500 kg, with buoyancy adjusted for underwater operations.

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– Depth rating: 50-100 meters, depending on design and materials.
– Propulsion: Electric thrusters or propellers, powered by rechargeable batteries or fuel cells.
– Endurance: 12-48 hours of continuous operation, depending on power consumption and mission requirements.
– Sensors: Sonar, cameras, depth sensors, temperatures sensors, and chemical detectors.
– Velocity 0,5 – 2,5m/s.
– Navigation: Inertial navigation systems (INS), Doppler Velocity LOG (DVL), and GPS (when surfaced).

Radio buoy Specifications:

Communication range: Up to 100 km (depending on environmental conditions)

Data transmission: GNSS and acoustic system, satellite communication for real-time data relay.

Power supply: Battery-powered with solar charging capabilities.

Deployment: Detachable or tethered to the AUV, depending on mission.

III. Operating modes of AUV radio buoy

The AUV with radio buoy operates in several modes to adapt to mission requirements:

Autonomous mode:
– The AUV operates independently, following pre-programmed missions.
– Data is stored onboard and transmitted to the buoy when within range

Remote control mode:
– Operators can control the AUV in real-time via the radio buoy.
– Used for precise maneuvers or mission adjustments.

Data relay mode:
– The AUV collects data and transmits it to the buoy, which relays it to a surface station or satellite.
– Enables real-time monitoring and analysis.

Emergency mode:
– In case of system failure or low power, the AUV surfaces and activates the buoy for recovery.

Hybrid mode:
– Combines autonomous and remote-control features for flexible mission execution.

IV.Characteristics of AUV with Radio buoy as an Object of Automation

The AUV with radio buoy is a complex automated system with the following characteristics:

Automation Features:

– Mission Planning: Pre-programmed routes and tasks using specialized software.

– Obstacle Avoidance: AI-based algorithms for detecting and avoiding obstacles.

– Adaptive Control: Real-time adjustments to navigation and sensor operations based on environmental conditions.

– Fault Tolerance: Redundant systems and fail-safe mechanisms to ensure operational continuity.

Control hierarchy:

– High-Level Control: Mission planning and decision-making by operators.

– Mid-Level Control: Autonomous navigation and task execution by the AUV.

– Low-Level Control: Actuator and sensor management by onboard systems.

Integration with External Systems:

The AUV and buoy system can interface with satellite networks, surface vessels, and ground stations for seamless data exchange and coordination.

V. Characteristics of AUV with Radio buoy Information Flows

The information flows in an AUV with radio buoy system are critical for ensuring efficient data collection, transmission, and processing.

Main information flows:

AUV to buoy

– Sensor data (sonar, temperature, pressure).

– Navigation data (position, depth, speed).

– System status (battery level, operational health).

Buoy to surface station

– Real-time data relay via RF or satellite.

– Emergency signals and status updates.

Surface Station to AUV

– Mission updates and control commands.

– Software updates and configuration changes.

Data Processing:

– Onboard Processing: Data is pre-processed by the AUV to reduce transmission load.

– Remote Processing: Data is analyzed at surface stations or cloud-based platforms for advanced insights.

Challenges:

– Bandwidth Limitations: Underwater communication is often constrained by bandwidth.

– Latency: Real-time control may be affected by communication delays.

– Data Security: Ensuring secure transmission to prevent interception or tampering.

VI.Conclusion

The integration of a radio buoy with an AUV significantly enhances its operational capabilities, enabling real-time data transmission, remote control, and extended mission profiles. The algorithmic and information support systems are critical for ensuring efficient and reliable operation in diverse underwater environments. Future advancements in communication technologies, AI, and automation will further expand the potential applications of AUVs with radio buoy s, making them indispensable tools for marine research, industry, and defense.

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