United States Patent Application Publication	20250256820
Kind Code	A1
Publication Date	August 14, 2025
Inventor(s)	Loccisano; Vincent

Autonomous Supercavitation Underwater Drone

Abstract

The present invention is a supercavitation underwater drone equipped with high-speed sensors configured for data acquisition and surveillance. A propulsion system generates gasses that are then used to generate a vapor bubble at the nose of the vehicle. An array of nozzles aids in directional control of the vehicle by altering the pressure profile of the vapor bubble. In some embodiments the vehicle operates autonomously. In other embodiments the vehicle operates semi-autonomously following a preplanned route and communicating with a base. In other embodiments the vehicle is controlled remotely by an operator.

Inventors: **Loccisano; Vincent (Wellesley, MA)**

Applicant: **Loccisano; Vincent** (Wellesley, MA)

Family ID: **96661590**

Appl. No.: **19/191677**

Filed: **April 28, 2025**

Publication Classification

Int. Cl.: **B63G8/00** (20060101); **B63G8/38** (20060101); **B63G8/39** (20060101); **B63G9/00** (20060101)

U.S. Cl.:

CPC **B63G8/001** (20130101); **B63G8/38** (20130101); **B63G8/39** (20130101); B63G2009/005 (20130101)

Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates generally to aquatic vehicles and more specifically to underwater vehicles employing supercavitation. Vehicles are designed for surveillance and data acquisition.

BACKGROUND OF THE INVENTION

[0002] Accurate and continuous monitoring of various physical and chemical parameters in diverse environments is increasingly critical for public safety. This necessity arises from a growing awareness of environmental degradation, the importance of water quality for human and ecological health, the optimization of industrial processes, and the advancement of scientific research.

[0003] Traditional methods for measuring these parameters often involve manual sampling and laboratory analysis, which are time-consuming, labor-intensive, and provide only discrete snapshots of environmental conditions. These methods can be inadequate for capturing dynamic changes and identifying transient pollution events.

[0004] The need for efficient and discreet underwater surveillance has grown significantly in both military and civilian applications. Traditional underwater vehicles, such as remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), face inherent limitations in speed and range due to the high drag forces encountered in water. These limitations restrict their ability to rapidly cover large areas or respond quickly to emerging threats.

[0005] Supercavitation, which creates a vapor bubble around a submerged object, offers a potential solution for overcoming underwater limitations. By significantly reducing drag, supercavitating vehicles can achieve speeds several times greater than conventional underwater vehicles. This technology has primarily been explored for high-speed torpedoes and projectiles, demonstrating its potential for rapid underwater movement.

[0006] The application of supercavitation to surveillance drones presents unique challenges. Existing supercavitating vehicles often prioritize speed and maneuverability at the expense of stability and sensor integration. Maintaining stable flight and accurate sensor readings in a dynamic supercavity environment is a complex engineering problem. Furthermore, the high-speeds associated with supercavitation make data acquisition and processing difficult, requiring advanced sensor technologies and real-time data-analysis capabilities.

[0007] An open-thermal propulsion system fueled by a monopropellant is a relatively simple method of generating thrust. A monopropellant is a single chemical compound that decomposes exothermically when triggered. Example monopropellants include hydrazine, hydrogen peroxide and hydroxylammonium nitrate-based liquids. Hot gasses produced by the monopropellant's decomposition are directly expelled into the surrounding environment, creating thrust.

[0008] Acoustic mapping is a process that uses sound or pressure waves to gather information about an environment, creating a visual representation of the environment. Acoustic mapping relies on the principles of sound-wave propagation, reflection and absorption. Information about an environment's properties may be obtained by analyzing waves' interaction with the environment. Acoustic sensors like microphones and sonar receptors acquire sound data, and that data is processed by an application to extract sound intensity, frequency and reflection time. The processed data is then used to create maps or other visual representations of an environment.

[0009] Temperature mapping may be accomplished at a high speed from a distance using infrared (IR) sensors. Turbidity may be measured using nephelometers that measure the amount of light scattered by suspended particles in a liquid, or turbidimeters which measure the reduction of light intensity as it passes through a liquid sample.

[0010] Chemical mapping may be accomplished by a range of sensors configured to measure chemical content, dissolved oxygen, nutrient content and contaminant content. PH is measured with electrochemical ph electrodes. These are typically a glass electrode sensitive to hydrogen ions and a reference electrode. The potential difference between these electrodes is proportional to the

PH of the solution. Combination electrodes integrate both sensing and reference elements into one body.

[0011] Dissolved oxygen sensors include electrochemical sensors referred to as Clark Cell or Galvanic Cell sensors, and optical sensors also referred to as luminescent or fluorescent sensors. Clark Cell or Galvanic Cell sensors use a membrane-covered electrode immersed in an electrolyte solution. Oxygen diffuses through the membrane and is reduced at the cathode, generating a current proportional to the dissolved oxygen concentration. Luminescent or fluorescent sensors use a luminescent or fluorescent dye immobilized on a membrane. The fluorescence of the dye is quenched by the presence of oxygen. By measuring the intensity or lifetime of the fluorescence the dissolved oxygen concentration can be determined.

[0012] Nutrient sensors commonly measure nitrogen and phosphorus. Current approaches often involve ion-selective electrodes measure specific forms of nitrogen and phosphate. These electrodes develop a potential in response to the concentration of the specific ion in the solution. Optical sensors combined with chemical reagents are another means of measuring nutrient content. Some optical sensors use colorimetric or fluorometric reactions. A reagent is introduced to the sample that reacts with the nutrient of interest, producing a colored or fluorescent compound whose intensity is proportional to the nutrient concentration. Spectrophotometric sensors measure the absorbance of light at specific wavelengths by the sample. Some nutrients or their reaction products absorb light in the UV or visible range allowing for concentration determination. Electrochemical methods include voltammetry and amperometry. These techniques can be adapted to measure certain nutrients by exploiting their electrochemical properties at specific electrodes and potentials.

[0013] Detecting metal contamination such as lead or mercury is accomplished with electrochemical sensors, ion-selective electrodes, optical sensors with chelating agents or atomic absorption spectroscopy and inductively coupled plasma mass spectrometry. Electrochemical sensors include voltammetry and stripping voltammetry. These are highly sensitive techniques where metals are deposited onto an electrode at a specific potential and then stripped off by scanning the potential. The current generated during stripping is proportional to the metal concentration. Ion-selective electrodes are designed to be selective for specific metal ions like lead or mercury. They develop a potential proportional to the ion concentration. However, selectivity and sensitivity can be limitations. Optical sensors with chelating agents are similar to nutrient sensors, some optical sensors use chelating agents that specifically bind to the target metal ion, causing a change in the optical properties (absorbance, fluorescence) of the reagent or the metal-ligand complex. Atomic absorption spectroscopy and inductively coupled plasma mass spectrometry while commonly lab-based, miniaturized versions are emerging for field deployment. These techniques offer high sensitivity and selectivity by atomizing the sample and measuring the absorption or mass-to-charge ratio of the metal ions. Submersible gamma spectrometers may be deployed on autonomous underwater vehicles to measure gamma radiation directly in the water column or on the seabed.

[0014] A supercavitating surveillance drone can address the above limitations. Such a device would maintain stable flight and accurate sensor readings within a supercavity environment; integrate advanced sensor suites for comprehensive surveillance capabilities; and operate covertly with minimal noise and heat signatures. The selection of the appropriate sensor for each measurement depends on factors such as the required accuracy, sensitivity, measurement range, environmental conditions, potential interferences, and the need for in-situ or laboratory analysis. Integrating multiple sensors with different operating principles into a single apparatus presents significant design and engineering challenges to ensure accurate, reliable, and simultaneous measurements.

SUMMARY OF THE INVENTION

[0015] The present invention is a supercavitation underwater drone equipped with high-speed sensors configured for data acquisition and surveillance. Data acquisition may include acoustic mapping as well as physical measurements such as temp or turbidity or chemical measurements like Ph, dissolved oxygen, nutrient mapping, measuring nitrogen or phosphorus and the like, or metal contamination mapping, measuring metals such as lead, mercury.

[0016] A propulsion system generates gasses that are then used to generate a vapor bubble at the nose of the vehicle. An array of nozzles surrounding a nose of the vehicle aids in directional control of the vehicle by altering the pressure profile of the vapor bubble. In some embodiments the vehicle operates autonomously. In other embodiments the vehicle operates semi-autonomously, following a preplanned route and communicating with a base. In other embodiments the vehicle is controlled remotely by an operator.

[0017] In one embodiment, the vehicle has an open-thermal propulsion system fueled by a monopropellant. The monopropellant decomposes exothermically when triggered by a spark or catalyst and creates high-pressure gas that provides thrust to power the vehicle. A nose cone has a central nozzle that is configured to generate a vapor bubble that surrounds the vehicle, preventing contact between the vehicle skin and the surrounding water, thus providing supercavitation. A control valve diverts some of the high-pressure gas to the central nozzle in the nose cone and feeds the vapor bubble. In some embodiments an array of control nozzles surrounds the central nozzle. Control nozzles are controlled individually or in groups to provide thrust at the nose of the vehicle to control the pitch, yaw and roll of the vehicle. In these embodiments, gas from the open-thermal propulsion system is stored in a storage tank for controlled delivery to the central nozzle and the array of control nozzles.

[0018] An iteration of the embodiment includes an electric propulsion system that includes an electric power source which powers an electric motor. The electric motor drives a propeller and powers a compressor that provides compressed gas to a storage tank. A control valve controls the flow of compressed gas to the central nozzle and the array of control nozzles for production of a vapor bubble and control of the pitch, yaw and roll of the vehicle. In other embodiments, fins mounted near the rear of the vehicle extend beyond the vapor bubble for additional control of the vehicle's pitch, yaw and roll.

[0019] A computer application works with sensors to gather information in the aquatic environment for environmental mapping. Sensors may include cameras, infrared sensors, sonar equipment, and proximity sensors to map topography. Temperature sensors include infrared sensors. Turbidity sensors include nephelometers and turbidimeters. pH sensors include electrochemical pH electrodes. Dissolved oxygen sensors include electrochemical clark cell or galvanic cell sensors or optical luminescent/fluorescent sensors. Nutrient sensors include ion-selective electrodes, optical sensors with chemical reagents, spectrophotometric UV sensors or electrochemical methods such as voltammetry and amperometry. Metal contamination sensors include electrochemical sensors, Ion-selective electrodes, optical sensors with chelating agents or atomic absorption spectroscopy and inductively coupled plasma mass spectrometry. Radiation sensors may include submersible gamma spectrometers.

[0020] In an example application, a pressure wave generated by the vapor bubble is reflected off objects in the environment and received by sonar equipment, then processed by the application for acoustic mapping.

[0021] In another example application, sensors for measuring temperature, turbidity, pH, dissolved oxygen, nutrient content and contamination due to metals, radioactivity or the like are deployed for high-speed data collection. Initial high-speed passage over an area may employ sensors that function at high-speed while collecting samples over the same area at a high speed. Multiple passes may track preliminary data, evolving trends or may track a large deviation that was the result of a rapid occurrence. A set of collection methods deployed separately, in sequence or in tandem by multiple vehicles include preliminary data collection, trend data collection and emergency response data collection to rapidly map the results of new events, trends such as global warming and transient environmental concerns such as an oil spill, chemical spill or radioactive leak.

[0022] In an example application, several vehicles are joined by communication hardware and software and are employed as part of a broad mesh network where multiple drones are deployed simultaneously to collect data over a large area. The data is received by one or more central processors in one or more drones for processing. This technology is particularly useful for active seafloor mapping as is commonly used in mineral, oil or gas exploration, for collecting data in the event of a transient environmental event, or to study changes in salinity, turbidity, pH levels, dissolved oxygen, nutrient content, or contamination due to metals or radioactivity.

[0023] In yet another example application, the pressure wave may be used to cloak other vehicles, such as boats or submarines, by creating a noise signature that can overwhelm traditional sonar sensor equipment.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0024] FIG. **1** shows an embodiment **100** depicting a vapor bubble.

[0025] FIG. **2** shows a cross-section of the embodiment of FIG. **1**.

[0026] FIG. **3** shows a separate embodiment **200**.

[0027] FIG. **4** illustrates a method of operating an example embodiment.

DETAILED DESCRIPTION

[0028] FIG. **1** shows an example embodiment **100** surrounded by a vapor bubble **120**. FIG. **2** is a cross-section of the embodiment **100**. The main body **110** supports a gas nozzle **112** configured for generating a vapor bubble **120** that is configured to extend past the aft end of the vehicle and to prevent contact between the vehicle's skin and the surrounding water. An array of gas jets **118** are activated individually to control the pitch and yaw of the vehicle. Fins **114** extend beyond the vapor bubble **120** to more precisely control the pitch and yaw of the vehicle. A propulsion system powers the vehicle and is made up of a monopropellant storage tank **128** that is in fluid communication with a decomposition chamber **130** where the monopropellant is fed into the chamber where it is initiated by a spark or catalyst to undergo rapid decomposition to produce thrust through the nozzle **116**. A portion of the gas from the decomposition chamber is transferred to high-pressure gas storage tanks **122** that are fed through the forward nozzle **112** to create the vapor bubble **120**.

[0029] A control system is housed in a main housing **124**. The control system regulates the feed rate of the monopropellant and catalyst/spark while controlling the distribution of high-pressure gas to control thrust as well as the vapor bubble and thrust through gas jets **118**.

[0030] The main housing also houses computer equipment to gather data from an array of sensors **126**. Some sensors may include motion sensors, cameras, infrared sensors, microphones and sonar receivers, for surveillance, mapping, and data acquisition. Other sensors for measuring temperature, turbidity, pH, dissolved oxygen, nutrient content and contamination due to metals, radioactivity or the like may also be included.

[0031] Another embodiment **200** is illustrated in FIG. **3**. A main body **210** supports a gas nozzle **212** configured to generate a vapor bubble **220** that is designed to extend past the aft end of the vehicle and to prevent contact between the vehicle's skin and the surrounding water. An array of gas jets **218** are activated individually to control the pitch and yaw of the vehicle. Fins **214** extend beyond the vapor bubble **220** to more precisely control the pitch and yaw of the vehicle. A propulsion system powers the vehicle and is made up of an electric motor **232** that drives a propeller **234** and further drives a compressor **236**. Compressed air from the compressor is stored in high-pressure gas storage tanks **222** that feed high-pressure gas through the forward nozzle **212** to create the vapor bubble **220**.

[0032] A control system and an energy storage are housed in a main housing **224**. The control system regulates the feed rate of the high-pressure gas to control the vapor bubble and thrust through gas jets **218**. The control system further manages the fuel levels, distance traveled and distance to return to a launch point or retrieval point, or to simply float and engage a beacon for retrieval or to begin transmitting gathered data.

[0033] To generate data for processing and mapping, microphones or sonar equipment in an example embodiment receive pressure waves reflecting off solid objects as they are generated by the vehicle as it travels underwater. A network of vehicles may be used to capture extensive datasets for comprehensive mapping and data collection over large areas.

[0034] FIG. **4** is a diagram of a method of operating the vehicle. The method begins by conducting preliminary data **110**. When preliminary data results in recognizing critical data **116**, the application evaluates the critical data and when the critical data signifies a significant change, the application begins conducting trend data collection **112**. When trend data collection results in recognizing additional critical data **116**, the method continues by deploying a network of vehicles **118**. When recognizing critical data **116** signifies a disaster, the method continues by conducting emergency response data collection **114**. When the disaster is significant the application responds by deploying a network of vehicles **118**. In some embodiments the method commences by Conducting emergency response data collection **114** is immediately followed by deploying a network of vehicles.

Claims

1. A supercavitation vehicle comprising: an open-thermal propulsion system fueled by a monopropellant; and a nose cone having a central nozzle configured to generate a vapor bubble around the vehicle; and a control valve configured to divert a portion of propellant to the central nozzle to form the vapor bubble; and an array of sensors configured to gather environmental data; and a computer storing an application configured to receive and process said environmental data; wherein data is rapidly gathered from an aquatic environment.

2. The supercavitation vehicle of claim 1 further comprising: a gas storage tank in fluid communication with the open-thermal propulsion system for storing high-pressure gas; and the gas storage tank further in fluid communication with the central nozzle; wherein high-pressure gas is diverted from the open-propulsion system fueled by a monopropellant to the gas storage tank for controlled distribution to the central nozzle for controlling the vapor bubble.

3. The supercavitation vehicle of claim 2 further comprising: an array of control nozzles radially disposed about the nose cone and configured to inject high-pressure gas from the gas storage tank to control pitch, yaw and roll of the vehicle.

4. The supercavitation vehicle of claim 1 wherein: the vapor bubble is configured to create a noise signature that overwhelms traditional sonar equipment; wherein nearby aquatic vehicles are cloaked to the traditional sonar equipment.

5. The supercavitation vehicle of claim 1 further comprising at least one sensor selected from the group consisting of: camera, infrared receiver, sonic receiver, temperature sensor, turbidity sensor, pH sensor, dissolved oxygen sensor, nutrient sensor, metal contamination sensor, submersible gamma spectrometer.

6. The supercavitation vehicle of claim 1 wherein: the array of sensors includes at least one sonic receiver; wherein a pressure wave generated by said vapor bubble is reflected off the aquatic environment and received by the sonic receiver, and wherein acoustic mapping of the aquatic environment is produced.

7. A supercavitation vehicle comprising: an electric-propulsion system having an electric power source driving an electric motor; and said motor rotationally engaged with a propeller configured do power the vehicle; and said motor rotationally engaged with a compressor; and a nose cone having a central nozzle configured to generate a vapor bubble around the vehicle; and said compressor in fluid communication with a high-pressure gas storage tank that is in turn in fluid communication with the central nozzle; and a control valve configured to control flow of said high-pressure gas to the central nozzle to form the vapor bubble; and an array of sensors configured to gather environmental data; and a computer storing an application configured to receive and process said environmental data; wherein data is rapidly gathered from an aquatic environment.

8. The supercavitation vehicle of claim 7 wherein: the vapor bubble is configured to create a noise signature that overwhelms traditional sonar equipment; wherein nearby aquatic vehicles are cloaked to the traditional sonar equipment.

9. The supercavitation vehicle of claim 7 further comprising: an array of control nozzles radially disposed about the nose cone and configured to inject high-pressure gas from the gas storage tank to control pitch, yaw and roll of the vehicle.

10. The supercavitation vehicle of claim 7 wherein: the array of sensors includes at least one camera.

11. The supercavitation vehicle of claim 7 wherein: the array of sensors includes at least one sonar receiver; wherein a pressure wave generated by said vapor bubble is reflected off the aquatic environment and wherein the aquatic environment is acoustically mapped.

12. The supercavitation vehicle of claim 7 wherein: the central processor includes communication circuitry configured to communicate with at least one other supercavitation vehicle; wherein an array of supercavitation vehicles gather data over an aquatic environment simultaneously for receiving said data in the central processor for processing and mapping.

13. The supercavitation vehicle of claim 7 further comprising at least one sensor selected from the group consisting of: camera, infrared receiver, sonic receiver, temperature sensor, turbidity sensor, pH sensor, dissolved oxygen sensor, nutrient sensor, metal contamination sensor, submersible gamma spectrometer.

14. A method for operating the supercavitation vehicle of claim 1 the method comprising: conducting preliminary data collection; and recognizing a critical data; and conducting trend data collection in response to critical data collected; and deploying a network of vehicles; wherein recognizing critical data engages trend data collection and recognizing critical trend data collection engages deploying of a network of vehicles.

15. A method for operating the supercavitation vehicle of claim 1 the method comprising: conducting preliminary data collection; and recognizing a critical data; and conducting emergency response data collection in response to critical data collected; and deploying a network of vehicles; wherein recognizing critical data engages conducting emergency response data collection and conducting emergency response data collection engages deploying of a network of vehicles.