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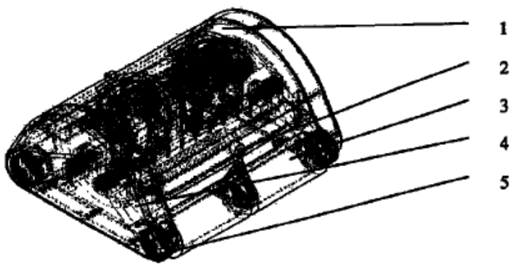
(54) Title of Invention

Underwater Cleaning Robot

(57) Abstract

The present invention discloses an underwater cleaning robot. The robot can operate in two working modes, remote control and autonomous control, and comprises a drainage mechanism, a cleaning and mobility platform, and a control system. Through the coordination between the drainage mechanism, the cleaning and mobility platform, and the control system, the robot can perform cleaning tasks autonomously or via remote control underwater on horizontal, vertical, and inclined surfaces. The present invention has the characteristics of being lightweight and having a large capacity, a compact and rational mechanical structure, and exhibits good practicality, stability, energy efficiency, economy, and versatility. It can be used for the underwater cleaning of swimming pool floors and walls.



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1. An underwater cleaning robot, comprising a drainage mechanism, a cleaning and mobility platform, and a control system;

wherein the drainage mechanism comprises a water discharger, a water flow channel (24) formed by a driving and control sealed housing and an inner wall of the robot housing, a water flow filter screen (23), and a water inlet with an anti-backflow device (25); the water flow filter screen (23) is fixed within the water flow channel (24) and, together with the inner wall of the robot housing body (1) and the driving and control sealed housing, divides the water flow channel (24) into two parts; the water discharger comprises a water outlet (10), a drainage propeller (11), a water outlet bracket (12), a water outlet mounting frame (13), a drainage propeller bracket (15), and a water outlet driving shaft (17); the water outlet (10) is installed and fixed on the water outlet bracket (12), is connected to the water outlet driving shaft (17) via the water outlet bracket (12), and is capable of rotating around the water outlet driving shaft (17); the drainage propeller (11) is driven by a drainage propeller high-speed DC motor (14) and is fixed on the drainage propeller bracket (15); the drainage propeller bracket (15) is also connected to the water outlet driving shaft (17) and rotates synchronously with the water outlet (10) around the water outlet driving shaft (17); the water outlet mounting frame (13) is fixed to the top of the driving and control sealed housing, it is also connected to the water outlet driving shaft (17), and is capable of rotating around the water outlet driving shaft (17); a water outlet driving servo (16) is connected to and drives the water outlet bracket (12) and the drainage propeller bracket (15) to rotate around the water outlet driving shaft (17); the water inlet (26) and the anti-backflow device (25) are located on the bottom surface of the robot housing (20) to ensure that water within the water flow channel (24) does not flow backward;

the cleaning and mobility platform comprises a robot housing body (1), cleaning driving wheels (3), synchronous belt gears (5), and driving synchronous belts (4); said robot housing body (1) comprises a robot top cover (18), robot side walls (20), and a robot main housing body (19); said cleaning driving wheels (3) comprise four independently driven cylindrical hubs, with the four cleaning driving wheels (3) arranged in two pairs and mounted to the robot via cleaning driving wheel side brackets (21) and cleaning driving wheel center brackets (22) on the robot side walls and the robot main housing body; two synchronous belt gears (5) and one driving synchronous belt (4) form a set, installed between a side panel of the robot main housing body (19) and a robot side wall (20); one of the synchronous belt gears (5) is connected to a cleaning driving DC motor (7), and the other synchronous belt gear (5) is connected to a cleaning driving wheel (3); these two synchronous belt gears (5) are driven by the driving synchronous belt (4);

the control system comprises a central processor, monitoring cameras, an image acquisition card, inertial navigation components, a remote control signal interface, motor drivers, a control system box (8), cleaning driving wheel DC motors (7), a water outlet driving servo (16), a drainage propeller high-speed DC motor (14), a driving and control sealed housing, and a control and power management system; the monitoring cameras (2) are connected to the central processor via the image acquisition card; the inertial navigation components and the remote control signal interface are also connected to the central processor; the central processor chip, image acquisition card, inertial navigation components, and remote control signal interface constitute the input part of the control system; the central processor drives the cleaning driving wheel DC motors (7), the water outlet driving servo (16), and the drainage propeller high-speed DC motor (14) via the motor drivers; the control system box encapsulates the control system, which includes the central processor, image acquisition card, inertial navigation components, remote control signal interface, and motor drivers; the driving and control sealed housing hermetically seals the parts of the control system, which include the control system box (8), the cleaning driving DC motors (7), the water outlet driving servo (16), and the drainage propeller high-speed DC motor (14), and has waterproof characteristics; the control and power management system implements control and power management for the robot.

2. The underwater cleaning robot according to claim 1, characterized in that the drainage mechanism can be optionally fitted with one or more water dischargers; when multiple water dischargers are installed, their water outlet driving shafts (17) must be kept coaxial.

3. The underwater cleaning robot according to claim 2, characterized in that said anti-backflow device (25) is divided into two parts, fixed by a shaft frame, covers the area above the water inlet (26), and can rotate around the shaft; when water enters the robot's water flow channel (24), the two parts of the anti-backflow device (25) rotate around the shaft due to the action of the water flow, opening the water inlet (26); when water stops entering, the anti-backflow device (25) returns to a closed state, ensuring that water within the water flow channel (24) does not flow backward.

4. The underwater cleaning robot according to claim 1, characterized in that said control and power management system comprises a control signal floating antenna (27), a signal relay and cable manager (28), and a signal and power cable (33); the control signal floating antenna is installed and connected to the antenna interface of the signal relay and cable manager to receive control signals from a control keypad, which are then relayed and

transmitted to the remote control signal interface of the underwater cleaning robot via the signal and power cable.

5. The underwater cleaning robot according to claim 4, characterized in that said control and power management system further comprises cable counterweight rings (34); the signal and power cable (33) includes control signal lines and power lines; the density of the cable is less than the density of water, and its density can be changed by fitting cable counterweight rings (34) to adjust its suspension state in the water.

6. The underwater cleaning robot according to claim 4, characterized in that said control and power management system further comprises a cable guide pulley frame (32); when the robot is operating with the cable, the cable guide pulley frame (32) is installed at a corner on the bank and includes a fixed pulley and a fixed pulley seat pivot shaft, enabling the fixed pulley to rotate on its own axis and the fixed pulley assembly to rotate around the fixed pulley seat pivot shaft.

7. The underwater cleaning robot according to claim 1, characterized in that said control and power management system comprises a control signal floating antenna (27) and a control signal floating antenna cable (35); the control signal floating antenna (27) communicates directly with the robot's remote control signal interface via the control signal floating antenna cable (35).

8. The underwater cleaning robot according to claim 1, characterized in that said underwater cleaning robot's operating modes include manual cleaning and autonomous cleaning; in said manual mode, control signals are issued by manual operation of a control keypad and control the underwater cleaning robot directly or indirectly via the control signal floating antenna (27); in said autonomous mode, control signals are generated by the central processor, which autonomously plans paths and actions based on perceived environmental information and its own position and attitude information, in conjunction with a preset cleaning task, to drive the robot's execution layer and complete the underwater cleaning task.

9. The underwater cleaning robot according to claim 1, characterized in that the water outlet (10) can rotate around the water outlet driving shaft (17), thereby changing the direction of water discharge and generating different forces that affect the robot's forward movement, cleaning, turning, and vertical wall-climbing movement.

10. The underwater cleaning robot according to claim 1, characterized in that said underwater cleaning robot is equipped with both a power input interface and a rechargeable battery box, allowing it to be powered either externally or, for short periods, by the battery box.

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Underwater Cleaning Robot

Technical Field

[0001] The present invention relates to a robot, specifically an underwater cleaning robot for cleaning in underwater environments. It possesses autonomous mobility and can be used for cleaning underwater horizontal, vertical, and inclined surfaces via remote or autonomous control, enabling it to autonomously complete underwater cleaning tasks in place of human labor.

Background

[0002] Swimming is a sport with a history spanning several thousand years. With the acceleration of modern life's pace and the improvement of living standards, swimming has become an important form of exercise for physical fitness, leisure, and recreation. The cleanliness and hygiene of a swimming pool directly affect the state and performance of swimmers. Therefore, maintaining the cleanliness and hygiene of the pool water and walls is of utmost importance. The method of cleaning a swimming pool varies with its type and size. Currently, both manual cleaning and automatic water circulation systems involve significant waste or redundancy in the use of water resources, other energy sources, and labor. This increases the maintenance costs of swimming pools and also directly raises the expenses for swimmers. Consequently, there is a need for an automatic underwater cleaning device to address this problem.

Summary

[0003] An object of the present invention is to provide an underwater robot that is agile, economical, energy-efficient, and capable of multiple operating modes, thereby better accomplishing underwater cleaning tasks.

[0004] The present invention is an underwater cleaning robot, comprising a drainage mechanism, a cleaning and mobility platform, and a control system.

[0005] The drainage mechanism of the present invention comprises a water discharger, a water flow channel formed by a driving and control sealed housing and the inner wall of the robot housing, a water flow filter screen, and a water inlet with an anti-backflow device. The water discharger comprises a water outlet, a drainage propeller, a water outlet bracket, a water outlet mounting frame, a drainage propeller bracket, and a water outlet driving shaft. The water outlet of the water discharger is installed and fixed on the water outlet bracket and is connected to the water outlet driving shaft via the water outlet bracket, allowing it to rotate around the driving shaft. The drainage propeller is driven by a high-speed DC motor and is also fixed on the drainage propeller bracket. It is also connected to the water outlet driving shaft and rotates synchronously with the water outlet around the driving shaft. The water outlet mounting frame, along with the water outlet bracket and the drainage propeller bracket, is connected by the water outlet driving shaft and can rotate around it. The water outlet mounting frame is fixed to the top of the driving and control sealed housing. Said water flow channel comprises the space formed by the outer wall of the driving and control sealed housing and the inner wall of the robot housing. Said water flow filter screen is fixed within the water flow channel and, together with the inner wall of the robot housing and the driving and control sealed housing, divides the water flow channel into two parts. Said water inlet and anti-backflow device are located on the bottom surface of the robot's bottom housing. It includes the water inlet and the anti-backflow device. The anti-backflow device is divided into two parts, fixed by a shaft frame, covers the area above the water inlet, and can rotate around the shaft. The drainage mechanism can be optionally fitted with one or more water dischargers. When multiple water dischargers are installed, their drainage driving shafts must be kept coaxial.

[0006] The cleaning and mobility platform of the present invention comprises a robot housing body, cleaning driving wheels, synchronous belt gears, and driving synchronous belts. The robot housing body includes a robot top cover, robot side walls, and a robot main housing body. The robot's housing is made of a single-molded polymer material. The cleaning driving wheels comprise four independently driven cylindrical hubs. The outer layer of the hubs can be fitted with wheel surfaces made of different materials according to cleaning needs. The four cleaning driving wheels are arranged in two pairs and are mounted to the robot via cleaning driving wheel side brackets and center brackets on the robot side walls and the robot main housing body. The synchronous belt gears and driving synchronous belts are arranged such that two synchronous belt gears and one driving synchronous belt form a set. This set is installed between a side panel of the robot main housing body and a robot side wall. One synchronous belt gear is connected to a driving DC motor, while the other is connected to a cleaning driving wheel. These two synchronous belt gears are driven by the driving synchronous belt.

[0007] The control system of the present invention comprises a central processor, monitoring cameras, an image acquisition card, inertial navigation components, a remote control signal interface, a power management module, motor drivers, a control system box, cleaning driving wheel DC motors, a water outlet driving servo, a drainage propeller high-speed DC motor, a driving and control sealed housing, and a control and power management system. It is characterized in that said central processor chip, along with the image acquisition card, inertial navigation components, and remote control signal interface, constitutes the input part of the control system; the central processor chip and the motor drivers constitute the output part of the control system. Said motor drivers and the cleaning driving wheel DC motors constitute the cleaning driving execution layer of the control system; the motor drivers and the water outlet driving servo constitute the water outlet rotation execution layer; the motor drivers and the drainage propeller high-speed DC motor constitute the propeller driving execution layer. Said monitoring cameras are installed on the two front panels of the robot main housing body. The monitoring cameras and the image acquisition card constitute the environmental perception layer of the control system. Said inertial navigation components are installed in the robot's driving and control sealed housing and constitute the self-attitude and positioning layer of the control system. Said control system box encapsulates the control system, which includes the central processor, image acquisition card, inertial navigation components, remote control signal interface, power management module, and motor drivers. It is equipped with both a power input interface and a rechargeable battery box, allowing it to be powered either externally or, for short periods, by the battery box. The control system box is fixed to the bottom of the driving and control sealed housing. Said power management module is used for voltage and current regulation, as well as for monitoring overcurrent and overload conditions in the robot's circuits to protect the robot's control system. Said cleaning driving wheel DC motors are equipped with reduction gearboxes and encoders. They are installed and fixed via front flanges to the side wall of the driving and control sealed housing and the side wall of the robot main housing body, and they drive the cleaning driving wheels via synchronous belt gears and synchronous belts. Said water outlet driving servo is installed and fixed on the water outlet mounting frame and drives the water outlet bracket and the drainage propeller bracket to rotate around the water outlet driving shaft. Said drainage propeller high-speed DC motor is installed and fixed on the drainage propeller bracket and drives the drainage propeller to rotate. Said cleaning driving wheel DC motors and drainage propeller high-speed DC motor are all equipped with encoders, enabling servo control with their respective motor drivers. Said driving and control sealed housing includes a sealed housing top cover and a main housing body. The sealed housing top cover includes a waterproof water outlet sliding groove. The driving and control sealed housing is installed and fixed inside the robot main housing body via the side walls at both ends of the main housing. It hermetically seals the parts of the control system, including the control system box, cleaning driving wheel DC motors, water outlet driving servo, and drainage propeller high-speed DC motor. It is made of a single-molded polymer material and has waterproof characteristics. Said control and power management system comprises a control signal floating antenna, a control signal floating antenna cable, a signal relay and cable manager, a signal and power cable, a cable guide pulley frame, and cable counterweight rings. It is characterized in that said signal relay and cable manager comprises a signal relay and a cable manager, is fixed to the pool bank ground via a manager bracket, and has the control signal floating antenna installed and connected to its antenna interface to receive control signals from a control keypad. These signals are then relayed and transmitted to the remote control signal interface of the underwater cleaning robot via the signal and power cable. The signal relay and cable manager is equipped with an external AC power source and an AC-to-DC transformer device, connecting to the power input interface of the underwater cleaning robot via the signal and power cable to supply power to the robot. The signal relay and cable manager's cable reeling motor is controlled by the underwater cleaning robot's central processor via a motor driver to execute cable reeling and unreeling. The signal relay of the signal relay and cable manager connects with the control signal floating antenna and sends data to the robot. The cable manager of the signal relay and cable manager includes a cable reeling motor with an encoder, which is controlled by the robot's central processor to achieve the cable reeling and unreeling function. The signal and power cable contains control signal lines and power lines. The density of the cable is less than that of water, and its density can be changed by fitting cable counterweight rings to adjust its suspension state in the water. The cable counterweight rings are made of a high-density polymer material, interlock tightly with the cable, and their installation position is adjustable. Said control signal floating antenna comprises a control signal antenna and a float carrier. Its density is much less than that of water, allowing it to float on the water surface and communicate wirelessly with the control keypad. It can communicate directly with the robot's remote control signal interface via a control signal floating antenna cable, or it can be installed and fixed on the signal relay and cable manager to communicate indirectly with the robot via the signal and power cable. The signal relay and cable manager can be connected to an external display device to show the working status and relevant performance indicators of the underwater cleaning robot. When the robot is operating with the cable, said cable guide pulley frame is installed at a corner on the bank. It includes a fixed pulley and a fixed pulley seat pivot shaft, enabling the fixed pulley to rotate on its own axis and the fixed pulley assembly to rotate around the fixed pulley seat pivot shaft.

[0008] The operating modes of the underwater cleaning robot proposed by the present invention include manual cleaning and autonomous cleaning. In said manual mode, control signals are issued by manual operation of a control keypad and control the underwater cleaning robot directly or indirectly via the control signal floating antenna. In said autonomous mode, control signals are generated by the central processor, which autonomously plans paths and actions based on information from the environmental perception layer and its own attitude and positioning layer, in conjunction with a preset cleaning task, to drive the robot's execution layer and complete the underwater cleaning task. For long-duration, global cleaning, the robot operates with a cable, using the signal relay and cable manager and the signal and power cable. For short-duration, local cleaning, the robot is powered by the battery box without using the signal relay and cable manager or the signal and power cable, instead using the control signal floating antenna and the control signal floating antenna cable, resulting in a relatively shorter operating time.

[0009] The process by which the underwater cleaning robot of the present invention completes a cleaning task is as follows:

[0010] The underwater cleaning robot controls its actions according to control commands issued by the central processor. In the drainage mechanism, the drainage propeller high-speed DC motor, under the control of its motor driver, drives the drainage propeller to rotate at a set speed. This expels water from within the robot's water flow channel, creating a high negative pressure inside. This pressure draws pool water from the bottom of the robot into the water flow channel through the water inlet. The water passes through the water flow filter screen, which filters out debris, and the clean water is then discharged. Meanwhile, by monitoring the motor's speed and current, the drainage propeller high-speed DC motor driver can determine the density of debris inside the water flow channel. When the debris reaches a certain density, it issues a "debris full" alarm. The water outlet driving servo is controlled by its motor driver to move the water outlet bracket along the water outlet sliding groove, rotating it around the water outlet driving shaft to change the direction of water discharge. An anti-backflow device is installed above the water inlet. When water flows in through the inlet, the force of the water causes the anti-backflow device to open. When the water flow stops, the device closes due to the absence of water force, which prevents debris from flowing out of the water flow channel. In the cleaning and mobility platform, the four independent cleaning driving wheels are controlled by their respective motor drivers, allowing for independent movement. By using different combinations of wheel speeds, the robot can perform tasks such as moving forward, backward, turning, and brush-cleaning. When the robot performs cleaning tasks underwater with the cable, it uses the inertial navigation components and the cleaning driving wheels to perform dead reckoning to obtain its position information. The central processor then controls the cable reeling motor to reel in or unreel the signal and power cable according to the required length. Based on the swimming pool's depth and actual needs, cable counterweight rings are installed at appropriate positions to adjust the cable's suspension state in the water. The signal relay and cable manager uses the cable guide pulley frame to guide the reeling and unreeling of the cable. When the robot performs tasks underwater without the cable, the control signal floating antenna is connected to the robot via the control signal floating antenna cable to receive remote control signals and control the robot's movement. During the autonomous cleaning process, a pool cleanliness image threshold is set. The robot uses its monitoring cameras to capture images of the pool floor and compares them with the threshold to determine the level of cleanliness. It then plans its cleaning movements to complete the cleaning task.

[0011] A feature of the underwater cleaning robot proposed by the present invention is that the high negative pressure within the robot's water flow channel and the force from the drainage mechanism enable the robot to adhere to and clean the vertical walls of a swimming pool, achieving vertical wall-climbing movement.

[0012] A feature of the underwater cleaning robot proposed by the present invention is that the water outlet can move along the water outlet sliding groove, which can affect the robot's forward movement, cleaning, turning, and vertical wall-climbing movement. The coordinated movement or positioning of multiple water outlets along the water outlet sliding grooves changes the direction of water discharge, generating different forces that affect the robot's movement. For example, when the robot is in a floating state in the water, adjusting the discharge direction and force of the two water outlets can regulate the robot's attitude in the water, helping it maintain a correct posture. Particularly when the robot is climbing a wall, factors such as pool steps may cause the chassis to be lifted, rendering the four cleaning driving wheels ineffective. In this situation, the position of the water outlets must be adjusted to provide a propulsive force to the robot, returning it to a normal operating state.

[0013] The beneficial effects of the present invention are: it is lightweight, has a large capacity, and is agile and nimble in movement. It features a compact and rational mechanical structure and exhibits good intelligence, practicality, stability, energy efficiency, economy, and versatility. It can assist with and autonomously perform underwater cleaning tasks in place of human labor.

Brief Description of the Drawings

[0014] Fig. 1 - Overall schematic diagram of the underwater cleaning robot, wherein: 1 - robot housing body, 2 - monitoring camera, 3 - cleaning driving wheel, 4 - driving synchronous belt, 5 - synchronous belt gear;

[0015] Fig. 2 - Schematic diagram of the underwater cleaning robot's driving and control sealed housing, wherein: 6 - driving and control sealed housing, 7 - cleaning driving wheel DC motor, 8 - control system box, 9 - water outlet sliding groove;

[0016] Fig. 3 - Schematic diagram of the underwater cleaning robot's water discharger, wherein: 10 - water outlet, 11 - drainage propeller, 12 - water outlet bracket, 13 - water outlet mounting frame, 14 - drainage propeller high-speed DC motor, 15 - drainage propeller bracket, 16 - water outlet driving servo, 17 - water outlet driving shaft;

[0017] Fig. 4 - Schematic diagram of the underwater cleaning robot's cleaning and mobility platform, wherein: 18 - robot top cover, 19 - robot main housing body, 20 - robot side wall, 21 - cleaning driving wheel side bracket, 22 - cleaning driving wheel center bracket;

[0018] Fig. 5 - Side cross-sectional view of the underwater cleaning robot, wherein: 23 - water flow filter screen, 24 - water flow channel, 25 - anti-backflow device, 26 - water inlet;

[0019] Fig. 6 - Schematic diagram of the underwater cleaning robot's control system.

[0020] Fig. 7 - Schematic diagram of the underwater cleaning robot operating with a cable, wherein: 27 - control signal floating antenna, 28 - signal relay and cable manager, 29 - cable manager, 30 - manager bracket, 31 - control keypad, 32 - cable guide pulley frame, 33 - signal and power cable, 34 - cable counterweight ring.

[0021] Fig. 8 - Schematic diagram of the underwater cleaning robot operating without a cable, wherein: 35 - control signal floating antenna cable.

Detailed Description of the Embodiments

[0022] The present invention will be further described below with reference to the accompanying drawings and embodiments.

[0023] Embodiment

[0024] The underwater cleaning robot of the present invention comprises a drainage mechanism, a cleaning and mobility platform, and a control system. As shown in Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7, and Fig. 8, said drainage mechanism comprises a water discharger, a water flow channel 24 formed by the driving and control sealed housing and the inner wall of the robot housing, a water flow filter screen 23, and a water inlet with an anti-backflow device 25. The water discharger comprises a water outlet 10, a drainage propeller 11, a water outlet bracket 12, a water outlet mounting frame 13, a drainage propeller bracket 15, and a water outlet driving shaft 17. The underwater cleaning robot can be installed with multiple independent water dischargers to coordinate their movements. The water discharger's water outlet 10 is connected to the water outlet driving shaft 17 via the water outlet bracket 12 and can rotate around the driving shaft. The drainage propeller 11 is driven by a high-speed DC motor and is also fixed on the drainage propeller bracket 15. It is also connected to the water outlet driving shaft 17 and rotates synchronously with the water outlet 10 around the driving shaft. The water outlet mounting frame 13 is fixed to the top of the driving and control sealed housing. The water flow channel 24 comprises the space formed by the outer wall of the driving and control sealed housing and the inner wall of the robot housing body 1. The water flow filter screen 23 is fixed within the water flow channel 24 and, together with the inner wall of the robot housing body 1 and the driving and control sealed housing, divides the water flow channel 24 into two parts. The water inlet 26 and anti-backflow device 25 are located on the bottom surface of the robot main housing body 19. The anti-backflow device is divided into two parts, fixed by a shaft frame, covers the area above the water inlet 26, and can rotate around the shaft. When water enters the robot's water flow channel 24, the two parts of the anti-backflow device 25 rotate around the shaft due to the action of the water flow, opening the water inlet 26. When water stops entering, the anti-backflow device 25 returns to a closed state, ensuring that water within the water flow channel 24 does not flow backward. The drainage mechanism can be optionally fitted with one or more water dischargers. When multiple water dischargers are installed, their water outlet driving shafts 17 must be kept coaxial. Said drainage mechanism uses the cleaning and mobility platform as a carrier and coordinates its movement with the cleaning and mobility platform. Said cleaning and mobility platform comprises a robot housing body 1, cleaning driving wheels 3, synchronous belt gears 5, and a driving synchronous belt 4. It is characterized in that said robot housing body 1 comprises a robot top cover 18, robot side walls 20, and a robot main housing body 19. The robot's housing is made of a single-molded polymer material. Said cleaning driving wheels 3 comprise four independently driven cylindrical hubs. The outer layer of the hubs can be fitted with wheel surfaces made of different materials according to cleaning needs. The four cleaning driving wheels 3 are arranged in two pairs and are mounted to the robot via cleaning driving wheel side brackets 21 and cleaning driving wheel center brackets 22 on the robot side walls and the robot main housing body. Said synchronous belt gears 5 and driving synchronous belt 4 are arranged such that two synchronous belt gears 5 and one driving synchronous belt 4 form a set. This set is installed between a side panel of the robot main housing body 19 and a robot side wall 20. One synchronous belt gear 5 is connected to a driving DC motor 7, while the other synchronous belt gear 5 is connected to a cleaning driving wheel 3. These two synchronous belt gears 5 are driven by the driving synchronous belt 4. The control system comprises a central processor, monitoring cameras, an image acquisition card, inertial navigation components, a remote control signal interface, motor drivers, a control system box 8, cleaning driving wheel DC motors 7, a water outlet driving servo 16, a drainage propeller high-speed DC motor 14, a driving and control sealed housing, and a control and power management system. The central processor chip, along with the image acquisition card, inertial navigation components, and remote control signal interface, constitutes the input part of the control system; the central processor chip and the motor drivers constitute the output part of the control system. The motor drivers and the cleaning driving wheel DC motors 7 constitute the cleaning driving execution layer of the control system; the motor drivers and the water outlet driving servo 16 constitute the water outlet 10 rotation execution layer; the motor drivers and the drainage propeller high-speed DC motor 14 constitute the propeller 11 driving execution layer. Said monitoring cameras 2 are installed on the two front panels of the robot main housing body 19. The monitoring cameras 2 and the image acquisition card constitute the environmental perception layer of the control system. Said inertial navigation components are installed in the robot control system box 8 and constitute the self-attitude and positioning layer of the control system. The control system box 8 encapsulates the control system, which includes the central processor, image acquisition card, inertial navigation components, remote control signal interface, power management module, and motor drivers. It is equipped with both a power input interface and a rechargeable battery box, allowing it to be powered either externally or, for short periods, by the battery box. The control system box is fixed to the bottom of the driving and control sealed housing. Said power management module is used for voltage and current regulation, as well as for monitoring overcurrent and overload conditions in the robot's circuits to protect the robot's control system. Said cleaning driving wheel DC motors 7 are equipped with reduction gearboxes and encoders. They are installed and fixed via front flanges to the side wall of the driving and control sealed housing and the side wall of the robot main housing body 19, and they drive the cleaning driving wheels 3. The water outlet driving servo 16 is installed and fixed on the water outlet mounting bracket 12 and drives the water outlet 10 and the water outlet bracket 12 to rotate around the water outlet driving shaft 17. The drainage propeller high-speed DC motor 14 is installed and fixed on the drainage propeller bracket 15 and drives the drainage propeller 11 to rotate. The cleaning driving wheel DC motors 7 and the drainage propeller high-speed DC motor 14 are all equipped with encoders, enabling servo control with their respective motor drivers. The driving and control sealed housing includes a sealed housing top cover and a main housing body. The sealed housing top cover includes a waterproof water outlet sliding groove 9. The driving and control sealed housing is installed and fixed inside the robot main housing body 19 via the side walls at both ends of the main housing 19. It hermetically seals the parts of the control system, including the control system box 8, cleaning driving wheel DC motors 7, water outlet driving servo 16, and drainage propeller high-speed DC motor 14. It is made of a single-molded polymer material and has waterproof characteristics. The control and power management system comprises a control signal floating antenna 27, a control signal floating antenna cable 35, a signal relay and cable manager 28, a signal and power cable 33, a cable guide pulley frame 32, and cable counterweight rings 34. The signal relay and cable manager 28 comprises a signal relay and a cable manager 29, is fixed to the pool shore ground via a manager bracket 30, and has the control signal floating antenna 27 connected to its antenna interface to receive control signals from a control keypad 31. These signals are then relayed and transmitted to the remote control signal interface of the underwater cleaning robot via the signal and power cable 33. The signal relay and cable manager 28 is equipped with an external AC power source and an AC-to-DC transformer device, connecting to the power input interface of the underwater cleaning robot via the signal and power cable 33 to supply power to the robot. The cable reeling motor of the signal relay and cable manager 28 is controlled by the underwater cleaning robot's central processor via a motor driver to execute cable reeling and unreeling. The signal relay of the signal relay and cable manager 28 connects with the control signal floating antenna and sends data to the robot. The cable manager 29 of the signal relay and cable manager 28 includes a cable reeling motor with an encoder, which is controlled by the robot's central processor to achieve the cable reeling and unreeling function. The signal and power cable 33 contains control signal lines and power lines. The density of the cable is less than that of water, and its density can be changed by fitting cable counterweight rings 34 to adjust its suspension state in the water. The cable counterweight rings 34 are made of a high-density polymer material, interlock tightly with the cable, and their installation position is adjustable. The control signal floating antenna 27 comprises a control signal antenna and a float carrier. Its density is much less than that of water, allowing it to float on the water surface and communicate wirelessly with the control keypad 31. It can communicate directly with the robot's remote control signal interface via the control signal floating antenna cable 35, or it can be installed and fixed on the signal relay and cable manager 28 to communicate indirectly with the robot via the signal and power cable 33. The signal relay and cable manager 28 can be connected to an external display device to show the working status and relevant performance indicators of the underwater cleaning robot. When the robot is operating with the cable, the cable guide pulley frame 32 is installed at a corner on the bank. It includes a fixed pulley and a fixed pulley seat pivot shaft, enabling the fixed pulley to rotate on its own axis and the fixed pulley assembly to rotate around the fixed pulley seat pivot shaft.

[0025] The operating modes of the underwater cleaning robot proposed by the present invention include manual cleaning and autonomous cleaning. In said manual mode, control signals are issued by manual operation of a control keypad and control the underwater cleaning robot directly or indirectly via the control signal floating antenna. In said autonomous mode, control signals are generated by the central processor, which autonomously plans paths and actions based on information from the environmental perception layer and its own attitude and positioning layer, in conjunction with a preset cleaning task, to drive the robot's execution layer and complete the underwater cleaning task. For long-duration, global cleaning, the robot operates with a cable, using the signal relay and cable manager 28 and the signal and power cable 33. For short-duration, local cleaning, the robot is powered by the battery box without using the signal relay and cable manager 28 or the signal and power cable 33, instead using the control signal floating antenna 27 and the control signal floating antenna cable 35, resulting in a relatively shorter operating time.

[0026] The process by which the underwater cleaning robot of the present invention completes a cleaning task is as follows: The underwater cleaning robot controls its actions according to control commands issued by the central processor. In the drainage mechanism, the drainage propeller high-speed DC motor 14, under the control of its motor driver, drives the drainage propeller 11 to rotate at a set speed. This expels water from within the robot's water flow channel 24, creating a high negative pressure inside. This pressure draws pool water from the bottom of the robot into the water flow channel 24 through the water inlet. The water passes through the water flow filter screen 23, which filters out debris, and the clean water is then discharged. Meanwhile, by monitoring the motor's speed and current, the drainage propeller high-speed DC motor driver can determine the density of debris inside the water flow channel 24. When the debris reaches a certain density, it issues a "debris full" alarm. The water outlet driving servo 16 is controlled by its motor driver to move the water outlet bracket 12 along the water outlet sliding groove 9, rotating it around the water outlet driving shaft 17 to change the direction of water discharge. An anti-backflow device 25 is installed above the water inlet 26. When water flows in through the inlet, the force of the water causes the anti-backflow device 25 to open. When the water flow stops, the device closes due to the absence of water force, which prevents debris from flowing out of the water flow channel 24. In the cleaning and mobility platform, the four independent cleaning driving wheels 3 are controlled by their respective motor drivers, allowing for independent movement. By using different combinations of wheel speeds, the robot can perform tasks such as moving forward, backward, turning, and brush-cleaning. When the robot performs cleaning tasks underwater with the cable, it uses the inertial navigation components and the cleaning driving wheels 3 to perform dead reckoning to obtain its position information. The central processor then controls the cable reeling motor to reel in or unreel the signal and power cable 33 according to the required length. Based on the swimming pool's depth and actual needs, cable counterweight rings 34 are installed at appropriate positions to adjust the cable's suspension state in the water. The signal relay and cable manager 28 uses the cable guide pulley frame 32 to guide the reeling and unreeling of the cable. When the robot performs tasks underwater without the cable, the control signal floating antenna 27 is connected to the robot via the control signal floating antenna cable 35 to receive remote control signals and control the robot's movement. During the autonomous cleaning process, a pool cleanliness image threshold is set. The robot uses its monitoring cameras 2 to capture images of the pool floor and compares them with the threshold to determine the level of cleanliness. It then plans its cleaning movements and adjusts the working state of the four cleaning driving wheels 3 and the water discharger to complete the cleaning task. Specifically, the speed of each wheel 3 can be adjusted. By using different combinations of wheel speeds, cleaning

actions of varying intensity can be achieved. For example, if the front wheels rotate quickly clockwise and the rear wheels rotate slowly counter-clockwise, the underwater cleaning robot will advance in the direction determined by the clockwise rotation of the front wheels, but the cleaning intensity in this case will be much greater than if the rear wheels were rotating clockwise. At the same time, adjusting the discharge position and direction of the water outlet 10 and the speed of the drainage propeller 11 can also change the cleaning intensity, making the robot's work more efficient. The same control strategy can also be used for cleaning vertical pool walls. The underwater cleaning robot of the present invention, due to the high negative pressure within its water flow channel 24 and the force from the drainage mechanism, can adhere to the vertical walls of a swimming pool for cleaning, achieving vertical wall-climbing movement. The underwater cleaning robot of the present invention, because its water outlet 10 can move along the water outlet sliding groove 9, can affect the robot's forward movement, cleaning, turning, and vertical wall-climbing movement. The coordinated movement or positioning of multiple water outlets 10 along the water outlet sliding grooves 9 changes the discharge direction of the water outlets 10, generating different forces that affect the robot's movement. For example, when the robot is in a floating state in the water, adjusting the discharge direction and force of the two water outlets 10 can regulate the robot's attitude in the water, helping it maintain a correct posture. Particularly when the robot is climbing a wall, factors such as pool steps may cause the chassis to be lifted, rendering the four cleaning driving wheels 3 ineffective. In this situation, the position of the water outlets must be adjusted to provide a propulsive force to the robot, returning it to a normal operating state. The underwater cleaning robot ensures autonomous navigation and operation through dead reckoning, using its installed inertial navigation components and the encoders of the four cleaning driving wheels 3. After completing a cleaning task, open the robot's top cover 18 and the water flow filter screen 23, and then clean the underwater cleaning robot's water flow channel 24.
[0027] The present invention is not limited to this embodiment. Any design that utilizes the design concepts of this invention and incorporates simple variations should fall within the scope of protection of this invention.

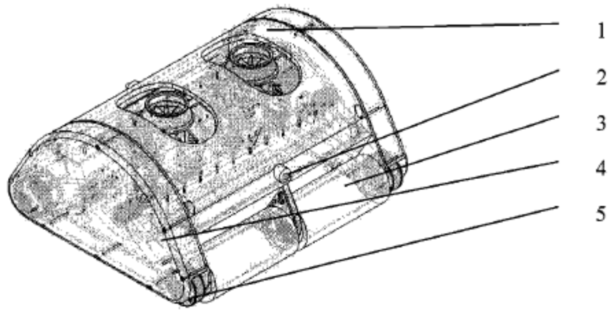

Fig. 1

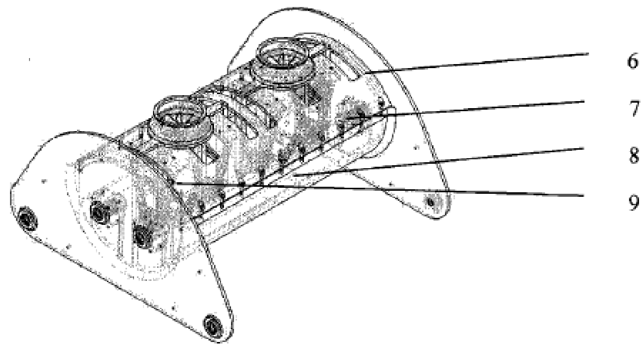

Fig. 2

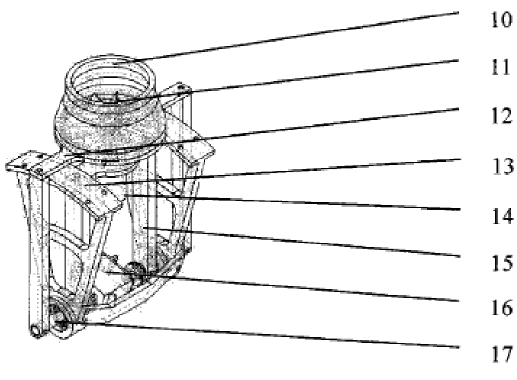

Fig. 3

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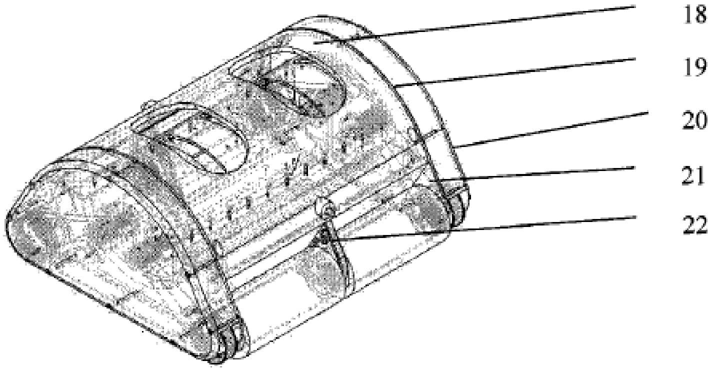

Fig. 4

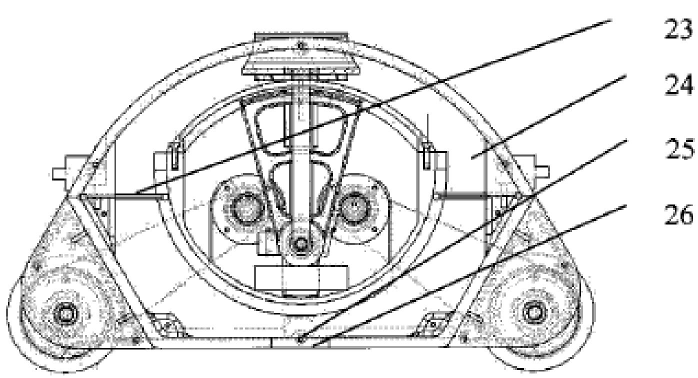

Fig. 5

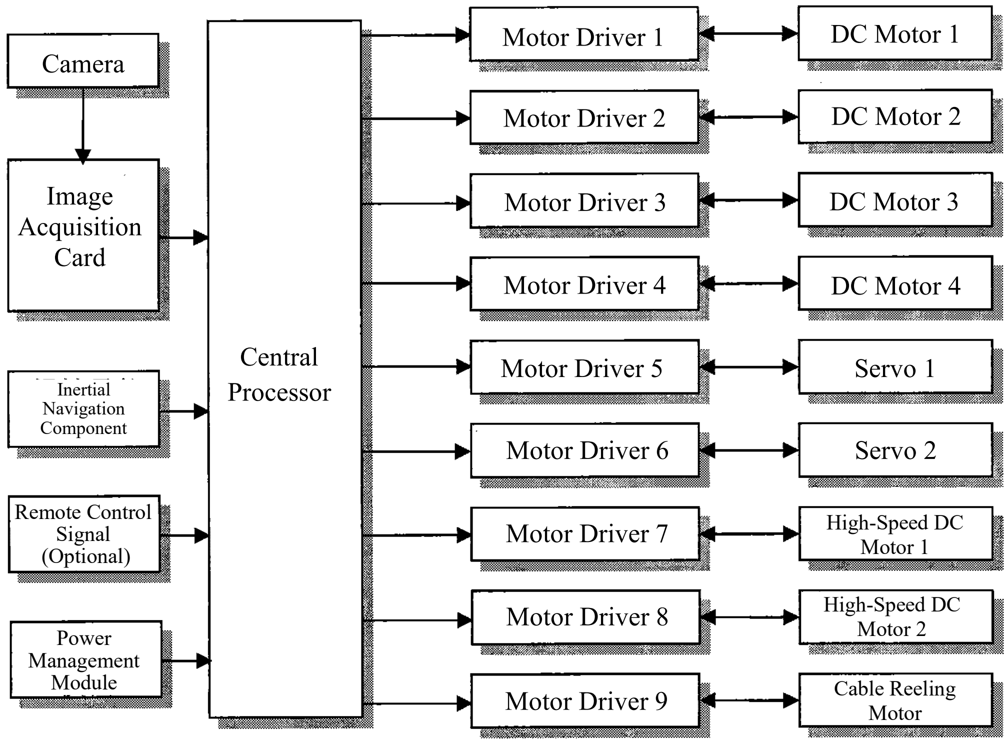

Fig. 6

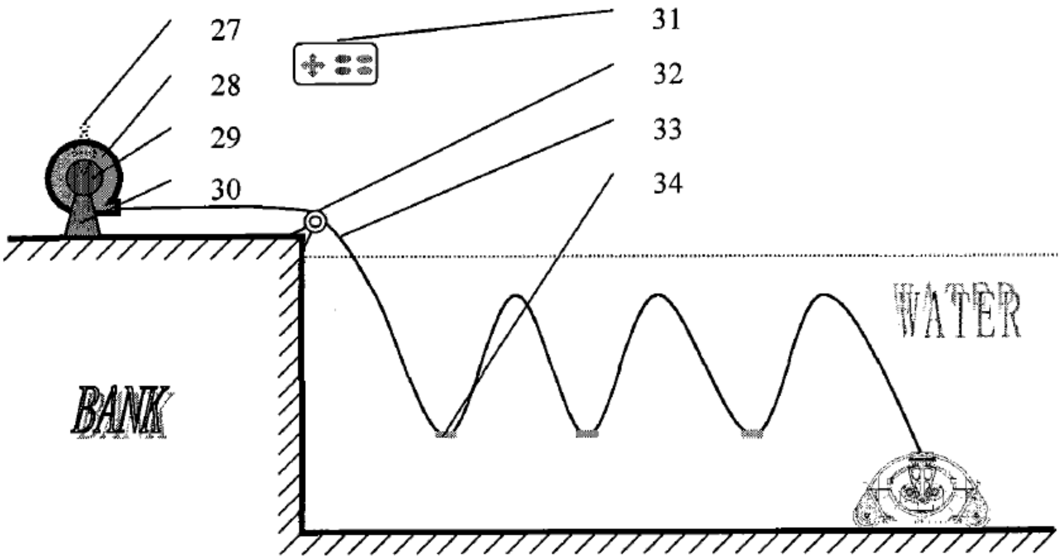

Fig. 7

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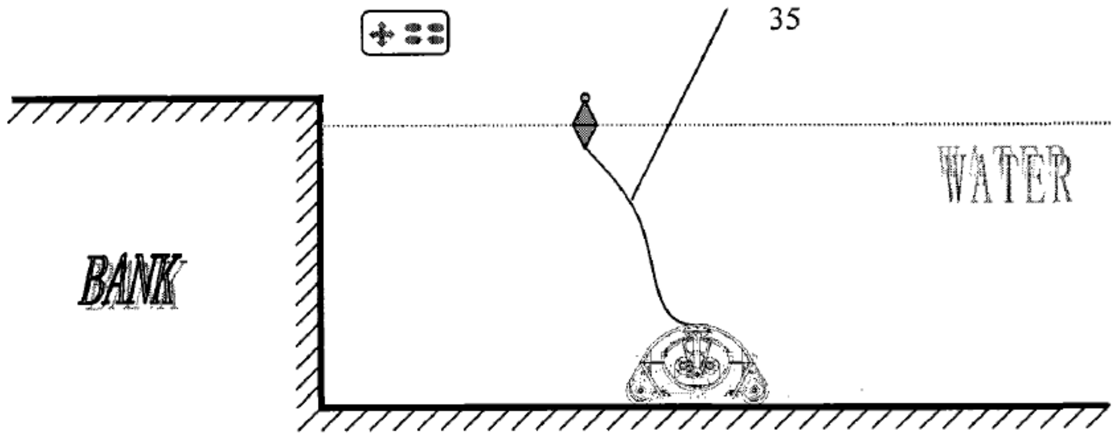

Fig. 8

November 3, 2025

Certification

Welocalize Translations

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