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Integrated treatment device for aquaculture waste gas based on coupled aerodynamics

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Abstract: *Aiming at the problem of low efficiency of waste gas and waste treatment in farms, this paper designs an integrated treatment device of waste gas and waste from aquaculture based on coupled pneumatics. The device uses raspberry pie control combined with TCP protocol network port and waste gas detection sensor to realize real-time detection and cleaning planning of waste gas concentration in the breeding house, and at the same time, it combines with waste gas treatment module to improve waste gas treatment efficiency. In addition, a farm working robot is designed to complete tasks in the farm environment, which solves a series of challenges in farm management and production process. Aiming at the task assignment and path planning of robots, the task assignment algorithm and path planning algorithm are studied, and the reliability and practicability of these algorithms are verified. These research results provide a reliable route for working robots to complete tasks safely and quickly in farms.*

Keywords: *the task assignment algorithm, cultivation, exhaust gas, integration*

1. Research purpose

1.1 Background of Work Research

With the development of science and technology and the improvement of intelligent level, farm working robots are more and more widely used in daily life and agricultural production. As an intelligent mobile robot, farm working robot has become an important part of farm management and production process, and has broad application prospects and development space. As shown in the Figure 1, the farm working robot can independently complete tasks in the farm environment, which brings convenience and efficiency improvement to agricultural production.

However, the farm environment is complex, dynamic and uncertain, which brings a series of challenges to the design, control and application of farm working robots. Among them, the task allocation and path planning of farm working robots are the key technologies to realize their scheduling, so they have become the hot topics of current research.

Robot task planning algorithm needs to assign tasks to working robots reasonably and make a reasonable task execution order. Traditional task allocation methods are mainly based on basic optimization algorithms such as artificial rules or genetic algorithm. This method is difficult to allocate a large number of tasks to working robots in real time in complex environment of farms, and working robots in farms have high autonomy and adaptability, so more advanced task allocation methods are needed to improve efficiency and accuracy.

In the path planning of the working robot in the farm, we mainly consider how to plan a safe, smooth, efficient and reasonable path independently according to the current position and target position of the robot. Traditional path planning algorithms include A* algorithm, Rapidly-Exploring Random Tree (RRT) algorithm and ant colony algorithm, but these traditional path planning algorithms can't cope with the path planning problem in complex environment, so it is necessary to adopt more efficient and intelligent path planning algorithms to realize autonomous navigation and autonomous motion control of robots [1-3].

To sum up, the task allocation and path planning of farm robots are the key technologies to realize their scheduling and autonomous navigation. Based on the actual working environment of the working robot, this paper studies the task allocation algorithm and path planning algorithm of the working robot in the farm, and verifies the algorithm proposed in this paper by designing a simulation system, thus contributing a reliable implementation route for the working robot to complete the farm task safely and

ISSN 2706-655X Vol.6, Issue 3: 53-66, DOI: 10.25236/IJFET.2024.060308

quickly.

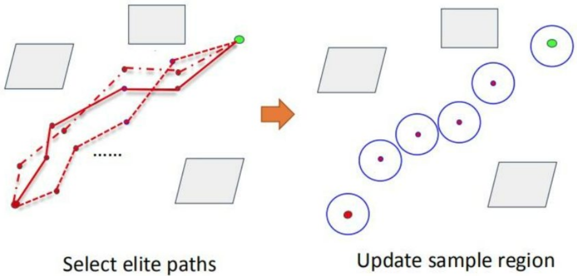

Figure 1: Schematic diagram of integrated treatment device for coupled treatment of aquaculture waste gas and waste

2. Content of Work Research

2.1 Comparative analysis of algorithms

Dynamic Window Method (DWA) searches for the combination of optimal speed and angular velocity in the speed space to avoid obstacles and achieve the goal. Its code structure includes initialization, speed sampling, evaluation, selection of the best and execution. The code structure includes initialization, calculation of gravity, calculation of repulsion, calculation of resultant force and updating position. A* algorithm is a heuristic search algorithm, which searches for the optimal path by estimating the cost from the starting point to the target. The code structure includes initialization, node expansion, path selection, update cost and repeated steps. RRT* algorithm is a fast exploration algorithm based on random sampling, which searches for the optimal path by expanding the tree structure. The code structure includes initialization, tree expansion, path optimization, target detection and path backtracking. Each algorithm has its own unique characteristics and applicable scenarios, and choosing the appropriate algorithm depends on the specific needs and environmental conditions.

2.2 Dynamic window method (DWA)

Dynamic Window Approach, DWA) is a path planning method based on predictive control theory, which is suitable for avoiding obstacles safely and effectively in unknown environment. The algorithm has the characteristics of small calculation, quick response and easy operation. As a local path planning algorithm, its core idea is to determine the speed sampling space in the speed space that meets the constraints of the robot hardware, and then predict the trajectory of the robot moving at these speeds for a period of time. The speed corresponding to the optimal trajectory is selected by the evaluation function, and it is executed circularly until the target point is reached in the Figure 2.

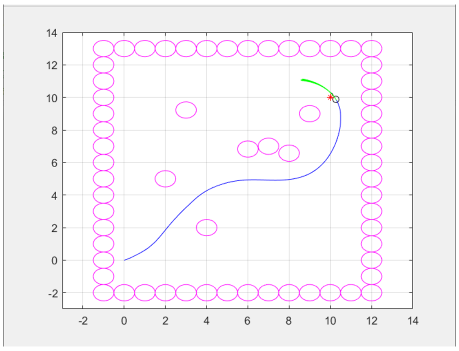

Figure 2: Schematic diagram of integrated treatment device for coupled treatment of aquaculture waste gas and waste

2.3 The artificial potential field method

The artificial potential field method is a path planning method, which guides robots or unmanned vehicles from the starting point to the end point by simulating the action mechanism of potential field or

ISSN 2706-655X Vol.6, Issue 3: 53-66, DOI: 10.25236/IJFET.2024.060308

gravity potential field, and avoids obstacles. By analogy with the potential field and gravity potential field, the robot is regarded as a positively charged or spherical body, which moves along the path under the action of the potential field. Artificial potential field method uses feedback control strategy to construct artificial potential field, which has the advantage of being robust to control and sensing errors, but there is a local minimum problem, which cannot guarantee to find the optimal solution.

2.4 A algorithm*

A* algorithm is a heuristic search method, which aims to find the shortest path from the starting point to the target point in the graphic structure. This algorithm combines the comprehensiveness of Dijkstra algorithm and the efficiency of greedy optimization search, and estimates the cost from the current node to the target node through heuristic function, thus guiding the search direction. In the process of searching, the node with the lowest cost among the current nodes is selected from the starting point, the cost of its neighboring nodes is calculated, and the cost of the target node is estimated according to the heuristic function, and then the node information is updated and added to the open list. Finally, the shortest path from the starting point to the target point is found by backtracking. As shown in the Figure 3 the core of A* algorithm is to design effective heuristic function and cost calculation, so as to give priority to exploring the node with the least cost, thus improving the search efficiency[4-6].

1) Setting parameters such as starting point, ending point and obstacles & initialization of open list and closelist.

2) Starting from the starting point, take the starting point as the parent node and record the path from the starting point to the parent node.

3) judging obstacles at eight points around the parent node, and finding out the child nodes that can advance.

4) Calculate the cost of the child nodes one by one, record the path from the starting point to its parent node and then to the child node, and put it in the openlist.

5) Move the parent node (including the path from the starting point to the parent node) to the closelist, and then find a node with the lowest cost from the openlist as the next parent node.

6) Repeat "3-5" for the new parent node until the new parent node is found to be the target node.

7) take out the last line from the closelist, the first element of which is the coordinates of the target point, and the second element is the optimal path from the starting point to the target point-a series of coordinate values.

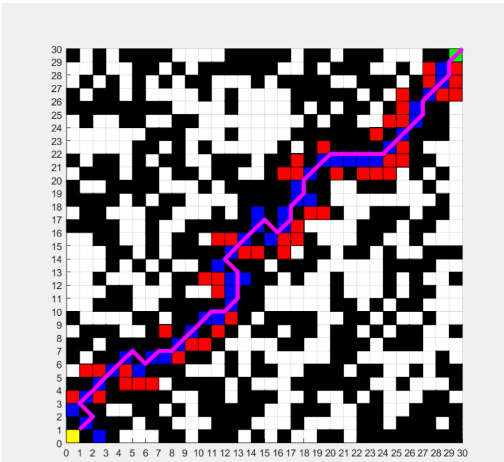

Figure 3: Schematic diagram of integrated treatment device for coupled treatment of aquaculture waste gas and waste

3. Theme design ideas

First of all, at the beginning of the simulation system design, it is necessary to abstract the real scene in the real work scene into the program design in the simulation system. The following is described from three aspects:

ISSN 2706-655X Vol.6, Issue 3: 53-66, DOI: 10.25236/IJFET.2024.060308

3.1 Physical abstraction

The main body of the simulation system is the working robot, as the only working body in the system; It is abstracted as an object, named ClearningRobot, which has properties and methods: including robot position and working state (including: Storage bin, duration, rolling, cleaning); The method functions include: start cleaning, stop, and move to the specified location;

Abstraction of Waste: waste management is a problem that farms must deal with, so waste can be abstracted into another object and named "waste". Waste objects can include attributes, such as type (solid, liquid), quantity, treatment method, etc. For waste objects, some methods can be defined, such as cleaning up waste, treating waste and recording waste quantity.

Simplification of robot's working action: in the simulation system, all the actions of robot are abstracted into specific action functions; Including:

Move, suck, put down, store and handle;

In the program design, the interaction among cleaning robot, livestock and waste should also be considered. For example, the cleaning robot may need to adjust the cleaning path according to the activity of livestock, or treat waste during the cleaning process. Therefore, it is necessary to design corresponding functions or methods to realize the interaction among cleaning robots, livestock and waste.

3.2 Rule design

In the actual working process of the robot, there are restrictions and changes caused by the actual environment, so it needs to be reflected as rules in programming according to the actual situation.

A. In actual waste treatment, due to the limited space and speed of the device, a large number of wastes cannot be treated at the same time; It is fixed that the device can only handle cleaning work at one place at a time;

Analysis of specific implementation problems: Definition: NP-hard problems are a kind of problems. They may not belong to NP problems, but they can be reduced to any NP problem by polynomial time. Specifically, for a problem X, if there is a NP problem Y that can be converted into X in polynomial time, then X is NP-hard. The mathematical expression can be expressed as:

If problem X can be reduced to NP problem Y in polynomial time, that is, there is a polynomial time algorithm to convert any instance of X into an instance of Y, and for each instance of X, its solution is also the solution of the corresponding instance of Y, then problem X is NP-hard.

3.3 Programming Object Understanding

NP-hard problem refers to a kind of problem, which is more difficult to solve than or equal to NP problem, that is, it cannot be solved in polynomial time and the correctness of the solution may not be verified in polynomial time. Task planning problems, such as project scheduling or resource allocation, belong to NP-hard problems in many cases. This means that although it is easy to verify whether a given solution is correct, it takes a lot of calculation overhead to find the optimal solution, which may even be infeasible in practice. Therefore, although we can verify the feasibility of a task planning scheme in polynomial time, it may take exponential time to find the optimal scheme.

In the actual design process, it is necessary to evaluate and analyze the designed algorithm reasonably. Specific example analysis: in order to facilitate the comparison of algorithm planning results, some problems are solved first and then compared.

1) The following is a task scenario: In the simulation system, there are two tasks with the same big object, and at the same time, one small object exists in this position and the other small object exists in a different position.

For the above task planning, if the continuity of task work is not considered in the normal state, it may make the working state redundant and time-consuming.

2) Simplification: constraint 1 corresponds to two tasks 1 and 2 at the same time, and constraint B corresponds to task 1. At this time, one task corresponds to two constraints, but considering that two tasks are executed and two constraints are broken, it should be executed according to the final corresponding result.

ISSN 2706-655X Vol.6, Issue 3: 53-66, DOI: 10.25236/IJFET.2024.060308

4. Program segments show

4.1 Overall structure:

CCWW' class contains a series of member functions and data members, which are used for initialization, task planning, instruction parsing, natural language parsing and other operations.

First, in the' Init' function, the member variables of the class are initialized, different values are set according to the passed-in parameters, and the objects and data structures are initialized.

Then, in the' Plan' function, the task planning is mainly carried out, including operations such as parsing environment, parsing instructions, executing tasks, and optimizing task list. The `parse instruction' function is used to parse instructions, and to parse out specific tasks and constraints according to the incoming task description. The ParseEnv' function is used to parse the environment description and initialize the position and state of the object according to the environment description. The `do behavior' function performs specific actions, such as moving, opening, closing, placing, etc. The SolveTask' function solves a specific task and performs the corresponding operation according to the task instruction. The PrintInstruction' and PrintEnv' functions are used to print instructions and environmental information, which is convenient for debugging and viewing status. The function of the whole structure is to realize a task planning and execution system. By analyzing instructions and environmental descriptions, specific task operations, including moving objects, opening, closing, placing and other operations, are performed to achieve the purpose of task planning and execution.

4.2 Firstly, in initialization, `CCWW:: init (int argc, char * * argv) `

`string path; : A string variable path is declared.

`path = "../example/words.txt"; `: Set the `path` variable to ".. /example/words.txt", which is the default file path.

`naturalParse = 0; errorCorrection = 0; askTwice = 0; autoConstrain = 1; : Several integer variables' naturalParse',' errorCorrection',' askTwice' and' autoConstrain' are initialized, and they are assigned to 0, 0, 0 and 1 respectively.

` if (argc > 1) {... }`: Check whether the number of command line parameters is greater than 1, and if so, enter the conditional statement block.

`for (int i = 1;  i < argc; I++) {... }`: Loop through the command line parameter array, starting with index 1, and index 0 is the name of the program.

`LOG("%s", argv[i]); `: Print the currently processed command line parameters.

`if (equals (argv [I], "-nlp")) {... }`: If the current command line parameter is equal to "-NLP", convert the next parameter (`argv [++I] `) into an integer and assign it to naturalParse'.

`LOG("nlp %d, err %d", naturalParse, errorCorrection); `: Print the values of ` naturalParse' and ` errorCorrection'.

`objects.push_back(shared_from_this()); `: Adds the shared pointer of the current object to the ` objects' container.

` if (errorCorrection) {...} else {... }`: Initialize a Boolean value in the ` posCorrectFlag' container according to the value of ` error correction'.

`nlp_parser = new parser(); : Create an object of type' parser' and assign its address to the' nlp_parser' pointer.

`nlp_parser->words_map_initialize(path); : Call the words_map_initialize method of the nlp_parser object, and pass the path' variable as a parameter to initialize the word mapping.

Implementation of function ` CCWW::Plan () `;

`limitcons=8; `: Set the value of the limitcons variable to 8.

`SetSolvedTaskNum(0); `: Call the ` SetSolvedTaskNum function to set the number of tasks solved to 0.

`printf(GREEN "%s\n" RESET, GetTestName().c_str()); `: use the printf function to print the test

ISSN 2706-655X Vol.6, Issue 3: 53-66, DOI: 10.25236/IJFET.2024.060308

name, where ` GREEN' and ` RESET' are macro definitions of the console text state, and ` GetTestName().c_str () ` gets the string of the test name.

`if (! ParseEnv(GetEnvDes())) { return; }`: If the environment description fails to be parsed, it will be returned directly.

According to the value of' naturalParse', the natural language or instruction description is selectively parsed.

Traverse the' infos' container and call the' ParseInfo' function to parse each element in it.

Calculate the number of constraints, add the number of task constraints, information constraints and non-information constraints, and assign them to the variable' consnumber'.

Back up the objects' container and other related variables separately.

Perform task optimization and save the results in the `tasks' container.

Restore variable values of partial backups.

Traverse the `objects' container, find the human object in it and assign it to the `human' variable.

Call the resettasks () ` function to reset the task.

Traverse each task in the `tasks' container, try to solve the task, and print the corresponding log information according to the situation. If the task container is empty, the move operation is performed.

The main function is to analyze the constraints and try to solve the task according to the environment description and task description. It includes environment printing, object location and backup, task optimization and other operations. Used to execute the task plan. Firstly, the number of constraints is set to 8, and the number of tasks solved is initialized to 0. Then print the test name, parse the environment description, and return directly if the parsing fails. Selectively parse natural language or instruction description according to the value of' naturalParse'. Then, traverse the information container and parse each information. Calculate the total number of constraints and back up related variables.

Perform task optimization and save the results, and backup and restore related variables during execution. Traverse the object container to find the human object and assign it to the `human` variable. Reset the task and print the environment description. Then traverse each task in the task container, try to solve the task and print log information according to the situation. If the task container is empty, the move operation is performed.

Finally, the call to the TestAutoBehave ()' function is commented out, which may be used for automatic behavior testing. This code is mainly used to analyze constraints and perform related tasks, including environment printing, object location and backup, task optimization and other operations.

Shows the interaction between objects and robots in a virtual environment. Various classes are defined in the program, such as Item, SmallItem, BigItem, Box, Robot, etc. There are inheritance relations and interactive behaviors among them. The program realizes the processing of objects and instructions through class member functions and operator overloading.

In the program, the Item class represents the basic object, including id, location, type and other attributes, and defines the ToString function to output the object information. SmallItem and BigItem classes inherit from the Item class and represent small items and large items respectively. SmallItem has more attributes of state and whether it is in the container, while BigItem is an extension of the basic object. The Box class represents a box, which, in addition to its basic attributes, also contains a list of small items stored in it and whether it is open or not.

The Robot class represents a robot, which has the function of holding objects and storage bins and can perform various actions. Instruction class is used to define instructions, including behaviors, conditions and related objects, as well as some auxiliary functions. CCWW class inherits from Plug class and Robot class, and represents the controller of the whole environment, which is responsible for planning tasks, parsing instructions, executing actions and so on.

The template function try_cast is used in the program to realize type conversion, and SyntaxNode and Condition structures are used to store syntax nodes and condition information. The program also includes some auxiliary functions and operator overloads, such as split function for string segmentation and ostream overload for outputting information.

The overall structure design is clear, the object-oriented programming idea is adopted, and the

ISSN 2706-655X Vol.6, Issue 3: 53-66, DOI: 10.25236/IJFET.2024.060308

abstraction and expansion of objects and behaviors are realized by inheritance and polymorphism. The program realizes the processing of objects and instructions by overloading the member functions and operators of the class, which makes the code readable and maintainable.

In terms of analysis, the program mainly realizes the state management of objects and the action control of robots in the virtual environment, and realizes the planning and completion of tasks through the analysis and execution of instructions. The program structure is clear and the function is perfect, which shows the characteristics and advantages of object-oriented programming. Through the definition and interaction of all kinds, the relationship between objects and the operation process of robots are displayed, which provides a basic framework for the simulation of virtual environment.

5. Device design background

5.1 Background of Work Research

At present, the production scale of aquaculture farms in China is increasing year by year. The waste and exhaust gas generated by breedingfarms are gradually expanding. Among them, the exhaust gases (ammonia, hydrogen sulfide, mercaptan, etc.) generated by aquaculture farms account for about 16.7% of the total atmospheric pollution in China, which has a significant impact on people's living environment and health. According to the emission standards for aquaculture waste gasin China, the concentration of ammonia emissions in aquaculture farms is below 39.85ppm. At present, the exhaust gas content in most breeding farms is within the range of 32-79.5ppm. When the concentration of ammonia and other exhaust gases is too high, it can affect the growth and vitality of livestock in the farm, and even cause risks such as poisoning and death of livestock. At the same time, the waste accumulation and cleaning efficiency of aquaculture plants have an impact on the overall environment. Therefore, reducing exhaust emissions from aquaculture farms and improving waste treatment efficiency are important aspects related to environmental issues and people's lives.Figure 4 Concentration and proportion of aquaculture waste gas.

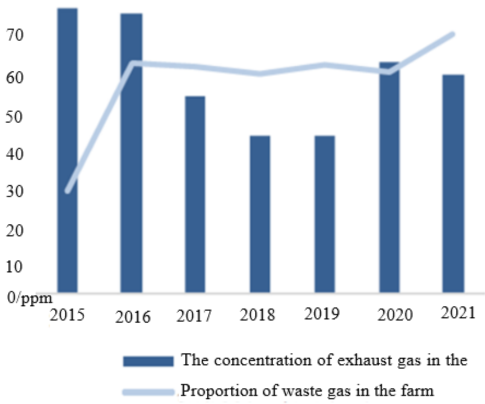

Figure 4: Concentration and proportion of aquaculture waste gas

The methods for treating waste gas in aquaculture farms include physical methods (dilution diffusion, masking agent method, etc.), chemical methods (absorption method, combustion method, ozone oxidation method), and biological methods (biological filters, etc.). The main waste gas substances it processes are ammonia, ammonia hydrogen sulfide, etc. The exhaust gas inside the breeding farm is mainly generated from two aspects: the action of its own enzymes to decompose animal excrement, feed, and other conversion products; On the other hand, it is produced by the decomposition and secretion of organic matter inside and outside livestock and poultry. The exhaust gas inside the breeding farm is mainly generated in breeding houses, sewage piles, etc.

At present, adsorption and ozone chlorination methods are widely used. Adsorption method involves adding enzyme inhibitors to feed and reacting in the body of livestock to reduce the production of waste gas, but it usually has an impact on the physiological health of livestock. The ozone oxidation law utilizes strong oxidizing properties to decompose pollutants. When the concentration of pollutants is high, there are problems such as incomplete oxidation and secondary pollution.

Another issue that also exists is the cleaning of dirt inside the breeding plant. At present, the methods for cleaning up waste from aquaculture farms include: full amount return to field method (all collected, oxidized, and harmless treated, but with a long cycle and low reliability); Composting and returning to

ISSN 2706-655X Vol.6, Issue 3: 53-66, DOI: 10.25236/IJFET.2024.060308

the field (short cycle, high odor generated by oxidation treatment, difficult to treat) and other methods. Therefore, as shown in the Figure 5 the separation of exhaust gas and waste in the breeding house has caused waste time, low efficiency and other treatment problems.

Based on the above problem summary, it is necessary to design an integrated device for coupling and treating waste gas and waste gas to improve the efficiency and effectiveness of waste gas and waste treatment.

Figure 5: Environment of the breeding house

5.2 Significance of Work Research

To address the issues of low efficiency and poor effectiveness in the treatment of waste gas and waste in livestock farms, a device for integrated waste gas and waste coupling treatment is designed to solve the problems of high concentration of waste gas accumulation and slow processing speed inside the farm. Intelligent detection ensures the safety of the air in livestock and poultry houses; Simultaneously connecting waste treatment and exhaust gas treatment through aerodynamic coupling to prevent waste accumulation and the problem of waste gas regeneration; For the issue of waste disposal, this project ensures comprehensive cleaning of ground pollutants, which is of great significance for solving the efficiency and effectiveness of waste gas treatment in breeding houses.

6. Current research status and development trends at home and abroad

In recent years, research institutions at home and abroad have gradually developed their research on emission reduction and waste treatment of livestock and poultry houses, and there have been more and more methods for treating livestock and poultry waste. However, no research, patents, or papers on integrated treatment of livestock and poultry waste have been found so far. The waste treatment in the breeding house includes the absorption of exhaust gas (to maintain a safe concentration), collection and cleaning of ground pollutants (to prevent accumulation, difficulty in cleaning, and secondary pollution). The working principle is to treat exhaust gas through exhaust gas absorption liquid, collect and roll the ground pollutants for dehydration, etc.

However, at present, using fans to discharge exhaust gas from livestock and poultry houses will cause pollution to the environment, while using biological methods to treat exhaust gas in livestock and poultry houses will have an impact and low efficiency on livestock and poultry; Cleaning up ground waste will result in low efficiency. Therefore, the project proposes an integrated treatment device for exhaust gas and waste, which is suitable for efficient working environments in aquaculture farms.

The integrated treatment of aquaculture waste gas and waste is to absorb and clean the waste gas and ground pollutants, and achieve the goal of simultaneous cleaning through the connection of mechanical mechanisms. How to ensure that the exhaust gas concentration in livestock and poultry houses is always maintained at a safe concentration and has a high exhaust gas absorption efficiency, and how to couple the two treatments into a unified whole is the key to the research and design of livestock and poultry house cleaning.

ISSN 2706-655X Vol.6, Issue 3: 53-66, DOI: 10.25236/IJFET.2024.060308

7. Technical roadmap, proposed solutions, and expected outcomes

7.1 Overall scheme design

Regarding the generation characteristics and treatment requirements of waste gas and waste in livestock and poultry houses, it is necessary to ensure that the concentration of waste gas in the breeding house is within the normal range, and to improve the absorption and treatment efficiency of waste gas; For the treatment of ground waste, it is necessary to ensure a comprehensive cleaning range and effectiveness; At the same time, in order to improve the overall cleaning efficiency of livestock and poultry houses, it is necessary to couple and integrate the treatment of exhaust gas waste.

In order to achieve the above cleaning function, a coupled pneumatic integrated treatment device for aquaculture waste gas was designed. In order to ensure that the concentration of exhaust gas in the breeding house is always within the normal concentration range, the project has designed a Raspberry Pi combined with TCP network port protocol (real-time transmission of exhaust gas data); In order to achieve high efficiency in exhaust gas absorption, a Kangda tube and a swirl intake structure were designed; At the same time, in order to achieve integrated treatment of exhaust gas and waste, a coupled pneumatic mechanism was designed; In order to achieve better ground cleaning results, a visual detection module based on OpenCV was designed, which captures the distribution of dirt on the ground through OpenCV and feeds feedback to the Raspberry Pi control module, thereby manipulating the ground cleaning structure to achieve cleaning. The schematic diagram of the device for this project is shown in Figure 6. The work flow chart is shown in Figure 7.

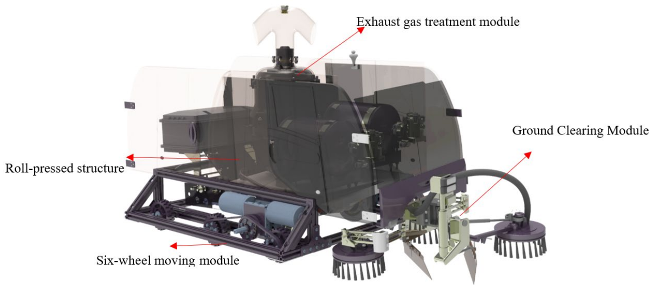

Figure 6: Schematic diagram of integrated treatment device for coupled treatment of aquaculture waste gas and waste

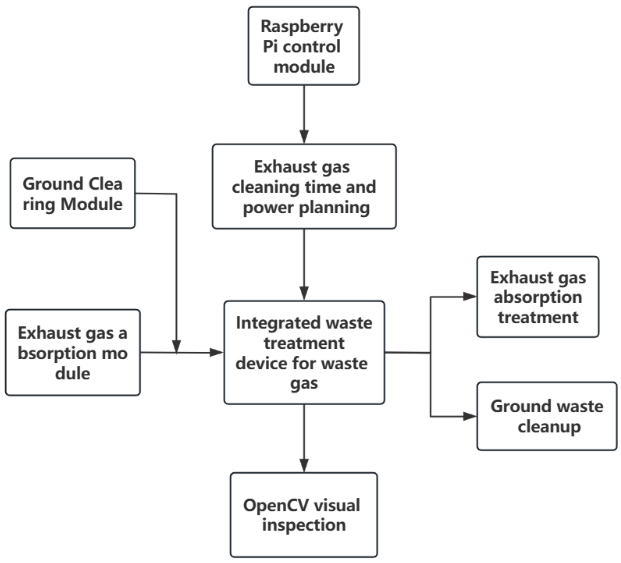

Figure 7: Workflow diagram of integrated treatment device for coupled treatment of aquaculture waste gas and waste

7.1.1 Exhaust gas absorption module

The function of the exhaust gas absorption module is to form a stable inlet airflow through the action of the Condor tube and the swirl intake, and then use a spray tower to absorb the exhaust gas in the

ISSN 2706-655X Vol.6, Issue 3: 53-66, DOI: 10.25236/IJFET.2024.060308

internal treatment chamber. And facilitate the subsequent transfer of the pressure and heat generated by the absorption of exhaust gas through the coupling pneumatic mechanism in the second part to the next round of exhaust gas treatment process. The exhaust gas absorption module mainly consists of a Kangda tube, a swirl intake structure, and a gas treatment chamber.When the device is started, the swirl intake structure drives the shaft through the motor, causing the twin turbine structure to form a pressure drop both internally and externally, and forming a stable swirl at the Kangda pipe, pushing the exhaust gas to the gas treatment chamber, and then absorbing the exhaust gas for treatment.

The Kangda tube and swirl intake structure are used to ensure that the exhaust gas in the working space of the device can stably enter the treatment device during operation, and effectively remove it by fully combining the swirl in the absorption treatment chamber. The swirl intake structure mainly consists of a twin turbine structure, an intake channel, and an internal motor shaft. During the operation of the device, a dual turbine structure is driven by an electric motor to form a pressure drop distributed along the pipeline due to the vortex flow[7-10].

The working principle is based on the Kantar effect. When the turbine rotates to the operating frequency, an airflow is formed at the pipe opening, promoting the surrounding fluid to flow along the concave convex structure of the pipeline and forming a stable gas transport layer inside the pipeline. To ensure the stable transmission of airflow within the Conda tube, the diameter of the tube is approximately 32cm-40cm. The turbine adopts RB-72S-4 vortex fan.The device diagram of treating liquid recovery tank is shown in Figure 8.

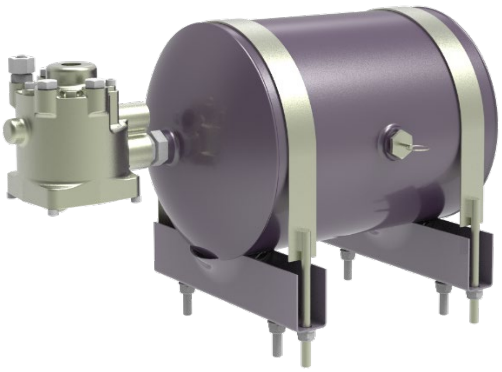

Figure 8: Processing liquid recovery tank body

7.1.2 Waste cleaning module

The waste cleaning module is mainly aimed at cleaning the waste generated inside the breeding farm, including scraping and collecting ground waste, roller dewatering, etc; Designed a three link ground cleaning structure and a rolling treatment mechanism, as shown in the figure 9.

The ground cleaning structure mainly consists of a three link cleaning mechanism, a water pipe, a scraper, etc. As shown in the figure 9. The three link cleaning mechanism consists of a connecting rod, a servo, and a brush. To ensure comprehensive cleaning of the ground, a connecting rod mechanism as shown in Figure 10 was designed, with a connecting rod length of 45cm. The RS485 model servo was selected for the servo. The length of the roller is 8

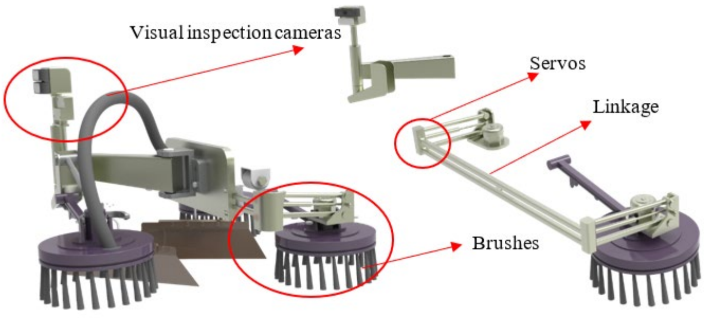

Figure 9: Schematic diagram of ground cleaning mechanism

The main task of this module is to operate the multi-stage drive linkage mechanism and scraper to hang and collect ground dirt when the detection device detects it, and to achieve the purpose of cleaning through the rotation of the brush and the water pipe. This section can be used for two types of waste treatment according to the needs of the breeding farm. If there is a need (such as for farmland) to use waste for composting and fermentation treatment, the collected waste will be transported to the collection warehouse; If there is no other need for utilization, extrusion dehydration can be directly carried out to prevent waste from spoiling and generating pollutants. The roller press mechanism is shown in Figure 10.

For the collection and rolling of waste, when ground dirt is detected, the driving device is activated, and the cabin and push rod begin to adjust their positions (the cabin adjusts the angle to facilitate the movement of waste; the push rod adjusts the force point according to the different shape and position of the dirt). When it moves to the front of the dirt, the double push rod structure pushes the dirt to the cabin. At the same time, the remaining waste residue on the ground is cleaned by driving a rotating brush with an electric motor. In the case of dehydration, the device transfers the waste to the roller dewatering section for further pollution prevention treatment. Finally, stack and collect the dehydrated compressed blocks uniformly.

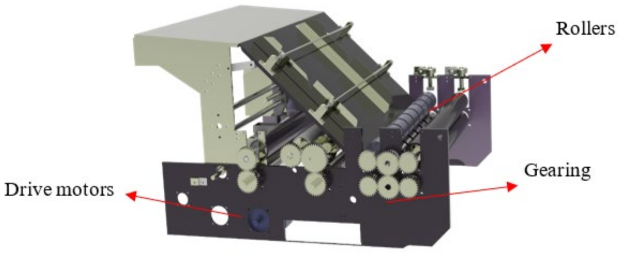

Figure 10: Roller pressing mechanism

7.1.3 Control, detection, and movement modules

The purpose of exhaust gas absorption treatment is to ensure that the concentration of ammonia and hydrogen sulfide inside the livestock and poultry house is kept within a safe range (about 39.85ppm or less). It is necessary to install a device to detect the concentration and distribution of exhaust gas in the livestock and poultry house in real time, and timely absorb and treat the exhaust gas inside the livestock and poultry house. At the same time, for the dirt on the ground, the device needs to be cleaned up in a timely manner to prevent the accumulation of waste and the generation of secondary exhaust gas, which increases the difficulty of treatment.

The control of this project is mainly achieved through the Raspberry Pi embedded development board and OpenCV visual detection, to achieve intelligent detection, absorption, and automated collection and cleaning of waste gas. For the exhaust gas in the livestock and poultry house, this project is connected to the TCP protocol of Raspberry Pi through the ammonia detection device installed in the main livestock and poultry house, which can transmit data on the concentration and distribution quality of exhaust gas in different spaces inside the house to the device. By reasonably calculating and setting the time and power for treating exhaust gas, the device can work efficiently.

The monitoring of ammonia and other waste gases in the project adopts spectral detection method (based on molecular absorption spectroscopy theory). The gas in the selected space is scanned by a light source, and the concentration and pressure parameters of the gas are obtained by analyzing the spectrum (the scope of this spectral detection device is between 1.8m and 2.2m). The second part is to adjust the processing power. After the detection is completed, the concentration and processing capacity of the measured exhaust gas are transmitted to the regulating system, and the regulating system then adsorbs the measurement space based on the data combined with the processing efficiency of the device.

The mobile module is driven by a motor to drive the pulley to rotate the shaft, causing the moving wheel to move the device forward, as shown in Figure 11 and Figure 12.

For the cleaning of ground waste, the device uses OpenCV's visual detection to visually inspect the surrounding ground and controls the cleaning mechanism to achieve automated cleaning of ground waste.

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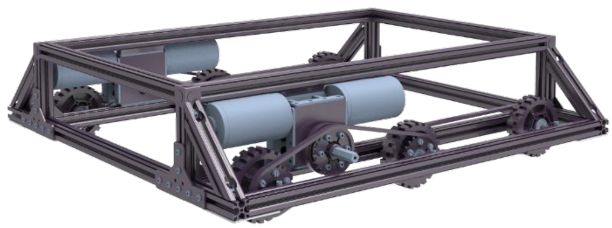

Figure 11: Schematic diagram of mobile structure

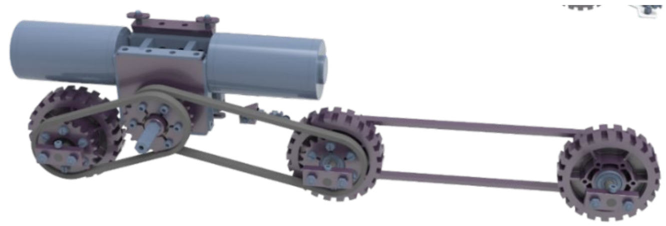

Figure 12: Schematic diagram of the transmission structure of the mobile mechanism

7.2 Feasibility analysis

7.2.1 Simulation analysis of swirl intake

In order to better illustrate that coupled pneumatic mechanisms can achieve better work efficiency, simulation analysis of coupled pneumatic mechanisms was conducted using Simulink in Matlab, as shown in Figure 13. The main parameters analyzed are the energy transfer of aerodynamics under working conditions, as well as the gas flow rate and pressure drop inside the cylinder. Firstly, analyze the internal flow rate and pressure of the cylinder:

$$p_1 = \frac{Q - q_0}{c} \tag{1}$$

In the formula, Q represents the flow rate inside the cylinder, in m3/s;

P1 is the pressure inside the cylinder, in Pa;

Q0 is the flow rate inside the ventilation pipe, in m3/s;

C is the flow coefficient.

$$q = C_d \cdot A\, sgn(p_1 - p_2)\sqrt{\frac{2}{\rho}(p_1 - p_2)} \tag{2}$$

In the formula: Cd is the flow coefficient with holes in the cylinder;

ρ Is the fluid density, in kg/m3;

P2 is the pressure at the lower nozzle of the cylinder, in Pa;

By querying relevant information and calculating the parameters of the model, it can be concluded that the flow coefficient with holes in the cylinder is 0.61; In the simulation, as shown in Figure 14, the initial flow rate of the ventilation pipe is 0.05m3/s. At t=0.04s, the pressure inside the cylinder decreases and then recovers and rises to normal working state; It can be seen from this that this pneumatic device can achieve good working conditions.

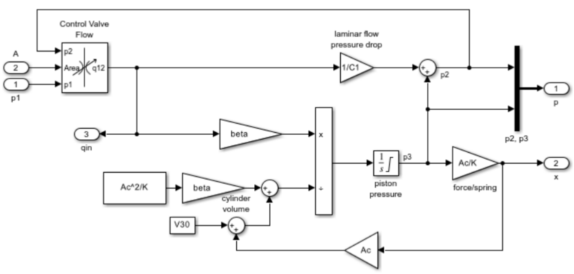

Figure 13: Simulink simulation of coupled pneumatic mechanisms

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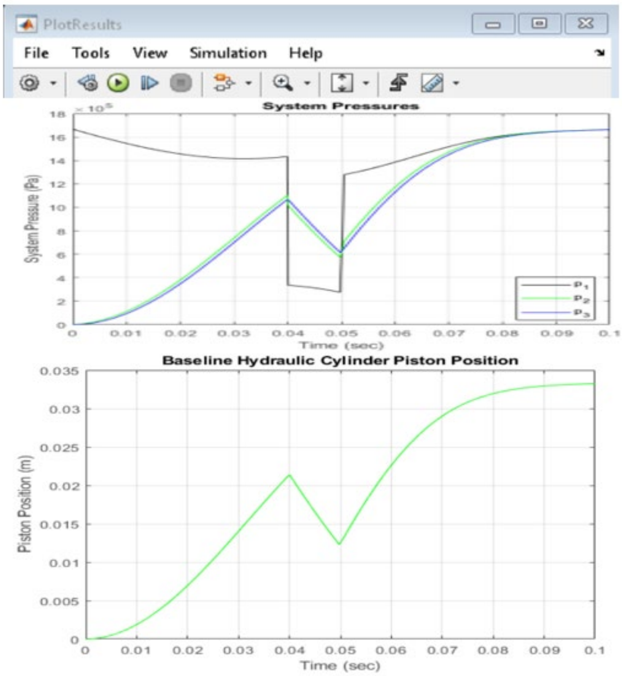

Figure 14: Model Simulation Analysis Results

7.2.2 Simulation Analysis of Three Link Cleaning Structure

To demonstrate that the three link cleaning structure can achieve ground cleaning without damage due to pressure, an inventor simulation model is established for simulation analysis. In actual working conditions, the connecting rod shaft is made of alloy steel, with a thickness of 2cm and a length of 8.5cm. Apply a force of 400N in three directions on the shaft and measure its compression situation. The simulation results obtained are shown in Figure 14.

In the simulation analysis, as shown in Figure 14, the maximum compression at the bending point of the connecting rod shaft is still within the acceptable range, which means that the connecting rod shaft can ensure normal operation, rotation, and movement.

7.3 Expected Results

1) Building a physical model of an integrated device for the treatment of livestock and poultry waste gas and waste;

2) Publish one patent or paper related to the project;

3) Write a project proposal.

8. Existing foundation

8.1 Research accumulation and achievements related to this project

This project is based on the current situation of waste gas treatment in aquaculture farms, and designs an integrated device for waste gas treatment. At present, there are many treatments and methods for exhaust gas and waste in aquaculture farms, but there is relatively little research on integrated treatment devices, and the treatment efficiency of related methods is generally low. This project combines the treatment principles of exhaust gas and waste, and designs various mechanical mechanisms and treatment methods to obtain the final integrated treatment device for exhaust gas and waste.

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