Journal of Applied Science and Agriculture, 10(8) Special 2015, Pages: 1-7

AENSI Journals

JOURNAL OF APPLIED SCIENCE AND AGRICULTURE

ISSN 1816-9112

Journal home page: www.aensiweb.com/JASA

A New Mobile Robotic System for Intensive Aquaculture Industries

[1]Muhammad Azmi Ayub, [2]Sahril Kushairi and [3]Amir Abdul Latif

[1]*Universiti Teknologi MARA, Faculty of Mechanical Engineering , Malaysia*
[2]*Universiti Teknologi MARA, Faculty of Mechanical Engineering , Malaysia*
[3]*Universiti Teknologi MARA, Faculty of Mechanical Engineering , Malaysia*

ARTICLE INFO

Article history:
Received 28 January 2015
Accepted 25 February 2015
Available online 6 March 2015

Keywords:
Keyword 1 (Font: Times New Roman 8pt)
Keyword 2
Keyword 3
(At least 3 and at most 8 keywords)

ABSTRACT

Background: In order to meet the increasing demand from agriculture industries in Malaysia, a fully automated robotic system is designed for intensive fish farm industries. **Objective:** The overall objective of this project is to introduce an automated method in fish feeding and water monitoring for intensive aquaculture industries. **Results:** This project is incorporating mechanical, electrical and software development, and will be focusing on design process of the robotic system. A structure approach will be discussed in designing and fabricating the drives and control mechanism, and the feeding mechanism of the robotic system. **Conclusion:** The results show that the automated feeding using mobile can reduce hire worker cost, enhance the table quality of fish, safe and practical to agriculture industries, improve agriculture technology, and more economic in long term fish food management.

To Cite This Article: Muhammad Azmi Ayub, Sahril Kushairi and Amir Abdul Latif., A New Mobile Robotic System for Intensive Aquaculture Industries. ***J. Appl. Sci. & Agric.,*** *10(8): 1-7, 2015*

INTRODUCTION

In line with the Malaysian government policy, the promotion of agriculture especially in intensive aquaculture industry is very emboldened. The growing demands for fish and the heavy expense involved in fish farming have generated increasing interest in intensive aquaculture. It is one of the potential sub sectors that can contribute to Malaysia revenue. In future, Malaysia can become a potential fish exporter resulting in research on aquaculture development and biotechnology. It is a fact that aquaculture sector provides about 60% of the protein intake of the world including Malaysia. As such, Malaysian government expects demand for fish for human consumption to increase from 1.2 million tonnages per year now to 2.9 million by 2020. However, it is difficult to supply the demand since there are many problems faced by these industries. The overall cost of feeding process is usually the greatest operating cost in aquaculture industry. Over feeding will results in leftover feeding foods in the fish pond and this leads to not only the extra-cost, but also poor water quality. Another main problem is that some aqua species are less mobile such as prawns, cuttlefish and crackles that need the distribution of food is spread well all over the ponds. Similarly, sampling of water also needs to be done at several locations throughout the pond. It is a fact that it is difficult to achieve even distribution of feeding food process or water sampling process by using manual techniques. As a result of this, the growth rate of fish will not be optimum due to either improper feeding or less quality of pond water. Other main problems that occur in this sector are shortage of workers, low growth rates of fish, high competition level for forage fish and low survival rates of hatchling fish (Hanafi, H. H.,1991).

Due to these problems, there is a need to automate the feeding process and the water monitoring process. Robot has been used to replace human job especially in the industrial manufacturing sector (Ayub *et al*. 2012, 2014). The robot technology also been applied in agriculture sector such as Autonomous Cucumber Picking Robot (Van Henten et. al. 2003) and Harvest Lettuce Robot (Kondo and Monta, 1999). In-line with this application, therefore, an automated robotic system for intensive aquaculture industry is developed. The final function of this robotic system is to be used as a multipurpose task on the fish farm industries such as water monitoring process and food feeding process. This robotic system can be controlled manually and automatically in order to manage the fish farm more effectively.

Corresponding Author: Muhammad Azmi Ayub, Universiti Teknologi MARA, Faculty of Mechanical Engineering , 40450 Shah Alam Malaysia,
E-mail: muhammadayub@salam.uitm.edu.my

1.0 Management of fish farm system:

Fish farms are usually managing in three major systems, that is open system, semi closed system and closed system (Matthew Landau, 1992). An array of fish cages are used in all of these systems. There are two types of cages. They are hard cages and soft cages. Hard cages are usually constructed of extruded plastic mesh and soft cages are constructed of nylon netting mesh.

Open system are usually build at the sea, river, lake or other source that does not need pump to operate. The cage are form as a floating bag that been supported by some floating system at the surface. A frame is used to keep it in open system. Usually it was constructed by polyvinyl chloride (PVC) pimping form into water tight square which supports the net to a ready made timber or metal assembly with build in polystyrene float chambers and working platform around the parameter. The cage sizes are depending on the type of species, stocking time and the number of fish. For examples, the recommended number of fish for cage size 2x3m of tilapia and catfish are 1000 and 1200 respectively. Semi Closed System is applied for freshwater fish farm. The water sources of system are taken directly a lake, river or other natural source. The pond in this system is simply holes in the ground and most of it in rectangular shapes as shown in Figure 1. The ponds are generally at least 1m depth with soil on sloping that depends on the stability of the soil. Closed system is a system that needs little or no water exchanged and treatment of the water technique was used. Tanks are usually been used in this system and made of concrete, plastic or wood. The tank are in circular shape to have a greater velocity, circulation and mixing of the water in circular tanks.

Fig. 1: Aquaculture ponds and different size of pallets food.

2.0 Feeding Techniques:

Some basic biological principles must be understood before a fish farm system can be properly managed. The quantities of fish that can be produced are affected by several factors: nutrients (increase the amount of food available to the fish, which results in greater fish production), the quantity and quality of fish food, proper brood stock and elimination of unwanted competition (Tempelton R. G., 1995). These factors need good management and they can be much easier to manage if the fish farm systems are properly constructed. There are a number of ways in feeding technique applied in aquaculture industries. The common techniques that have been used by farmers in feeding technique are manual feeding technique, semiautomatic feeding technique and automatic feeding technique.

Manual feeding technique is a technique that refers to scooping by feed out of bag or tube and flinging into the pond. This technique also called hand feeding technique. This technique is slow and commonly used at cage and small pond industries. Semiautomatic feeding technique is commonly used in large commercial farm. A semiautomatic feeding device are used and placed on a truck, or pulled by a tractor. The pellets or food then will be shot into the pond or raceways. Automatic fish feeders are still new in aquaculture industries. The purpose of automatic fish feeder is to reduce human jobs. Currently, this devise are very expensive and usually very complex. There are a few types and models have been invented to improve the function of automatic fish feeder system (Gieling *et al*.,1996).

One of automated fish feeder is called demand feeders which are controlled by the fish. This device operates when the fish bumps into the trigger. These devices are not practical in commercial fish farm industry since the quantity of the fish is very big. Usually this device is used for analysis of fish behaviour, dietary and other types of biological study(V.C.Rubio *et al*., 2003). Another automated feeding technique shoots the pallet foods in one direction and can be positioned hanging out over the water or on the side of the pond. The feed dispersed directionally up to forty-five feet. Since it was placed statically, it only practical for open fish farming or pond only but not suitable applied at cage type farming. Uneven distribution of food delivery to the fish is another major disadvantage of this type of fish feeder.

3.0 Design methodology of an automated feeder for intensive fish farm industries:

Designing a automated fish feeder requires a comprehensive understanding of fish behaviour and attributes so that it is easier to relate these attribute with the engineering characteristic of the automated feeder system. Besides that the system must be robust so that it can withstand under a severe weather condition. Therefore, a systematic design

Journal of Applied Science and Agriculture, 10(8) Special 2015, Pages: 1-7

methodology is required in order to obtain optimum design result. A structured design approach similar to (Pahl G., and Beitz W. 2001) has been adopted in the development of automated feeder technique for the intensive fish farm industries. The overall procedure of the design methodology for the development of the automated robotic system consists of 5 steps, which are; problem identification, conceptual design, preliminary design, detailed design, design communication and final design.

An important first step in the design methodology of the robotic system is problem identification. The techniques involved in this step are discussion and understanding of the needs of the intensive fish farm industries and Ministry of Agriculture. The overall objective tree of the robotic system, including both the drive mechanism and the food delivery and water monitoring mechanism, is shown in Figure 2. The objective tree shows in a diagrammatic form the ways in which different objectives and constraints are related to each other, and the hierarchical pattern of objectives and sub-objectives. As depicted in the objective tree, the prime objective of the test-rig development is to have a high performance robotic system. This prime objective is divided into two main sub-objectives, which are reliable operating characteristics of the robotic system, and high feeding and monitoring quality. These main sub-objectives are expanded into several other lower sub-objectives and then finally it is expanded to the lower hierarchy of the objectives. In order to have reliable operating characteristics, the robotic system must have a stable handling , high safety, high structure integrity and good system dynamics. In general, problem identification requires the objective and requirement of the robot to be effectively clarified. The objective tree offers a clear and useful format for depicting the design objectives and requirements.

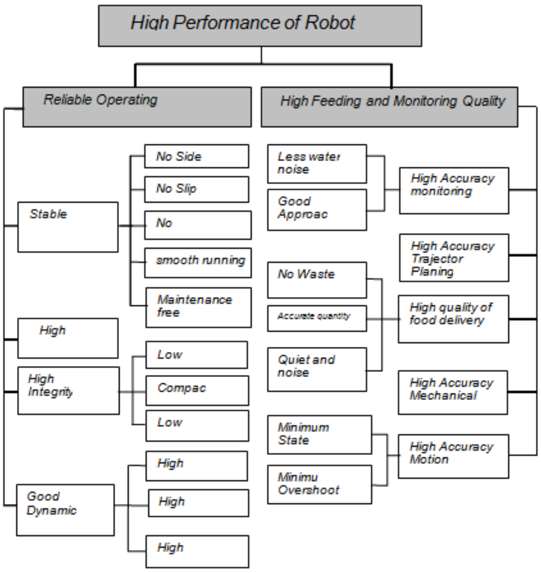

Fig. 2: Objective Tree of the robot System.

The house of quality for the robotic system is shown in Figure 3. The robot attributes basically is what the fish farm industry needs relative to their importance. Relative value 10 is very important and relative value 1 is the least important. The engineering characteristics are the technical features of the robot system. This perception shows the competitiveness between the existing manual approach and the automated robotic approach for the intensive fish farm industries. Perception value 5 indicates that the cutting approach is very competitive and value 1 indicates that it is less competitive.

4.0 Detailed Design of the robotic system:

Figure 4 shows the picture of the final test-rig for the automated robotic system for the intensive fish farm industry. The features of the mechanical design for the robotic system are based on a mobile robot system. The mobile robotic consists of a carriage, manipulator, controller, drive mechanism, end-effectors, power supply and food delivery mechanism. The carriage is mounted on a track slide that runs on the cages of fish pond industry. The mechanical design of this material handling system allows for high speed and acceleration with minimum flexing and vibrations. These characteristics have been achieved through the following design measures,

- Unique design concept of material handling mechanism
- Minimised mass of moving parts without compromising structure integrity

Journal of Applied Science and Agriculture, 10(8) Special 2015, Pages: 1-7

- Closely matched inertia of the system to the servo-motor inertia
- Use of pneumatic system for quiet food delivery system

The mobile robot it is statically balanced and moves on the track that runs over every cage of the pond. The mobile robot is driven by four wheel drive system. A DC-servomotor coupled with worm gearing system is used to drive the four wheels. Four guide rollers are employed to ensure that the carriage is always securely and smoothly run on the track. The feed delivery system will dispersed fish food as the mobile robot reach the required location of the cage. The mobile robot and the automatic feeder operates by using a peripheral interface controller, PIC 16F84A microcontroller, with programming timer that allows for delivery of different quantities of fish feeding food. The microcontroller will control the motor drive system, read sensors and communicate. The program of robot is written in MPLAB software and burn into PIC chip by PIC start Plus device. For this robot, the programme has been set up for automatic and manual operation. The capabilities of controller are supported by several printed circuit boards. Each of these printed circuit boards serves an important function in the total operation of the robot and food delivery system. The electronic circuit consist of the electronic components use to support the controller. The electronic components of the robot consists of 12 volts relays, Tip 41c Transistor, Power Transistor MJ 11016, Diode IN 4001, Resistors, Push Button Switches, PIC 16F 84A, Voltage Regulator 7805 1, Capacitor 10 mf, control console. The robot uses a 12 volts sealed rechargeable battery as a power supply. The battery will deliver the power for operating of the controller and the motor of drive mechanism.

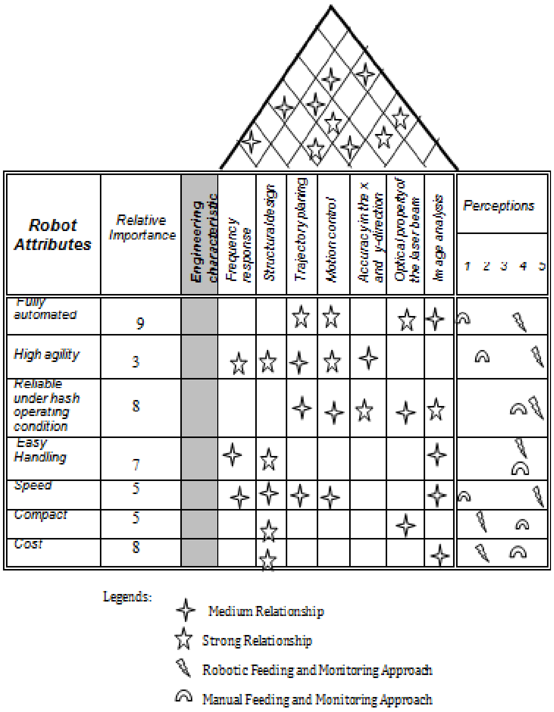

Fig. 3: House of Quality for the Robotic System.

Two end-effectors are attached to the body of robot and these end-effectors will rotate to distribute the fish food. The end-effectors are made from hollow steel with particular shape. The carriage of robot is design to be light in weight and with small size as possible. The shape of the structure is rectangular and the material of the structure is an aluminum plate with 2mm thick. The body consists of base, upper body, top cover, front cover, back cover, front support and back support. The structural was made by galvanized materials to ensure years of trouble free.

5.0 Performance of the drive mechanism of the mobile robot:

The agility of the drive mechanism of the mobile robot system is one of the important criteria. The simulated performance on the agility of the drive mechanism of the mobile robotic system was performed under Matlab and simulink environment. Frequency response technique is used to evaluate the agility of the mobility robot. Figure 5 shows the result of the frequency response of the drive mechanism for different gear ratio. The drive mechanism uses worm gear that drive the four wheels of the mobile robot. The result s show that a

Journal of Applied Science and Agriculture, 10(8) Special 2015, Pages: 1-7

higher gear ratio give higher system bandwidth. However, as the gear ratio reach to a certain value the bandwidth of the system does not change significantly. Therefore, the smaller gear ratio value that higher system bandwidth is the best to be used for the drive mechanism. This is to ensure high speed as well as maximum acceleration of mobile robot.

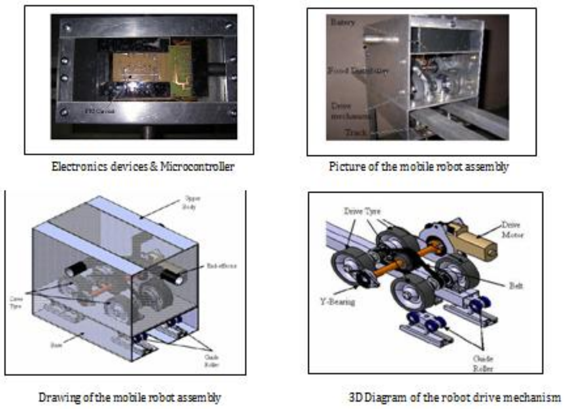

Fig. 4: Detailed design of the robotic system.

6.0 Food delivery mechanism for the mobile robotic system:

The food delivery system uses a vacuum system to deliver the food. The system consists of vacuum, hose and end-effector as shown in Figure 6. An aspirators vacuum system (powered by compress air) is use to generate the vacuum power in the food delivery system. The vacuum attached to the compressor use a Bernoulli’s principle (where the velocity of a fluid is height, the pressure is low). A hose connect between a vacuum and an end-effector will deliver the food to an end-effector where the food will distribute to the pond. The drive system is use to placed the robot from pond to pond. The vacuum is basically like a pipe with a narrow constriction (the throat). The following air speed from the compressor up as it passes through this constriction and so, the pressure is lower. Because of the reduced pressure, food under atmospheric pressure in the tank is forced into the air stream in the throat and into a hose. The food then been distributed to the ponds through end-effector.

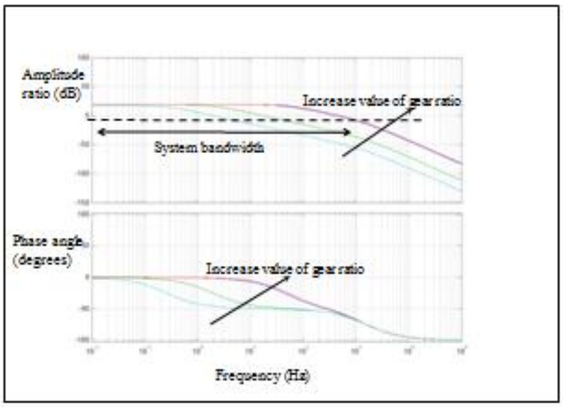

Fig. 5: Result for the frequency response of the drive mechanism.

Besides the quality, source and quantity of water, fish food needs proper management in order to produce quality of fish and to avoid financial loss. There are several factors that need to be considered for a good feeding management; types of food, feeding rate and time, and method of feeding. Fish must be feed nutritionally complete diets which have protein, amino acids, energy levels, vitamins and minerals. The pallet foods manufactured by commercial feed companies which consist of these supplemental diets are use for feeding fish as shown Figure 1. There are three size of pallet food: 1) Small: 2.7 mm to 3.0 mm, 2) Medium : 5.0 to 5.5 mm, 3) Large : 6.5 mm to 7.5 mm. The fishes need to be fed about six hours apart and about the same time each day (once in mid-morning and again in early evening). They should be given only what they can eat in a 15 to 20 minute interval. Fish feed best when water temperatures and dissolved oxygen concentrations are high. The feeding method must be less noise so that it will not disturb and stressed the fish. Two sizes of foods were used in order to determine the performance of the food delivery mechanism as shown in Figure 7. Figure 7 shows the experiment result for small size 2.7mm to 3.0 mm and for medium size 5.0 to 5.5mm respectively. The results show the amount of food delivery in grams to the cage for different suction pressure as the pressure are varied from 6 bar, 4 bar and 8 bar. As predicted the higher the pressure, the amount of food delivers to the cage is increasing for both sizes of food. For all the three different pressures show that the small size of food have higher amount of food delivery for the same duration of 50 seconds. For example, the same suction pressure of 8 bar will deliver 880 gram of small size food or 730 gram of medium size of food. This is due to the fact the medium size food has greater individual weight of granular size. The nonlinear shape of the curve is main cause of the turbulence flow in the delivery hose.

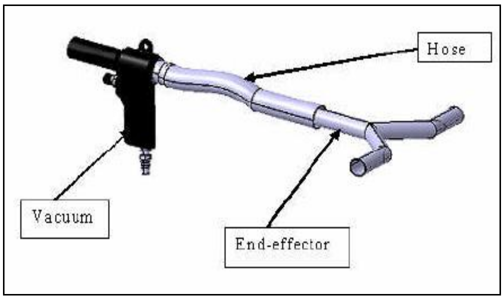

Fig. 6: Schematic drawing for the food delivery system.

7.1 Performance of the food delivery mechanism:

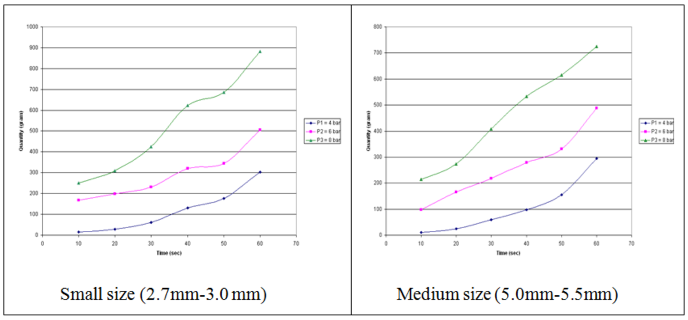

Fig. 7: Results for the food delivery system.

There are several advantages using this novel automated fish feeding process compare to the existing manual method of fish feeding. These include faster process of food delivery mechanism, less noise, even distribution of the food, accurate amount of food quantity and less long term capital.

7.0 Conclusions:

There is no doubt that the short term objectives of this research project has been achieved This includes upgrading the fish farm technology, extending the application of mobile robot and introducing a novel method in food management in fish farm sector. A structure design process to realize the novel design concept mobile robot has been proposed. The performance of the drive mechanism and the food delivery system are evaluated. The performance results show that the automated feeding using mobile robot system is far better that the manual technique of fish feeding. Therefore, this mobile robot system is suitable for aquaculture environment that can reduce hire worker cost, enhance the table quality of fish, safe and practical to agriculture industries, improve agriculture technology, and more economic in long term fish food management.

ACKNOWLEDGEMENT

The authors thankfully acknowledge the financial support from the Malaysia Government Research Grant (Ref: FRGS/1/2014/TK01/UITM/02/1, Safety augmentation of human-robot interaction based on real-time visual and force servoing control information)

REFERENCES

Ayub, M.A., R. Tajuddin and M.R. Jackson, 2012. Intelligent gripping system for handling

Journal of Applied Science and Agriculture, 10(8) Special 2015, Pages: 1-7

flexible web fabric, Assembly Automation, 32(3): 276-283.

Ayub, M.A., B.M. Azmi, A.H. Esa, 2014. In-line Inspection of Roundness Using Machine Vision, Elsevier Procedia Technology, 15: 808-817.

Gieling Th., H., E.J. van Henten, E.A. Van Os, O. Sakaue, A.T.M. Hendrix, 1996. Conditions, Demands And Technology For Automatic Harvesting Of Fruit Vegetables. ISHS Acta Horticulturae 440, International Symposium on Plant Production in Closed Ecosystems.

Hanafi, H.H., 1991. Present Status Of Aquaculture Practices And Potential Areas For Their Development In South Johore, Malaysia, Proceedings of the ASEAN/US Technical Workshop on Integrated Tropical Coastal Zone Management 28-31 October 1988 Temasek Hall, National University ofSingapore

Kondo, N., M. Monta, 1999. Chrysanthemum cutting sticking robot system. Journal of Robotics and

Matthew Landau, 1992. Introduction to Aquaculture. John Wiley & Son, Inc, Canada.

Pahl, G. and W. Beitz, 2001. Engineering Design: A Systematic Approach, 2nd. Edition, Springer, ISBN 3540199179.

Rubio, V.C., 2003. Self-Feeding Of European Sea Bass Under Laboratory And Farming Conditions Using A String Sensor, Department of physiology, University of Murica, Spain.

Tempelton, R.G., 1995. Freshwater Fisheries Management, 2thedition." Fishing News Books.

Van Henten, E.J., 2003. Collision-free motion planning for a cucumber picking robot. Journal of Robotics and Mechatronics.