IoT Application on Aquaponics System Energy Optimization

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Abstract. The increasing need for foodstuffs with the availability of less productive agricultural land, causing the shortage of food to meet people's food clothing. Modern cultivation techniques such as aquaponics system, methods and combined advances in the field of communications technology, in this case the use of the internet of things with web interface technology can be the best solution to reduce food needs are increasing every year. This research designs internet of things application on aquaponics cultivation system with web interface technology consisting of Raspberry Pi, ATmega328, Turbidity Sensor, LDR Sensor, DHT22 and Relay as output control. Produced a modern crop and fish cultivation system, capable of providing real-time information to users. So that users can monitor water turbidity, plant lighting intensity, temperature and humidity of cultivation space and control fish feeding, plant lighting and water circulation pump aquaponics aquaculture system through web interface technology although from long distance. The design result of this tool proves that the use of internet application of thing is very useful especially in the field of cultivation because it can reduce the time needed to care fish and plants.

Keywords: personnel identification, voice recognition, neuro fuzzy, RDE, Shannon Entropy

1. Introduction
The use of internet of things is growing rapidly in Indonesia, because it is influenced by the rapid development of telecommunication technology in the last decade. The development of internet technology of things affects all areas of science that exist in society, including also in the field of cultivation or modern agriculture. Modern agriculture can be applied because it does not require a large area of land, this is in accordance with the decreasing availability of productive land so as to meet the demand and the need for food which increases due to the increase of population.

The model of cultivation on the land or narrow narrow, one of the cultivation model that can be used in the fulfillment of food needs is aquaponics cultivation model. In this system with the same area it will be able to produce two commodities ie plants, especially vegetables and fish. The concept is to plant the plants in small pots and then put on a large pipe that has been perforated pot-size so that water residual watering drip from the pot can be channeled to the pond under it, to be reused as fish pond water, which will also be used for Watering the plants.

However, the problem with aquaponics aquaculture model is that people do not have much time to take care of plants or fish in the yard though. Lack of attention to feeding and rarely replaced the pond water to make plants and fish eventually died because the turbid water is not well maintained. So we need a system of treatment with control and monitoring in order to maintain the fertility of plants and...
fish. Current control or control systems are beginning to shift to control systems that demand the use of computers and telecommunications technology (internet of things), so that human intervention is very small and able to access it without face to face.

Based on these needs, then it is made: "IoT Application on Aquaponics System Energy Optimization" with the aim of facilitating the maintenance of fish and plants and ponds becomes easier.

2. Theory

2.1. Internet of Things

Internet of things (IoT) was first introduced by Kevin Ashton in 1999. Although it was introduced 15 years ago, there is currently no global consensus on the definition of IoT (Wikipedia, Internet of Things, 2017). But in general the concept of IoT is interpreted as an ability to connect intelligent objects and allow them to interact with other objects, the environment and other intelligent computing devices via the internet network. IoT in its various forms has begun to be applied to many aspects of human life. CISCO has even targeted that by 2020, 50 billion objects will be connected to the internet (Bloomber, 2017). The widespread adoption of various IoT technologies makes human life much more comfortable. In terms of individual users, IoT is very influential in the domestic field, such as in home applications and smart cars.

In terms of business users, IoT is very influential in increasing the amount of production and the quality of production, supervising the distribution of goods, preventing counterfeiting, shortening the time of availability of goods in the retail market, supply chain management, etc. IoT used in medical equipment applications such as glucose monitors connected to diabetic patients, will make it easier for doctors to receive patient data in real time, monitor the patient's condition and adjust the drug dosage. Thus disease management becomes easier to do. Similarly, the smart automation application, which allows the owner to manage all equipment remotely by using one application. To implement IoT as in the example above, many of the technologies involved include; web technology, computing and others. The technologies in this IoT are connected with various data collection institutions through the internet network and other communication networks. Information about the environment around the object is taken in real time, then converted into the appropriate data format to be transmitted over the network, and sent to the data center. The data is then processed by intelligent processors using cloud computing and other intelligent computing technologies that can process large amounts of data, to achieve IoT goals (Dewi, 2015).

2.2. Aquaponics

Aquaponics is a revolutionary food production system by cultivating fish and plants in an integrated manner. The aquaponics system is a "marriage" between aquaculture or aquaculture with agricultural hydroponic systems that use the principle of landless plants. A combination of fish cultivation and hydroponic plants that are developing for urban communities that have limited land. The main results obtained from aquaponics are fish, vegetables and fruits (Sungkar, 2015). Vegetable products from the aquaponics system proved to be cleaner, free of pesticides and the process without using chemical fertilizers. The reason is that plant nutrients are obtained from fish droppings that are converted by Nitrosomonas microbes which break down Ammonia into nitrite and Nitrobacter continues its task by converting nitrite to nitrate which is a nutrient for plants. Meanwhile, fish in aquaponics cultivation also produce weight gain compared to conventional fish farming (Fitriana, Adani, & Rahmawati, 2016).

Besides that, aquaponics cultivation systems have many advantages that can be applied either in narrow land or in the agricultural industry, fish and plant stocking densities are quite high, more
efficient in the use of water and electricity resources, and the waste produced in aquaponics cultivation systems is very small and environmentally friendly (Sungkar, 2015).

3. Research Methods

3.1. Tool Description
Aquaponics cultivation with IoT is built using sensors used as inputs to display data or environmental state of the cultivation environment, and use relay modules as outputs to control or control the device.

Apply the method of draining water regularly using water pump from fish pond to gutter of water (gully plant), so that flowing water give nutrition to plants and keep fish healthy. Environmental conditions in Aquaponics Aquaculture system with IoT read by sensor then processed with microcontroller328 into data, then data or information stored in the database and can be displayed on the website interface based on Raspberry Pi 3 model B. The following is a sketch of Aquaponics Aquaculture that uses IoT system.

3.2. Block Diagram
The following Figure 2 is a block diagram of the work system, and Figure 3 is a device topology design that is applied to Aquaponics Aquaculture with Internet of things.
The following Figure 4 is a 3D design of the construction form and Aquaponics Aquaculture system with IOT.

The design of miniature aquaponics cultivation of plants is not planted in pots but is grounded in gully NFT or like gutter of water but has been perforated and located above the aquarium. Here is a figure of the design of miniature aquaponics cultivation NFT.
3.3. Hardware Design

The design of miniature aquaponics cultivation of plants is not planted in pots but is based on NFT gully or like gutters but has been perforated and is located above the aquarium. The following is a figure of the results of the NFT aquaponics miniature design.

In the minimum system hardware design used for this design, based on the Raspberry Pi and Atmega328 microcontroller (Arduino Nano) which is also equipped with several other supporting modules. Microcontroller functions as data processing, with analog and digital ports used to input each module and as load output. These ports can be connected to various sensors that can be monitored and the output device is controlled through the website interface. The following is a schematic drawing of a trainer module for internet applications of aquaponics cultivation.

![Aquaponics IoT Wiring](image)

**Figure 5. Aquaponics IoT Wiring**

IoT Aquaponics also has 3 kinds of sensors that are used as monitoring inputs and can operate according to the test scenario, including the following.

a. Sensor DHT22
   DHT22 temperature sensor is placed in the plant area to detect temperature and humidity in the air of the plant area.

b. LDR sensor
   LDR sensors are placed at the top of the plant canopy buffer, with the position facing upwards to function as solar lighting monitoring in aquaponics cultivation environments.

c. Turbidity sensor
   Sensor turbidity is placed on the edge of the fish pond with the tip of the sensor submerged in water.

In addition to sensors, IoT Aquaponics has a control or control device. This system has four devices, including the following.

a. Plant Lighting
   The plant stimulating lamp or led grow light is used to help plants do photosynthesis when the sun's intensity is lacking.

b. Circulation Pump
Water pumps are used to help the distribution of water from the fish pond to the plant media and the water will return to the fish pond and also function as a controller of water circulation in the event of turbidity in the water.

c. Plant Cooling Fan
The fan placed at the top of the canopy facing the plant is used to regulate temperature and humidity when the air in the plant area is in hot conditions.

d. Fish Feed Giver
Stepper motors are used as fish feed by providing instructions on the web interface. The provision of fish food can be arranged with a period of time determined through the control website, so that the fish being treated will grow rapidly because the fish gets adequate food intake. The following is a design figure of a fish feeder with a 5V stepper motor drive with an uln2003 driver.

3.4. Software Design
The design of the software in the internet of things application on aquaponics cultivation system based on raspberry pi and atmega328, aims to monitor and control each input and output (I/O) so that the system can work properly. The program flow diagram is as follows.

![Flowchart Program](image-url)
In this design, the website used is based on Apache Mysql PHP (LAMP) on Raspberry Pi3. The software functions are Apache as a web server, MySQL as a database server, and PHP as a website programming language. So that the website program can perform its function as a viewer of data values from sensors that have been processed by raspberry pi, and also as a command indicator for the output to be controlled. The following is a block image of the implementation of the internet of things system diagram for the website interface.

4. RESULT AND DISCUSSION

4.1. Design Results
The results of the internet of things application tool on aquaponics cultivation systems are based on ATMEGA328 and Raspberry Pi as a whole have two parts, namely miniature aquaponics and sequences in the form of trainer modules. The aquaponics miniature has dimensions with a length of 60cm × width 45cm × height 125cm, and for trainer modules have dimensions with a length of 50cm × width 40cm × height 15cm (Figure 4).

At this stage of the discussion will be discussed about how the tool can work starting from the preparation stage of the network connection between aquaponics cultivation with a series of trainer modules, testing the readings of sensors, and controlling devices that can be processed on the website interface. As for some tests conducted to measure system performance on internet of things application tools on aquaponics cultivation systems based on ATMEGA328 and Raspberry Pi, which include:

a. Testing the performance of the sensor turbidity in reading turbidity data in water samples by displaying the monitor IDE arduino serial program.
b. Testing the response of the DHT22 sensor which in reading temperature and humidity data by displaying the monitor arduino IDE program serial.
c. LDR sensor performance testing that reads light data is displayed monitored by the arduino IDE program series.
d. Performance testing of real time clock modules in displaying time data on sensor data retrieval to be sent to the database with Arduino IDE serial display.
e. Testing the performance of stepper motors for feeding fish.
f. Relay performance testing as a connecting access between the control system and the device.
g. Preparation of testing the website interface with the wifi router access point as a link between the webservice and the client.
h. Website monitoring performance testing in reading data from sensors used iot with the website interface.
i. Testing the performance of the controlling website in controlling the iot device with the website interface.
j. Functional analysis of the IoT Aquaponics website in running the scenarios that have been designed.

4.2. Functional Analysis
From the results of the existing application analysis, the usecase diagram for monitoring and controlling aquaponics cultivation systems with IoT can be seen in the following Figure.
The figure above is an overall activity that occurs when the user monitors sensor data and controls the device through the website. Activity in the activity diagram starts when the user accesses the login first. After the login is successful, then the user will enter the system and run the application with monitoring and controlling options.

For monitoring options the user will display sensor data that has been stored in the database so that the user will know the situation in the aquaponics cultivation system.

As for the controlling option the user can control the fish feed / lamp / pump / fan, as well as being able to see the status of the device with the OFF button display for the off condition and ON the on condition. However, for different fish feeds, the status is not shown because it is exclusively programmed with automatic shutdown settings after the stepper motor rotates according to the programmed one. To stop the monitoring and control process by accessing the logout on the application. The system ends after the user accesses logout and returns to the login menu view.

5. Conclusion
After carrying out various tests and analyzes of tools that have been designed and made, it can be concluded that:
a. The use of IoT applications or websites can provide convenience in running an aquaponics cultivation system, as well as being an alternative in growing crops and maintaining fish that are increasingly advanced technology by relying on narrow land and limited water resources.

b. Monitoring describes the state of the aquaponics cultivation environment, with sensors as data readers and ATmega328 microcontrollers as data processors and then the data is stored in the webservice or raspberry pi database to be displayed in the form of a situation or value in the monitoring menu.

c. Control of control devices in this case fish feeders, plant lights, water circulation pumps and plant cooling fans can be done by accessing the controlling menu then pressing the buttons of each control device and displayed also the state of the device is ON / OFF.

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