Internet of things for aquaculture in smart crab farming

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Abstract. Internet of Things (IoT) has been introduced and applied in many applications and become an emerging technology in digital era. The major economic in southern part of Thailand is aquaculture such as fishery, shrimp, pearl, mud crab and so on. The concept of IoT which is about connecting the sensors and gathering all necessary data to cloud platform allowing us to control, monitor, maintain and manage farm efficiently. Soft shell crab is most important ingredient in Chinese, Japanese, and co-fusion menu requiring in many premium restaurants. Unfortunately, the productivity of soft-shell crab industry is very small due to a low survival rate in raising process and lack of small crab. In tradition soft-shell crab farm, each small crab has been grown separately of a small box in the old shrimp pond. Farmer has to feed them individually and monitor them every 4 hours in order to avoid soft-shell crab turns to hard shell. In this work, thus, we propose to apply IoT and intelligent system to improve the productivity in the traditional soft-shell crab farm. Water quality sensors, motion sensors, and feeding system are designed and developed to enhance the survival capability of soft-shell crab farm. Meanwhile, with the same concept, our system can be applied in another aquaculture to be smarter farm and be precision aquaculture in the southern path of Thailand.

1. Introduction

Thailand is a developing country based on agriculture and tourism which has a national transformation policy called Thailand 4.0. sciences, research, and innovation are applied to increase the value of products and services. Many emerging technologies such as Internet of Things (IoT) [1], data analytics and Artificial Intelligent (AI) have been used in various domains extensively in order to enhance the performance for each applications.

IoT is widely used in many applications such as environment monitoring, animal tracking, industrial management, precision agriculture and so on. With the concept of IoT applied in agriculture, many data have been gathered via the connected sensors and the system which can be controlled and performed automatically. These optimizes the laboring jobs. The farmer can organize his time in addition to important tasks. Moreover, the precise information from IoT increase the productivities in farm, especially in a high risk and complicated routines. Therefore, IoT and intelligent system, have been developing in the raising crabs farm. The system consists of water quality sensor, feeding, notifying, and monitoring system connected to cloud-based application. This information can be learnt and analyzed to create a extensive sustainable aquaculture [2].

The basic IoT in agriculture is a simple system which allows farmer can control pump or monitor soil moisture or temperature from smart devices. While the precision agriculture – aquaculture focus to optimize and improve agricultural process for maximum productivity and minimum cost. Thus, several
sensors and more intelligent system are required to combine for those expectations. Many related new technologies are also applied such as a long range and low power wireless communication like LoRaWAN [3-5] in order to cover the large field and support many numbers of sensors.

This paper presents the IoT and intelligent system applied in soft-shell mud crab farm which consists of water quality monitoring, feeding system and soft-shell monitoring. Our raising system is a closed loop environment (Vertical boxes farm) to give awareness to the farmer to main the water quality to reduce the loss of their mud crabs. Moreover, intelligent system using real-time camera can also detect and alert to farmer when having a soft-shell crab.

This paper is organized as follows: section 2 discusses related work, section 3 explains system design and realization, section 4 shows the results and concludes in section 5.

2. Related research
Aquaculture management, as the soft-shell crab farmers do not know when mud crab is molting and still survived. Using the water quality sensor and using the camera to monitor the crab when molting and sending the notification simultaneously. Water quality affects the survival rate of mud crabs following the effect of physic chemical properties of water such as salinity, temperature, pH, DO, Ammonia, Nitrate, and Nitrite on growth and survivability of mud crab, but 3 main parameters are temperature, salinity and pH. presented by Sandeep and Kurva [6].

A. Water temperature
Water temperature is an important factor to consider when evaluating the water quality. Aside from that, it effects on temperature also influence many other parameters and can change the physical and chemical properties of water. In this regard, the water temperature should be suitable controls. The optimal temperature of mud crab values between 23 °C to 30 °C.

B. Salinity
Salinity is most important for better survival and growth of mud crabs, so mud crabs are resistant to a variety of salinity conditions, from a salinity between 10 to 34 parts per thousand (ppt). This paper uses the variation of the Electrical Conductivity to determine the salinity in the water.

C. Power of Hydrogen or potential for Hydrogen (pH)
The pH value is determined by the level requiring similar temperatures. This means that the water's pH is not a physical parameter that can be measured at concentration or volume between 0 and 14. The optimum pH of mud crab between 8.0 to 8.5.

D. Oxygen in water
Crab breathes underwater by pulling water. Above the gums using an organ called scaphognathite which is located at the bottom of the crab near the base of the claws the water flows through the gums which extract oxygen. The oxygen in the water must not be lower than 8.

In recent years, there has a technology called deep leaning that can separate objects: object recognition. Previously, there were R-CNN and fast R-CNN. Ross Girshick proposed to use CNN for object recognition and searching for bounding box objects, but this type of method requires one more step in creating a potential boundary box before performing the recognition. So, Technology for object classification and can show what the object is, using You Only Look Once (YOLO) because they have multiply box [7]. Other technology for automation feeding Niswar et al (2017). proposed the automatic feeding system design for soft shell crab The system aims to feed crabs according to predefined food quantities, such as 5% of crab body weight to accelerate crab growth and avoid wasting food which results in dirty water [8].

3. System design and realization
In various sensors, it is a high-precision fishery, therefore, analysis purposes very important to use sensors measures humidity, sunlight, adjusts the amount of light, water quality, temperature measurement, and temperature adjustment system with database of aquatic animals for search Soft-shell crab. For installation that is suitable for raising animals enable to control. Adjusting the environment is also a cloud system and then sent image to classification object finally sent message to user as shown in figure 1.

The sensor data is connected via HTTP and sent to the IoT gateway for control water quality, feed auto, and camera sent video to process with object detection for separating the crab when molting, To alert the user when the food is out of stock and crab molting. The system has 3 parts including water quality system, Feed auto, and Image processing.

A. Hardware
The main microcontroller is Raspberry Pi 3B+ (Rpi). The Rpi then communicates with the sensor via GPIO and the Arduino UNO via USB to send electrical signals to the stepper motor to control motor movements following on figure 2 and details sensor in table 1.

### Table 1. Block diagram.

| Parameter         | Value                        | Range        | Accuracy         |
|-------------------|------------------------------|--------------|------------------|
| pH                | Industrial pH Probe          | 0 – 14       | ± 0.002          |
| Dissolved Oxygen  | Dissolved Oxygen Probe       | 0 – 100 mg/L | ± 0.05 mg/L      |
| Temperature       | Industrial Conductivity Probe K 1.0 | 0 – 110 °C | ± 1 °C          |
| Conductivity      | Industrial Conductivity Probe K 1.0 | 5 – 200,000 μS/cm | ± 0.1 μS/cm |

B. Recirculating water crab indoor farming specification
a. Area: water crab indoor 20boxes with size 0.25*1.5*1.8 (length * width * height: m) in system 290L each layer is 34 cm 4 apart and 4 filter tanks. consist me, of fitter waste tank, ceramic material, oyster shell and sea plants, bio-ball for each parts as shown in figure 3.
b. Carb: Mud crab.
c. Food: Feed ingredients fish meant, tuna pasta, wheat flour, broken rice, vitamin, and mineral.
4. Results

A. Water Quality
The system water quality control is main key of the aquatic animals. Unable to control water quality make causing crabs in the system to die. So sensor must be accurate. Water quality control the water quality of crab's livelihood and control nutrients in the water. In terms of data, data was sent to process the survival of soft-shell crab. The sensors used are as follows pH, Dissolved Oxygen, Temperature, Conductivity. Sensor placed at the bottom of the last pond that sends water before up to the system as shown in figure 4.

Finally, water quality is sent data from sensor into cloud at https://connexthings.io/ for data storage to process with image also sent data to user on web and line application as shown in figure 5.

When the value is lower than the standard value background was changed orange to blank for users to recognize and check your equipment. Connexthings (In-house PSU IoT Platform) have 2 functions to the record the first function which is presented value for real-time as shown in figure 6.
The second record data to time series can be covert to .json for get HTTP data and then send data to LINE application as shown in figure 7. And then have notifications on LINE chat every hour or when request status in LINE message status detail water quality with D.O., EC, Ph, temperature. User can know status about water quality via Firebase as shown in figure 8.

B. Feed Auto
Feed auto system control by stepper motor in spiral one spin will make food to fall in the box to a spiral twist show on figure 9. Inside pipe for conveyor food on slide rail length 150 cm. and plant to side left and right feed system to feed every day at time 00.00 AM here on figure 10.

![Figure 9. Food conveyor equipment.](image9)

![Figure 10. Plates for control left and right.](image10)

![Figure 11. Camera find soft-shell crab and unknown.](image11)

C. Image Processing
Image is divided into 2 sets: 1,000 for training dataset and 500 for test of dataset without duplication use labeling to create model classification of crab and soft-shell crab using yolov2 for detect 3 type of crab, soft-shell crab, and unknown. When camera detected soft-shell crab and unknown. System was sent the message to LINE as shown on figure 11. Shell of crab reflected infrared and soft-shell crab do not infrared reflect as shown in figure 12.

![Figure 12. Shell of crab reflect infrared light (left) and c soft-shell crab do not reflect (right).](image12)

Image model classification crab by reflection infrared of shell this system is most effective at night because infrared light easily disturbed by sunlight. Therefore, it decreases confidence in image process.
from average precision. When an object is greater than or equal to 0.5 mean positive sample, while lower is a negative sample. Testing 30 images for each type, each set is repeated. average precision (AP) of the object detection as shown in table 2.

Table 2. Accuracy average precision (AP) of 3 types of object detection.

| Category     | Average Precision (AP) |
|--------------|-------------------------|
|              | Daytime | Nighttime |
| Crab         | 0.62    | 0.72      |
| Soft-shell crab | 0.25   | 0.81      |
| Unknown      | 0.83    | 0.83      |
| Mean         | 0.553   | 0.786     |

From table 2, the use of a camera for classification soft crab at night is more effective using infrared light. This model work in nighttime is better than daytime. From the results, the system was reduced the time of human action to look for crab approaching to soft-shell crab. This means that we can change the traditional aquaculture which has to take care for many times per week, for instead of the waste time, the proposed system just spends only 2 hours per week.

5. Conclusion and future
Technology are intended for automation control devices. This technology will save time to aquaculture soft-shell crab. aquaculture need some technology helps in the different stages of crop growth and the guidance should be given at the right time responses for measuring environmental water such as oxygen in water, Electrical Conductivity in water, power of hydrogen or potential for hydrogen, temperature. Aquaculture are suffering a lot of problem, economy, social, and politics. In future work, smart farmer can do as commercial for precision farming increasing the 100 boxes or more. We will predict the production with advanced artelen in higher and deep leaning for contributing the infrastructure supported to whom it may concern in beyond technology.

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