Development of a Gamified Interactive Fish Monitoring Tank

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ABSTRACT

Nowadays, there has been a noticeable decline in people adopting fish as pets. The main reason for this trend is that many perceive fish to be less interactive compared to pets like dogs or cats. According to a recent survey, many respondents also find fish care to be challenging. This project aims to address both issues by developing an interactive aquatic monitoring tank that incorporates gamification elements to foster a sense of engagement between the owner and the pet. The proposed tank features both semi-automatic and automatic systems, including a food feeder, pH monitor, and temperature sensor. Instead of creating a fully automated ecosystem that requires no human involvement, this system is designed to encourage regular interaction from the owner, thereby strengthening the bond between them and their aquatic pet. To achieve this, the system includes a virtual avatar of the fish within a companion app. This avatar provides feedback and responds when the owner completes tasks prompted by the tank, such as feeding the fish or turning off the lights at night. These tasks are designed in the spirit of the classic *Tamagotchi* game, creating a playful and engaging experience that makes fishkeeping more interactive and rewarding.

Keywords: Fish; monitoring device; interactive; gamification; Arduino

INTRODUCTION

In today’s era, it can be observed that Generation Z is increasingly less interested in keeping fish as pets compared to other furry animals such as cats and dogs. This decline is primarily due to two reasons:

1. Many respondents feel that fish are not as interactive as dogs or cats.
2. Fish are often perceived as difficult to care for.

To address these issues, this paper proposes the development of an interactive aquatic monitoring tank enhanced with gamification elements. The project aims to solve both problems: the first by incorporating gamified features that foster a sense of interaction between the owner and the pet, and the second by designing a system that monitors and communicates essential information about the pet’s condition.

Gamification is not a new concept—it has been widely applied in educational kit prototypes [1–15]. In this project, it is used to simulate pet-like behaviour, encouraging owners to engage with their aquatic pets through interactive tasks and feedback mechanisms.

In order to achieve the main aim of the project, three sub-objectives were formulated:

1. To design and build a prototype fish tank system capable of monitoring key parameters related to the aquatic pet using an Arduino microcontroller.
2. To design and develop an Android application that provides real-time updates on the pet’s status and collects user input as feedback to the tank system.
3. To conduct scenario testing to evaluate the functionality and performance of the complete system.

From a product perspective, the proposed interactive aquatic tank should be equipped with the following key parameters:

1. Food.
2. Light.
3. Temperature.

Features related to the food parameter:

1. Notifies the owner via the app when the aquatic pet is hungry by tracking the hours since the last feeding session.
2. Receives feedback from the owner through the app to dispense an appropriate amount of food stored in the container.
3. Automatically dispenses food if the owner does not respond to the pet's feeding request within a set time limit.
4. Restricts excessive feeding by ignoring requests if the owner attempts to feed the pet too frequently within a short period.

Features related to the light parameter:

1. Notifies the owner via the app when the aquatic pet wants to sleep and suggests turning off the light based on the current time.
2. Receives feedback from the owner through the app to turn off the light, and the system executes the command.
3. Notifies the owner via the app when the aquatic pet has woken up and requests the light to be turned on, based on the current time.
4. Receives feedback from the owner through the app to turn on the light, and the system executes the command.

Features related to the third parameter/temperature monitoring:

1. Displays the current ambient temperature to the owner through the app.
2. Sends an alert via the app if the ambient temperature exceeds the predefined upper threshold.
3. Sends an alert via the app if the ambient temperature drops below the predefined lower threshold.

Previous literature reveals numerous efforts to develop fish monitoring systems. For instance, Jr P. B. Bokingkito et al. [16] focused on designing a reliable and adaptable water temperature monitoring framework aimed at reducing reliance on manual labour at the monitoring site, thereby lowering operational costs. S. Nocheski et al. [17] proposed an Internet of Things (IoT)-based system for monitoring fish farming ponds. Their framework integrates various sensors to measure critical water quality parameters such as temperature, light intensity, and water level. A central processing unit analyses the data and sends both audio and visual alerts to the fish farm owner. T. K. Lim et al. [18] introduced a standardized procedure for fish farming that incorporates an automated system. Sensors and actuators were used to monitor water conditions in fish tanks, while automated components such as a programmable food dispenser and water current generator were implemented to meet the basic needs of the fish. B. Y. Lin [19] proposed a personalized feeder for pet fish in aquarium tanks, which requires proper setup and ongoing maintenance.

From these studies, it is evident that most existing research focuses on developing autonomous fish monitoring systems. However, none have explored the integration of gamification elements into such systems. This gap highlights the novelty and unique contribution of the current project.

METHODOLOGY

Figure 1 shows the prototype of the project. The dimensions of the prototype are approximately 150 cm x 120 cm x 50 cm, and its weight without water is around 1.2 kg. The largest container houses the fish tank, while the two smaller tanks serve as compartments for the electronic circuitry and fish food storage.

Figure-1. Project Design

Figure-2 shows the proposed prototype's framework which can be divided into four distinctive groups (square in shape). The first group is input which consists of LDR sensor and DHT sensor. The LDR sensor is use to monitor the light intensity. This allows the gamification of the need of the light to turn ON or OFF based on the time and light intensity that the fish experience. DHT sensor captures 2 information which are the tank temperature (different from the water temperature) and humidity inside the tank. This allows the gamification element of whether the room temperature is to COLD or HOT based on the temperature experience by the tank. Not illustrated in the figure, is DS3231 which is the real-time clock module. This module ensures that the system able to identify the current time when it is not connected to its mobile application. If the mobile application is connected, the time from mobile application is used as reference. The second group is controller. For this project only one controller is used which is Arduino Mega 2560. The selection of Arduino Mega as the controller is due to its higher capacity of IO pins compared to Arduino Uno yet still cost-effective compare to Raspberry Pi. All the algorithms that dictate the flow of the system is burned inside this microcontroller. The third group showed is the communication. This project employs Bluetooth communication using HC-05 Bluetooth Module. This communication is essential to establish information exchange route between Arduino Mega with the mobile application. The last group is the output which contains several components: 5V water pump, 16 x 2 LCD display, Sound module, 5V fan and 2 RGB LEDs. The 16 x 2 I2C alongside Android telephone is utilized to show the yield of the multiple sensor examination result. The I2C modules is attached as interfaces between Arduino Mega and 16 x 2 LCD in order to decrease numbers of pin related with Arduino The 16 x 2 LCD and Android phone are used to display the value as for temperature and humidity and the status for fish based on triggered sensors parameter. The water pump motor is used to pump the water to the filter. Sound module is used to play music to the fish when the fish is bored.

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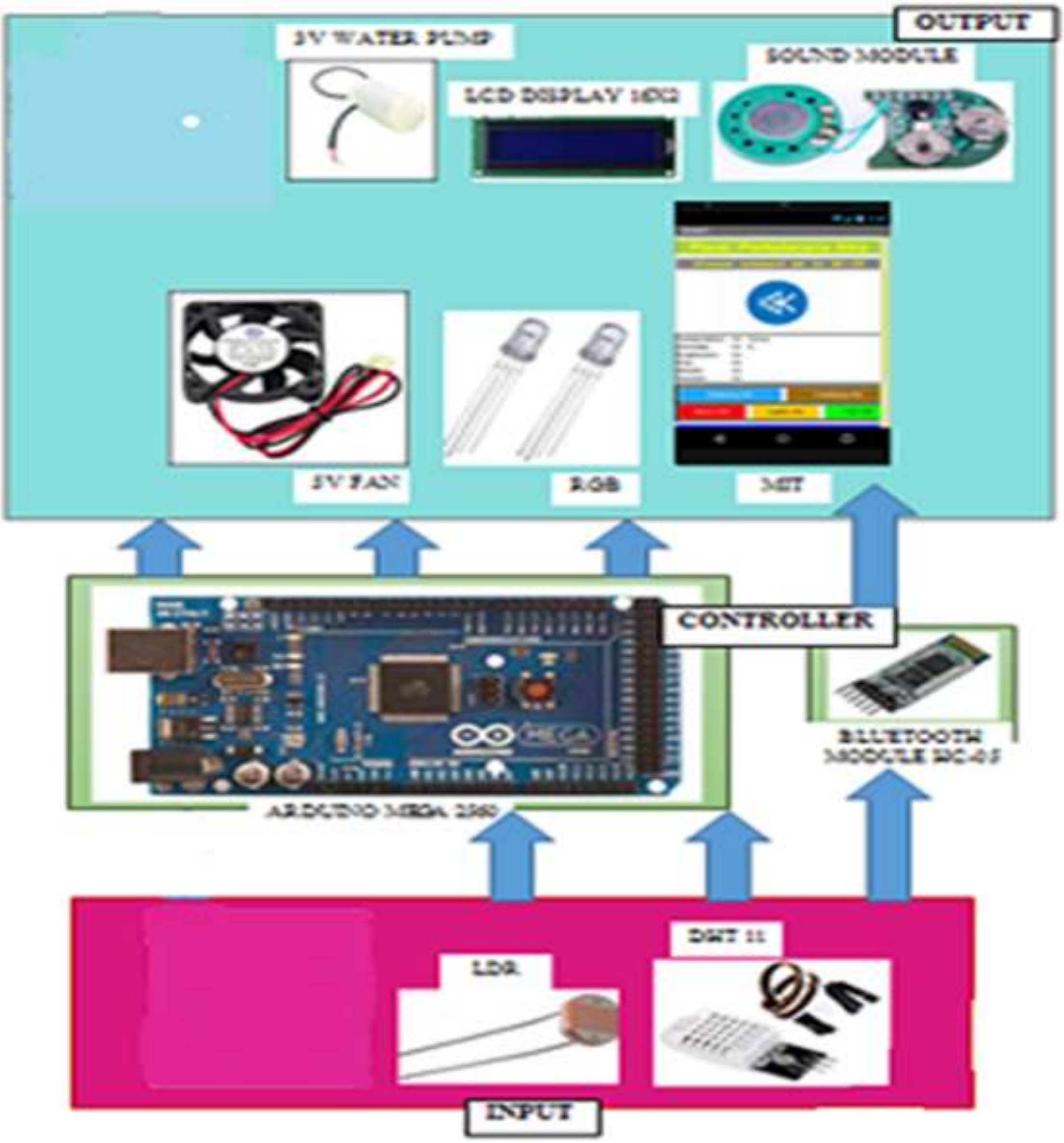

Figure-2. Block diagram of Fish Gamification Monitoring System

Table-1 provides detail information on the possible states that the fish might experience based schedule timer. Each state comes with scenario that leads to the state. Assuming appropriate action taken by the user as suggested in the 'Action Taken' column, the expected respond by the system is as shown in the 'Results' column. There are five possible scenarios that might occurred which are hungry, boring, sleeping, lazy, and 'What's up'. Taking the first scenario as an example, the first scenario occurs when the fish is hungry. The 'hungry times' are pre-defined times which are at 8:00AM and 8:00PM. Once the mobile app detects the 'hungry times', it will change the emoji of the avatar of the fish in the app to the emoji of a hungry fish. Thus, the expected respond from the user will be to press the second button which move the appropriate servo motor that dispense the fish food. Once the motor completes its task, the emoji of the fish avatar will return back to the original emoji that indicates the fish in normal condition.

Table-1. Scenarios based on schedule timer

Scenario	**State**	**Action Taken**	**Results**
Hungry At 08:00 & 20:00	Emoji changed from "I am good" to "I am hungry"	Press on button 2 for feedings.	Emoji back to "I am good"

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Boring At 10:00 & 14:00 & 18:00	Emoji changed from "I am good" to "I am boring"	Press on button 3 for music.	Emoji back to "I am good"
Sleeping At 21:00 – 06:00	Emoji changed from "I am good" to "I am sleeping"	-	Emoji back to "I am good" after 05:59
Lazy Ldr < 300 At 06:00 – 20:00	Emoji changed from "I am sleeping" to "I am lazy"	Click on button 4 for lights on	Emoji back to "I am good" or "I am sleeping"
What's up? Ldr > 300 At 06:00 – 20:00	Emoji changed from "I am sleeping" to "what's up"	Click on button 4 for lights off	Emoji back to "I am sleeping" or "I am good"

Other than the five scenarios mentioned in Table-1, there also scenarios that respond to the sensors embedded into the system as indicates in Table 2. The first one is related to temperature where ambient temperature that is less than 15 degrees Celsius will trigger the emoji of a chilling fish avatar. The second one occurred when the ambient temperature is greater than 35 degrees Celsius which trigger the emoji of a sweating fish avatar as indicator of the temperature is too hot. If the temperature is around 16 degrees Celsius to 28 degrees Celsius, the normal emoji of the fish avatar will appear. The other two scenario occurred related to the light intensity.

Table-2. Parameter setup for temperature and light sensor

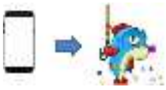
Parameter Setup		
Temperature		
< 15 c "I am feeling cold"	<= 16 c, >= 28 c "I am good"	> 35 c "I am feeling hot"
Light intensity		
< 300 AT 21:00 – 05:59 "I am sleeping"	-	>= 300 AT 21:00 – 05:59 "What's up?"

RESULTS AND DISCUSSION

In order to verify the functionality of the functions of the system, a checklist of expected result is compiled. Each of the expected result is tested on the prototype and the actual result is recorded. Table-3 shows the comparison between the expected result and actual result. It can be seen that all the functions performed as expected and all the sensors reading are within the acceptable margin of error.

Table-3. The expected and actual results based on the functionality checklist

No	Functionality Checklist	Expected Result	Actual Result
1	16 x 2 LCD display Error in temperature measurement should be within +/- 2 degree Celsius Error in temperature	The 16 x 2 LCD display will display the ambient temperature and humidity inside the tank	The 16 x 2 LCD display will display the ambient temperature and humidity inside the tank within the error of +/- 1 degree Celsius and +/- 2 percent of humidity

	and +/- 4 percent of humidity		
2	Hungry at 08:00 & 20:00 Real time Clock module indicates time 08:00 or 20:00 Error in time should be within +/- 2 minutes	Time in the smartphone shows 8:00 and 20:00. Emoji changed from “I am good” to “I am hungry” 	Time in the smartphone shows 8:00 or 20:00. Emoji changed from “I am good” to “I am hungry” 
3	Boring at 10:00, 14:00 & 18:00 Real time Clock module indicates time 10:00, 14:00 or 18:00 Error in time should be within +/- 2 minutes	Time in the smartphone shows 10:00, 14:00 or 20:00. Emoji changed from “I am good” to “I am bored” 	Time in the smartphone shows 10:00, 14:00 or 20:00. Emoji changed from “I am good” to “I am bored” 
4	Sleeping at 21:00 to 06:00 Real time Clock module indicates time 21:00 to 06:00 Error in time should be within +/- 2 minutes	Time in the smartphone shows 21:00 to 06:00. Emoji changed from “I am good” to “I am sleep” 	Time in the smartphone shows 21:00 to 06:00. Emoji changed from “I am good” to “I am sleep” 
5	Lazy LDR value is less than 300 at 06:00 to 20:00 Error in LDR value should be within +/- 50 Real time Clock module indicates time 21:00 to 06:00 Error in time should be within +/- 2 minutes	Time in the smartphone shows 21:00 to 06:00 and value of LDR is less than 300. Emoji changed from “I am good” to “I am sleep” 	Time in the smartphone shows 21:00 to 06:00 and value of LDR is less than 300. Emoji changed from “I am good” to “I am sleep”. Error in reading of LDR is within +/- 25. 

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A validation process was carried out by conducting a simple survey with the target users. Twenty-five respondents, consisting of students aged 10 to 20 years old, were selected. Each respondent was required to answer five 5-point Likert-scale statements. The statements are listed below, where 1 represents strongly disagree, 5 represents strongly agree, and 3 represents neutral:

1. The gamified features make caring for the fish more enjoyable.
2. The interactive features increase my overall satisfaction keeping a fish as pet.
3. The product motivates me to maintain the tank regularly.
4. The product's game-based approach encourages me to learn more about fish care.
5. The gamification elements are more effective than traditional fish tank maintenance methods I've used.

Figure 3 shows the distribution of the responses obtained from the survey. Eighty percent of the respondents strongly agreed with the first statement. The second statement has three respondents feel neutral regarding the statement, while others have positive view on the statement. Having said that, statement three still has the same mean value as statement one at 4.72. The only statement that has negative view is statement four where one respondent feels disagreed with the statement. Statement four also produces the lowest average value of 4.48. All 25 respondents strongly agreed with statement five making it obtained a perfect mean score of 5.00.

CONCLUSIONS

This project presented the technical aspect of the development of a gamification fish aquatic pet system which consists of a multi-sensors and multi-outputs aquatic tank systems. The tank system complements with an Android App that not only provides related information and retrieve relevant respond from the user. The Android App also is designed as interactive with the gamification element. The prototype is tested using a functionality checklist where all the actual results are compared with the expected results.

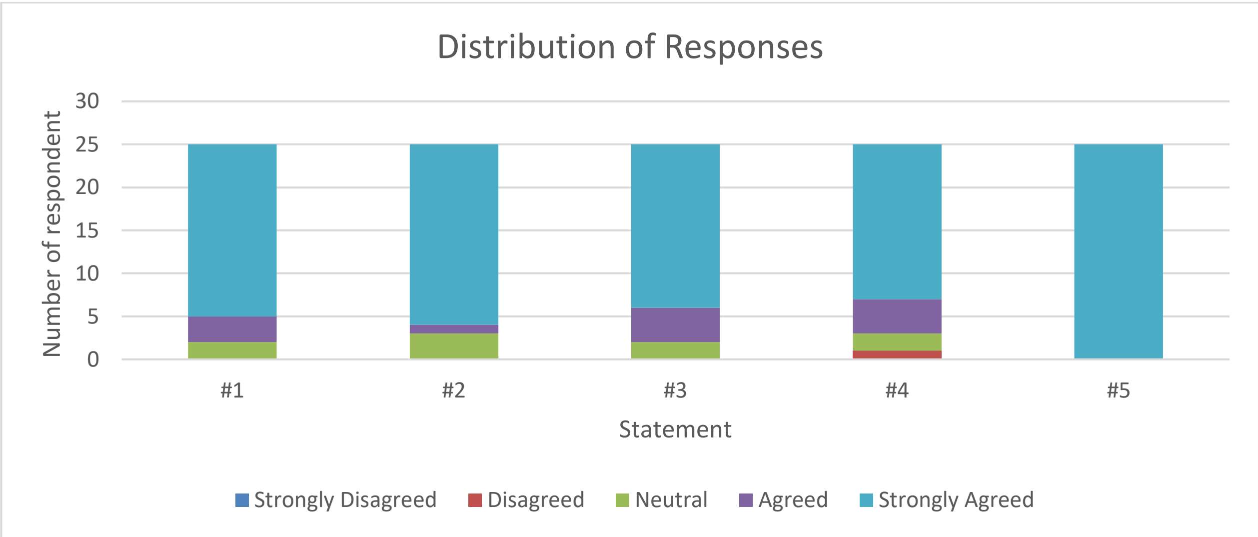

Figure-3. Result of the survey.

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