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Time controlled automatic fish feeder for indoor aquarium

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Abstract

The purpose of this research is about the design and implementation of an automatic feeder to feed fishes in the aquarium when their owners leave home for a prolonged time or forget to feed timely due to their busyness. The mechanical drawing of the feeder is prepared in Auto Desk Fusion 360 software which is followed by the fabrication in a 3-D printer. For automatic feeding, an Arduino microcontroller board has been integrated with the designed mechanical system to control the opening and closing of the food chamber door with the help of a servo motor. An easy digital LCD programming system allows the user to set the time interval between two successive food deliveries and the number of servo rotation at each delivery to supply their desired amount of food. The performance of this portable and the low-cost feeder has been tested which has shown the reliability to dispense the accurate amount of food.

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Introduction

At present, especially urban people lead a very busy life. Being exhausted through the discharge of various duties is a daily occurrence there. Thus, to enjoy a little tranquility or just by mere hobbies, amid of hundredth busyness, one may fish in an aquarium or may fowl on the porch, while someone may feed cats or other pet animals. However, there is a problem when one forgets to feed his pets in time for busyness or goes on a long vacation during the occasions of Eid, Durga Puja, or Christmas festivals (especially in Bangladesh people go to their native villages to celebrate these occasions with their relatives). It is difficult to take these pet animals, especially the fish aquarium with them. Again, it is impossible to leave them behind, because without food the animals or fishes may become sick or even may die. There are many options available for feeding dogs and cats while away from home. But, the choices of fish owners are

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limited. It is not feasible for them to drop extra food in their fish tanks before leaving for a vacation as overfeeding is one of the leading causes of fish fatality. The sediment of excess food spoils the water by releasing ammonia and nitrites which reduce the pH level and the amount of oxygen in the water (Anon, 2020a). These are harmful to the fish. On the other hand, fish can die due to long time starvation. This can put stress on fish owners' minds who need to leave home and do not have a consistent pet sitter. In order to solve this problem, a feeder that can handle good control of fish feedings has been designed and developed.

Importance of the research

Recently, there has been an increasing number of people who keep fish as a pet at their home either as a hobby or for aesthetic purposes. Displaying live fishes in aquariums, garden ponds, artificial lakes, and as a part of beautification and recreation in government offices, companies, tourist places, hospitals, schools, research institutes, and public areas is becoming popular. At the same time, low labor maintenance, less operating costs, high but short time returns make aquarium fish business very lucrative. As a result, both in the domestic and international market ornamental fish trades are rapidly expanding. Approximately 15 billion USD of the global ornamental fish industry trades more than 2 billion live ornamental fishes. About 7.2 million homes in the USA and 3.2 million homes in the European Union have aquaria. The top exporters are Singapore followed by Hong Kong, Malaysia, Thailand, Philippines, Sri Lanka, Taiwan, and Indonesia. The largest importer country of Ornamental fish is the USA followed by Europe and Japan, whereas the emerging markets are China and South Africa (Raja *et al.,* 2014; Satam *et al.,* 2018). Like developed countries, ornamental fish keeping is gaining popularity in many developing countries. For example, in Bangladesh, colorful fishes were imported in 1992 for the first time (Alam, 2018), and within two decades this has become very common in all over the country such as Barisal, Khulna, Sylhet, Rajshahi, and Chittagong divisions while the Pet market at Katabon area of Dhaka city still plays its master role (Alam, 2018; Alam *et al.,* 2016; Kangkon, 2013; Rahman *et al.,* 2009). By the side of the primary product - "Ornamental fish", the shopkeepers also sell aquarium and its accessories such as aerator, colorful stone, artificial aquatic plant, colorful light, and medications which are essential parts of rearing these type fishes. Another essential ingredient for rearing ornamental fishes is food which is also sold by the aquarium sellers. There are several types and brands of feed that are available in the local market named as Osaka, Nova, Safy, and Optimum, all of these are floating pellet types (Alam, 2018; Alam *et al.,* 2016). The promising thing is that 73% of the hobbyists belong to the young age group of 20 years to 30 years while 60% shopkeepers are in the age group of 30 to 40 years (Alam, 2018). Therefore, the ornamental fish business may be one of the emerging business sectors to remove the unemployment problem in developing countries like ours. Now it is time to give support for the sustainability of this industry and as a part of technology development in this sector, we attempt to make an automatic fish feeder.

Problem analysis

In the study of Abu Saleh *et al,* the main difficulties in aquarium business are the transportation of fish (60%) and diseases (40%) as indicated by the shopkeepers (Alam 2018). Rahman et al. sorts out a limitation of feeding technology in their Khulna divisional aquarium business case study project based on considering local situations (Rahman *et al.,* 2009). The common claim from the fish rearing hobbyists is about feeding the fishes while they have to leave home for an extended period or could not maintain a regular feeding schedule due to their busyness. The situation becomes worse during Eid, Puja, or other holidays while they have to leave for a prolonged time. Here, in this research, we focused on the problem of the hobbyists. This problem can be solved by developing several direct and indirect techniques. For direct adjustment, self-feeders may be used such as pet sitters. Indirect methods have also been applied through automated devices to feed the fishes. However, the fish feeders are not available in the local market or typically expensive as these types of accessories are imported. Therefore, we have come up with an idea to develop a low cost automated feeder to feed aquarium fishes in the absence of their owners and to fulfill their basic requirements as a primary contribution in the aquaculture industry of our country. In this paper, we will discuss the design, construction, operational procedure, and functionalities of our developed fish feeder.

Literature survey on existing fish feeders

A lot of research has been conducted on "automatic fish feeder". Different types of fish feeders are available in the market. Among them, eBoTrade Aquarium Auto Fish Food Timer (Fig. 1. A) and EHEIM Automatic Feeding Unit (Fig.1. B) are very popular. The eBoTrade Aquarium Auto Fish Food Timer has manual and automatic capabilities; an adjustable serving size can feed between one and four times per day. In this system, the food reservoir rotates and a door on the bottom opens to release the food into the aquarium. A negative review about this system is that even at the smallest serving size it drops too much food for a single fish. Like eBoTrade feeder, the food reservoir of EHEIM Automatic Feeding Unit rotates to dispense the food. It has the following

features: an adjustable opening for different serving sizes, a timer, a manual snack option, a large food reservoir, and able to feed up to eight times per day (Dhavale *et al.,* 2019). However, it is difficult to obtain the appropriate amount of food to come out by this system. Moreover, the systems are costly in terms of our local hobbyists.

(A) eBo Trade Aquarium Auto Fish Food Timer **(B) EHEIM Automatic Feeding Unit**

Fig. 1. Commercial Fish Feeders (Admin, 2020)

Management of food delivery is the main thing of an automatic fish feeder. Keeping it in mind, most of the researchers design their own fish feeders while some added extra features such as IoT based monitoring of temperature and pH level in the aquarium water, sensors for taking feedback from the food reservoir, Liquid Crystal Display (LCD) attachment with the feeder, keypad for time setting and camera for real-time monitoring. Some of the researchers also use the Global System for Mobile Communication (GSM) to send SMS as a warning at critical conditions. Some developers try to control the device by a mobile app or from the web. Arduino Uno or Raspberry Pi is more preferable as a microcontroller in these projects (Farheen *et al.,* 2018; Prangchumpol, 2018; Premalatha *et al.,* 2017; Uddin *et al.,* 2016). Although, these additional features increase the efficiency of the device, the features make the device expensive. Thus, we attempt to develop a simple, efficient and low-cost feeder that can fulfill the basic requirements of our local consumers.

Proposed fish feeder design and controlling methodology

To survive and remain healthy, the fish require regular care. The vital part of caring is to feed them at least once in a day. So, the fish owners feel stressed to be away from home, whether it is for school, work or leisure for an extended time. This creates the necessity of an automat ed device that can reliably feed the fish. A fish feeder is a device that can automate the process of feeding the fishes in the aquarium. It replaces the manual feeding by a human with a combined system of electronics and mechanics that provides food into the aquarium at a user-defined time interval.

The goal behind this research is to design and develop an automatic feeding system for indoor aquarium fishes. For this reason, we propose a Buchner Funnel-shaped fish feeder (see Fig. 4 A). The orifice of the funnel is attached to a rectangular-shaped basement plate (Fig. 4 B). The top of the Buchner funnel is enclosed with a removable cap (Fig. 4 C) so that food tank can easily refill. On the other hand, the funnel orifice (food releasing point) remains blocked by a disk-shaped lid although the lid contains a hole at its periphery (Fig. 4 D) and normally the two openings are kept mismatch. A servo motor is used to hold and rotate the lid along with the bottom surface of the basement plate by its drive shaft while the servo motor is mounted on the top surface of the basement plate (Figs. 2 and 5). This mechanical arrangement uses the gravitational force to drop-down the food into the aquarium only when the two openings (peripheral hole of the lid and funnel orifice) meet each other as the lid rotates. By following the above explained working principle, the designed feeder should be controlled or adjusted according to the demand of the user. For example, to give a certain amount of food in the aquarium at preset intervals, the motion of the servo motor needs to be controlled. A microcontroller plays the role of a pet-sitter in this regard. It takes inputs from the user by a keypad and displays them on an LCD. The microcontroller makes decisions based on the user-defined time interval and the timer (Real-Time Clock module) to operate the servo motor,

hence to drop the food into the aquarium. The block diagram of mechanical structure and the basic controlling mechanism of this proposed fish feeder is shown in Fig. 2.

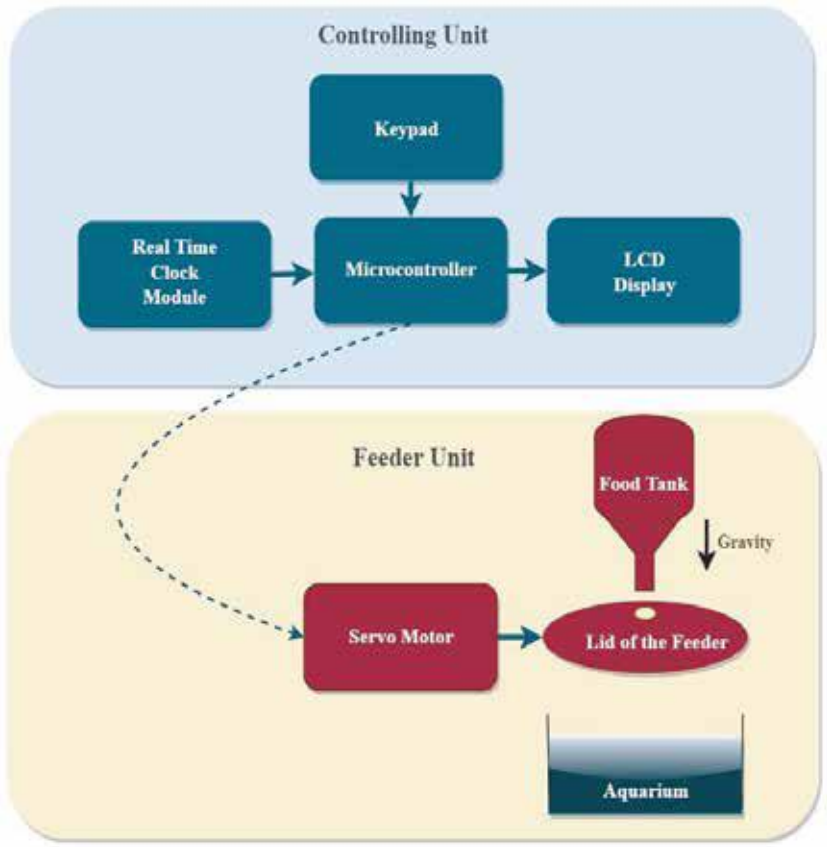

Fig. 2. Block diagram of proposed automatic fish feeder

Materials and methods

Structural material

The body of the fish feeder device should be highly stable to hold all the electronic components at the same time it should be light-weighted. Again a smooth surface for the mechanical structures is good to avoid friction. Therefore, we choose plastic to construct the frame of the feeder because it's easy to fabricate a smooth and robust surface using plastic material. At the same time, plastic is light-weighted and cheap which are important parameters for material selection in our design consideration. We have designed the structure of the fish feeder using Auto Desk Fusion 360 software followed by a fabrication process using a 3-D printer (Sindoh 3DWox 2X). Poly-lactic acid (PLA) material is used for 3-D fabrication of the feeder. The structure of the feeder will be discussed later in this section.

Electrical components

The electrical components used in this project are shown in Fig. 3 and described below.

Micro-controller

In all automated devices, there must be a unit that is able to receive inputs so that the output can be controlled based on them. The microprocessor or microcontroller is used to carry out these duties for small automated devices. In this food delivery system, the microcontroller also plays a vital role in the automation process. Here, we use an Arduino Nano Microcontroller board, based on ATmega328p which controls the motion of a Servo motor. The Arduino Nano is a low cost and small size microcontroller board of the Arduino family. The ATmega 328 has 2 KB of SRAM and 1 KB of EEPROM. The Arduino Nano can be programmed with the Arduino open-access software and can be powered via the Mini-B universal serial bus (USB) connection (Anon, 2020b).

Servo motor

In recent times, the servo motor is an important device in various industrial applications. Unlike a normal motor, servo motors can only rotate at a specific angle from 0° to 180°, whereas a normal motor is able to rotate 360° (Haidar *et al.,* 2013). The servo circuitry is built right inside the motor unit and has a positional shaft, which usually is fitted with a gear system as shown in Figure 3 (B). The motor is controlled with an electric signal which controls the drive shaft movement. In our device, we use a Tower pro SG 90 servo motor to rotate a lid of an inversely mounted food reservoir. The lid is held by the servo arm and fixed at the drive shaft of the servo motor. So, with the rotation of the drive shaft, the lid rotates which opens the food delivery point of the reservoir, hence food is delivered.

Keypad

According to our proposed methodology, users are allowed to fix the time interval between two successive food deliveries and the number of lid rotations (stroke number) at each delivery time. This data entry can be performed by using a 3x4 matrix keypad which can read with 7 pins (3 columns, 4 rows) from the microcontroller. The time interval and stroke number can be set by pressing on the digit buttons (0-9) of this membrane keypad. The asterisk "*" button is used to REST the system while the hash "#" button remains unused as indicated in Fig.3 (A).

Liquid crystal display

The LCD screen is an electronic display module and has a wide range of applications. A 16x2 LCD (Figure 3 D) is a very basic module and is common in various devices and circuits because of its special features such as low cost, easily programmable, displaying capability of special and custom characters, animations and so on. A 16x2 LCD has been used to show various messages and indications to the users for easy installation of the device shown in Fig. 8.

Tiny real-time clock module

To count down a tiny real-time clock module (DS3231) has been integrated with the microcontroller is shown in Fig. 3(C). The timer module is powered by a 3.6v Li-ion battery so that it can keep counting in case of any power outage of the microcontroller due to discontinuous electric supply.

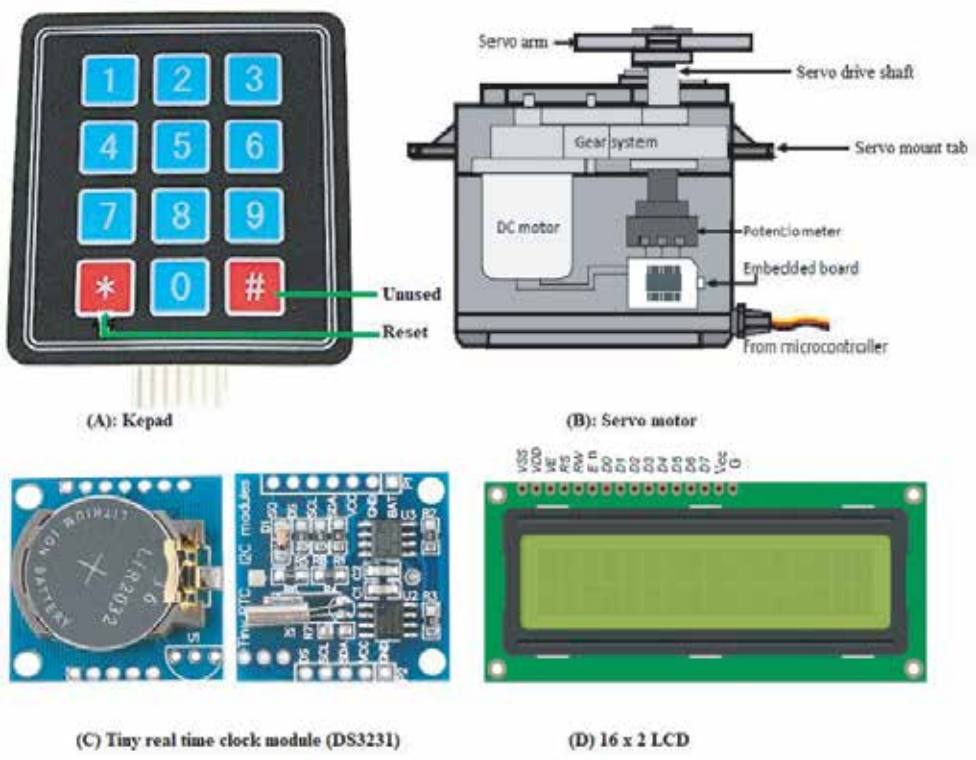

Fig. 3. Electrical components used for automation (A) 3x4 keypad (B) Servo motor (Hwang *et al.,* 2018) (C) Timer module (D) 16x2 LCD

Cad design of the fish feeder

The designed fish feeder contains three parts- Basement plate; Food tank cap and Servo arm plate or lid are shown in Figure 4. The dimensions of the rectangular-shaped basement plate are 7mm (length) x 5mm (width) x 1.6mm (height). At one side of the basement plate, a rectangular hollow of size 3x2 inches has been kept to hold a printed circuit board (PCB). The PCB contains all the electronic components while exposing the LCD on the top. Just at the opposite side of the PCB placement, the membrane keypad has been mounted on the solid surface of the basement plate. Between these two, a Buchner funnel-shaped food storage tank and servo mounting tab holders are positioned (Fig. 4 A). The Servo motor is kept fixed at the mounting tab holders by two screws. The drive shaft of the servo motor can be accessed at the bottom side of the basement plate through a hole in the middle of these mounting tab holders. A circular-shaped lid/servo arm plate (Figs. 4 D and 5) of diameter 72 mm containing two holes one at its center to insert servo drive shaft and another of diameter 4 mm at its periphery for food dropping is used to block the funnel orifice. The servo arm (Fig. 3 B) gives the back support to fix the lid with the servo drive shaft. The gadgets are assembled in such a way that the lid/servo arm plate can rotate with light friction along with the bottom surface of the basement plate. In this way, the lid blocks the orifice of the funnel (food delivery point) to prevent the drop-down of food from the food chamber. However, as the servo drive shaft rotates, the lid fixed with it also rotates and due to gravity, food is delivered when the two openings meet each other. It should be kept in mind that the center distance between the peripheral hole and the hole to insert servo drive shaft of the lid is equal to the center distance between the funnel orifice and the servo drive shaft hole of the basement plate which is 25 mm as indicated in Fig. 5.

Besides, different dimensions of the Buchner funnel (food tank) have been indicated in Fig. 5. The food tank has the capacity to store approximately 30 gm. (Nova aquarium fish food) pellet type food which is sufficient to feed 6-10 fishes for a month. For other floating pellet types of food, this capacity may vary slightly depending on the size of the food particles. The top side of the food tank is enclosed by a cap that can be removed to fill the food chamber. Most importantly, the peripheral circular and rectangular holes of the basement plate will help to robust the attachment of the feeder with the aquarium.

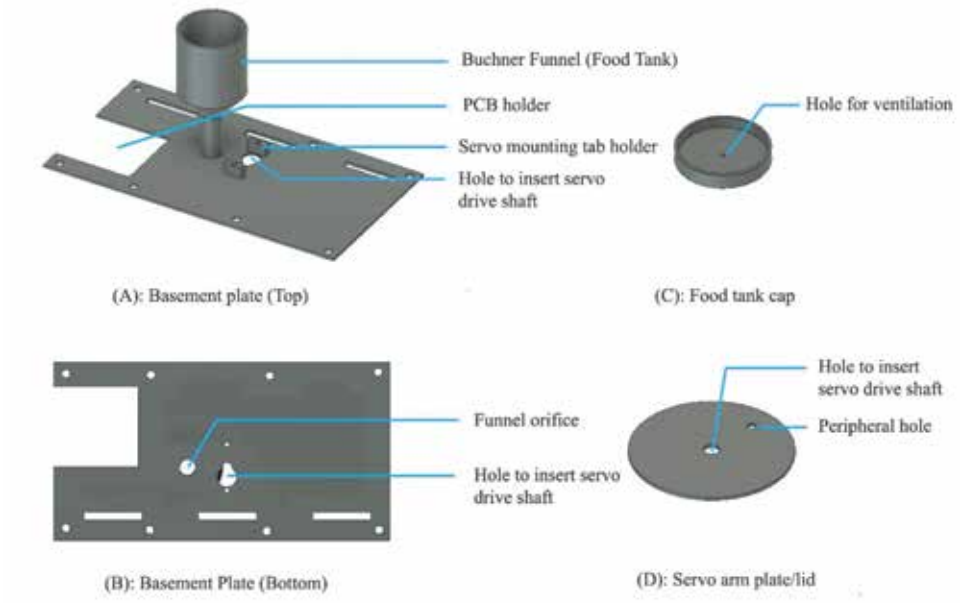

Fig. 4. Different parts of the fish feeder designed in Auto desk fusion 360

Volume calculation of food tank

In Fig. 5, the "P" and "R" portions of the Buchner funnel are cylindrical. So, the volume of these portions can be

calculated using Equation 1 as follows.

$$\text{Volume of portion, } P = \pi r^2 h \text{ .....(1)}$$
$$= \pi \times 20^2 \times 44$$
$$= 17600\pi \text{ millimeters}^3$$

$$\text{Volume of portion, } R = \pi r^2 h$$
$$= \pi \times 5^2 \times 28$$
$$= 700\pi \text{ millimeters}^3$$

The "Q" portion of the Buchner Funnel is Conical Frustum. Therefore, its volume can be calculated using Equation 2 as follows.

$$\text{Volume of portion, } Q = \frac{1}{3}\pi h(r^2 + rR + R^2 \text{ .....(2)}$$
$$= \frac{1}{3}\pi \times 19(5^2 + 5 \times 20 + 20^2$$
$$= 3325\pi \text{ millimeters}^3$$

$$\text{Therefore, Volume of Food Tank} = (17600r + 3325\pi + 700\pi) \text{ millimeters}^3$$
$$= 21625\pi \text{ millimeters}^3$$
$$= 67936.94 \text{ millimeters}^3$$
$$= 67.93 \text{ ml}$$

Controlling mechanism

Automatic fish feeder refers to control of the food supply system, specifically the control of opening and closing of the food delivery point. For this purpose, we use a mini Tower Pro SG 90 servo motor to open the food delivery point of the feeder at user-defined time intervals. The Tower Pro SG 90 servo is one of the cheapest motors, available in the market. It is controlled by sending a pulse width modulated (PWM) signal through the control wire from a microcontroller. However, the drive shaft of the servo motor cannot rotate any further to a built-in mechanical stoppage and can be rotated from 0 to 180 degrees. Servo checks the pulse width every 20 milliseconds and the position of the shaft is determined by the width of the pulse (Haidar *et al.,* 2013). The stall torque of SG 90 is 1.8 kg-cm which is sufficient enough to rotate the lid of the fish feeder weighted approximately 1.5 g.

The lid is fixed at the drive shaft with the help of the servo arm. A screw is used to tighten the attachment between the servo arm and the drive shaft while the servo arm is fixed with the lid by glue. The attachment is such that, initially the peripheral hole of the lid and the funnel orifice (food delivery point) are at right angles to each other i.e., the peripheral hole of the lid remains at point A (Fig. 5). Since the position of the funnel orifice is permanent at point B, it remains blocked by the lid. But, with the forward and backward motion of the servo drive shaft between 0 and 180 degrees, the peripheral hole moves from point A to C and C to A (Fig. 5) at a constant angular speed of 10°/sec. The two holes meet two times each other during one cycle of movement and food drops twice into the aquarium which is termed as a single stroke. Under these conditions, the minimum amount of food delivery depends on the diameter of the peripheral hole and the size of the food particles. We optimize the system to deliver approximately 100 milligrams of food in a single stroke (Table I). This amount is determined statistically only for Nova fish food and hence, the diameter of the peripheral hole is chosen to 4 mm. Users can set a suitable time difference and the stroke number to supply their desired amount of food in a day. The controlling flow chart and circuit are discussed below.

Controlling flow chart

Our proposed controlling algorithm works in such a way that food is delivered daily at least once. At first, the user has to set the time interval between two successive food deliveries from the keypad. The maximum time difference cannot be exceeded 24 h. After that, the user has to program how many strokes of food should be delivered. One stroke means two times food delivery due to forward (0 to 180 degrees) and backward (180 to 0 degrees) movement of the servo drive shaft. Then the automation process begins. The battery-powered timer module starts counting until the preset time. If the microcontroller is powered on, it compares the value of the timer with the user-defined time and sends a signal to the servo motor when both are equal. A common occurrence at the home is sudden power outage due to discontinuous electricity supply causing the microcontroller to turn off. At the moment electricity becomes available, it shows a power failure message on the LCD and does its routine check. In that case, if counting time exceeds the specified duration, it will continue to send pulses to the servo until the rotation number is equal to the specified stroke number. Then, it resets the timer module to zero and starts a new cycle. Otherwise, the time counting continues until it does not exceed the scheduled duration. The controlling flow chart is given in Fig. 6.

Controlling circuit

The schematic of the controlling circuit has been drawn in the Fritzing open-source software. In Fig. 7, the pin connections

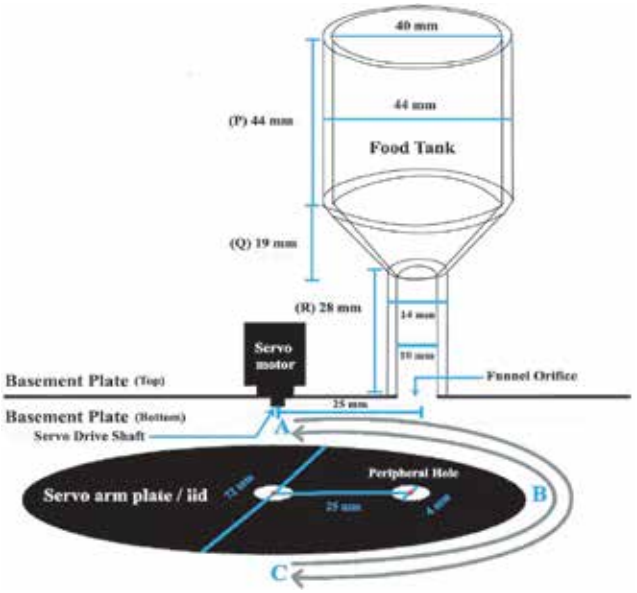

Fig. 5. Food delivery mechanism and different dimensions of food tank

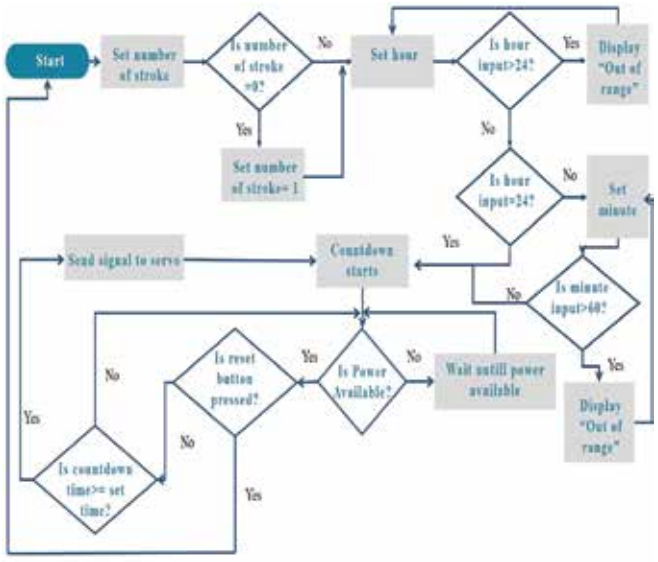

Fig. 6. Flow-chart of automatic fish feeder controlling mechanism

of the microcontroller with different electrical components have been shown. From the analog pin A_3 of the Arduino Nano microcontroller board, a pulse is sent to control the servo motor. Digital pins 3, 4, 5, 6, 7, 8, and 9 are connected with the 3x4 matrix keypad. The SDA and SCL pins of the tiny timer module are connected at analog pins A_4 and A_5 of the microcontroller board, respectively. The RS, EN and D_4 to D_7 pins of the 16x2 LCD are connected to digital pins sequentially with 12, 11, 10, 2, 0 and 1 of the microcontroller board. A variable resistor is used as a potential divider to adjust the contrast of the LCD at V_o pin. Finally, we fabricate a PCB to compact the circuitry and fix it to the basement plate.

Device installation procedure

The Arduino Nano microcontroller board is powered on via the Mini-B USB connection. When the microcontroller is powered on, the servo drive shaft takes its initial position so that the peripheral hole of the lid stays at position "A" (Fig. 5) and displays the message of steps 1 and 2 as shown in Fig. 8, sequentially. At step 3, it gives information about the amount of food delivery per stroke which is approximately 100 milligrams. This was determined statistically and the experiment was done only for Nova aquarium fish food by maintaining a constant angular servo speed of 10 degrees/sec and keeping 4 mm diameter of the peripheral hole. For other types of food, users can give a trail to get an idea about the amount of food being served by selecting all the inputs to zero. Selecting all the inputs to zero is termed as a Test option which automatically delivers 1 stroke meal at 30-second intervals. From this test option or trail, users can estimate the food delivery frequency and stroke number to supply their desired amount. The maximum number of strokes one can set is 99. At steps 4 and 5, the microcontroller shows the range of hour (00-24) and minute (00-59) values and waits for inputs within these ranges from the user. Beyond this range, it gives the following message "Out of range". If the hour is set to 24, the microcontroller automatically skips step 5 as we would like to ensure food delivery at least once in a day. The timer module starts counting and the microcontroller compares the set time with it. If counting time becomes equal or greater than the set time, the microcontroller transmits pulses to move the servo drive shaft from its initial position 0° to 180° (from point A to point C in Fig. 5) and in the reverse direction at a speed of 10°/s. During this movement, the peripheral hole of the lid crosses the funnel orifice (point B in Fig. 5) twice and causes food to drop into the aquarium. After food is served, the timer module starts counting from zero and the microcontroller repeats steps 6 and 7. Once the user sets the time interval and stroke number, in case of any power interruption, the microcontroller displays a message "Current Failure!" on LCD and starts from step 6. Someone may need to change the stroke number or the duration of successive food deliveries. In that case, s/he has to press the asterisk "*" button up to 2 s. The microcontroller will take reset and begin

from step 1. A pictorial representation of the whole installation process has been given in Fig. 8.

Performance analysis

We implement our developed automatic fish feeder at an indoor aquarium to test its performance as shown in Figure 9 and a comparative study has been given in Table II. We fill the food reservoir with the Nova fish feed of approximately 30 g. which is sufficient to feed 6-10 fishes for a month. The feeder is designed in such a way that it also has the ability to dispense other locally available dried feed of various forms such as pellets, tablets or granules. In that case, the storage capacity will depend on the size of the food particle. However, the performance of the device was quite well. It could work according to users' command and could feed fishes at preset intervals. Most automatic fish

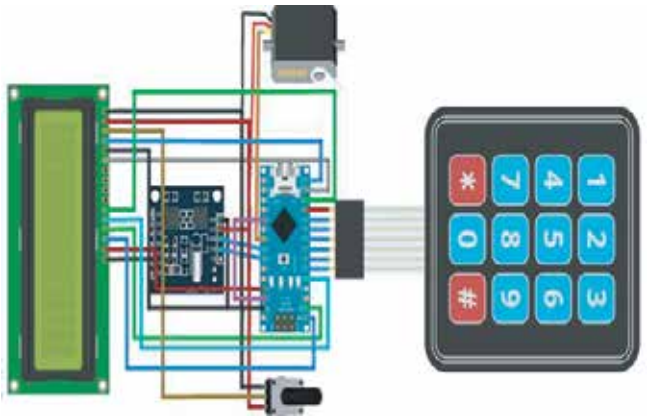

Fig. 7. Schematics of controlling circuit diagram (Fritzing design)

feeders have the problem to control the precise amount of food release. Too much feed pollutes the water in the tank and too little causes fish starvation. Therefore, we optimized the minimum amount of food to dispense is approximately 100 milligrams (Nova aquarium fish feed) by maintaining constant servo speed at 10 degrees/sec and keeping a 4 mm diameter of the lid peripheral hole as indicated in Figure 5 and the calculation has given in Table I. One can deliver integer multiples of this amount by increasing the stroke number. For other brands of food, users need to give a trial to find out this critical amount from the test option.

In our one-month observation, several times electricity failure occurs which did not hamper on timely food delivery as the timer module was battery-powered. This device also comes with its own limitations. The main

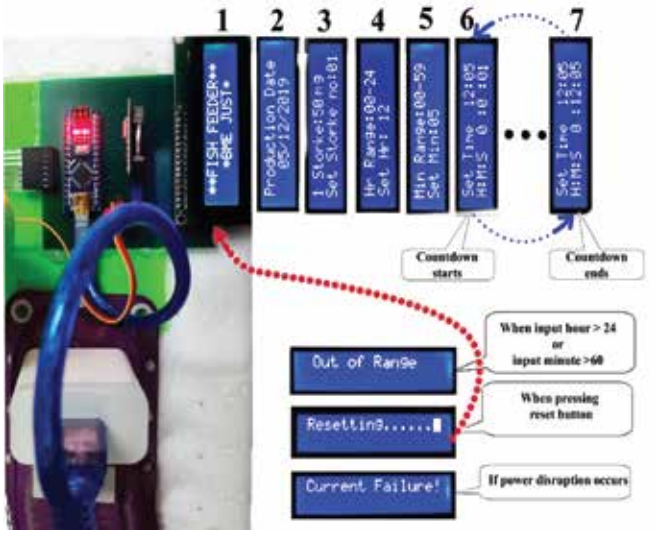

Fig. 8. Operational steps of the developed fish feeder device

Fig. 9. Developed fish feeder device (A) Implementation on the aquarium (B) Refilling of food (C) Food releasing moment

drawback of this system is that wrong input values may drop out excess or insufficient amounts of feed into the tank, hence input values must be properly given by the user before feeding the fish. The user should have pre-knowledge about fish feeding. Refill of food storage is manual and there is no feedback system to supply the food based on temperature and pH level of water.

Table I. Calculation of food amount release per stroke

Types of food		Pellet		
Brand name		Nova aquarium fish feed		
Servo speed		10 degrees/s		
Diameter of food release hole		4 mm		
1 stroke		Two times food dispense (Forward and backward motion)		
Amount of food to dispense	Trail no	Number of strokes required to dispense	Amount of food release per stroke	Average
10 g	#01	109	91.74 mg	
10 g	#02	103	97.08 mg	
10 g	#03	105	95.23 mg	94.15≈100 mg
20 g	#04	209	95.69 mg	
20 g	#05	213	93.89 mg	
20 g	#06	219	91.32 mg	

Table II. Comparison of developed fish feeder with existing fish feeders

Features	eBoTrade Aquarium Auto Fish Food Timer (Amazon.com, 2020)	EHEIM Automatic Fish Feeding Unit (Amazon. Com : EHEIM Everyday Fish Feeder Programmable Automatic Food Dispenser)	Developed Fish Feeder
Dispensable food types	Most types of food, including flakes, pellets or crumbles.	Ideal for most types of food	Pellets or crumbles, granules.
Feeder drum volume	70 ml	100 ml	63.93 ml
Aeration of food chamber	Integrated fan and ventilation system keeps the food dry	Actively aerated food chamber	Natural, through the hole of food tank cap.
Daily food deliver frequency	One to four meals	Maximum of eight feedings	User-defined

Table II. Comparison of developed fish feeder with existing fish feeders (Continued)

Minimum feeding amount can dispense per stroke.	For small particles (φ1.5) 5 g and for large particles (φ4.5) 2 g able to dispense.	Adjustable slider allows to set desired amount	100 mg (Nova Fish Food)
Installation process	Easy digital LCD programming	Easy digital LCD programming	Easy digital LCD programming
Attachment Method	Retaining clips or Velcro fixed	Universal installation clamp	Cork Sheet mounted
Device operation	Manual and automatic	Manual and automatic	Automatic
Power management	Battery operated includes 2 AA batteries	Battery operated includes 2 AA batteries	Microcontroller and Servo are powered directly from main supply. Tiny Real-Timer Clock Module uses 3.6 V Li-ion Battery.
Price	Amazon price = $18.99 + Shipping & Import Fees Deposit to Bangladesh	Amazon price = $23.40 + $136.66 (Shipping & Import Fees Deposit to Bangladesh)	Arduino Nano = $4; Tiny Real Timer Module with battery = $2.5; PCB = $0.5; Keypad = $1; LCD = $2; Feeder Chamber = $2.5; Adapter = $1; Others = $1.5; Total = $15. (Anon, 2020c)

Conclusions

In terms of marketing, hobbyists will not be interested in buying an overpriced product. That's why we have to balance between the costs and features to fulfill the basic demands of our local users. Finally, we can say that the device will help the aquarists to prevent the death of the fishes due to starvation which will encourage the hobbyists to rear fishes in aquariums. The device is simple, compact in structure, and efficient in operation while the cost will be within the limit of the users. Furthermore, the controlling system can be implemented in other feeding systems such as for the cat and bird or even in ponds for large scale fish cultivation. In the next phase of development, we would enhance the features by implementing IoT to send an alert message when the storage is empty or at critical temperature and pH level of tank water.

Conflicts of interest

The authors declare no conflict of interest.

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