GSM/SMS-Based Automated Spread-Type Fishpond Feeder

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Chapter 1 - Introduction

1.1 Background of the study

In 2016, Aquaculture made up 40% of the Philippines' fisheries industry, and an estimated 1.2% of the country's Gross Domestic Product. It provides livelihood for approximately 226,195 recorded operators and their employees, as well as many more unrecorded smaller-scale businesses. (Fisheries Statistics of the Philippines, Vol. 25, 2017)

A good number of these fish farms are privately-owned family businesses. These businesses tend to be of a smaller scale compared to industry-operated aquaculture farms. Due to this, they must maximize profits and minimize costs in order to balance factors and keep their business afloat. One of these factors is employment. A fish farm that can only employ a limited number of caretakers can find it hard to expand their operations.

The entire feeding process, when done manually, presents two notable problems. First, each fish pond must be fed around 2 to 4 times daily. This takes up time that can be used for other maintenance tasks, such as checking on each batch's population, health, and average size and weight measurements. Second, the amount to be used for feeding is usually only estimated by the feeders. This can cause an inconsistency in the feeding amounts, one of the factors that affect average batch growth. (Ajesta, 2018)

Accurate record-keeping is also a necessity. Regular records of the feeding process and fish growth can serve as guides for making adjustments to the feeding patterns. This allows fish farms to figure out which combination of feed types, amounts, and schedules will produce batches with a high average market value.

1.2 Statement of the Problem

Business owners want to lessen the cost of production, while at the same time still guaranteeing a level of quality in their produce. However, that requires a lot of manpower and meticulous records of feeds, growth, and related expenses. The system aims to help with all those, while at the same time providing the convenience of being able to interact with the system using only texting, via SMS technology.

Chapter 2 - Objectives

The general objective of this research project is to develop an automated system to help fish owners and related business in fishpond management.

Specifically, the system should be able to

- Develop a microcontroller-controlled fish feeding field unit that automatically carries out the fish feeding process when prompted either by server command or schedule.
- Allow users to use SMS messaging or a web portal to update or access relevant data, manually send commands to their owned field units, and record and track batch sample-related statistics.
- Develop a dedicated SMS-capable server that will store and organize important data for users, as well as control existing field units via SMS messaging or a web portal.
- Create a secure database containing important data about the user, their owned field units, and records regarding each unit's feeding and population sampling details.
- Provide a web portal that serves as an alternative medium of user-server communication that is capable of the same functionalities as the SMS-controlled option.

Chapter 3 - Review of Related Literature

3.1 GSM-SMS Technology as a Medium of Communication

The GSM-SMS network is a cheap and reliable packet-based medium of data communication between field and server units. A feasibility study on the use of this network was conducted using a system that involved a field unit that collected the data of a farm such as humidity, temperature, and wind speed, and a server unit that gathered the data. The authentication tests yielded an almost 100% data correctness rate over the course of 915 data transmissions, with a data loss rate of only 0.66%. The one-way SMS transmission time of a field unit to a server unit is about 10 to 15 seconds, while the average response time of a field unit to a command sent from the server unit averaged at 30.5 seconds. (Tseng, et. al., 2006)

In the past few decades, sea water rescue systems have sought as a solution to the problem of marine vessels stranded in open waters. These systems are designed to guide research and rescue teams as accurately and quickly as possible to the vessels in distress. The systems currently available to the public are made for either far-shore vessels or for general rescue purposes. These systems are usually very expensive. This project serves as a low-cost rescue system for near-shore vessels. It makes use of GPRS/GSM technology, along with a few others, to communicate between stranded ships and strategically placed web server units.

This system is designed to be usable on a global scale. As of 2016, the GSM network is accessible by up to 90% of the world's land areas. Any other areas not covered by the terrestrial

GSM network will instead connect via the GSM satellite roaming service. The only significant drawback is the high power consumption when transmitting data over long ranges. (Al-Zoubi, 2016)

3.2 Using Pneumatic Action for Feed Delivery

Stationary feeding equipment can be either mobile or stationary. Stationary feeders can be further split into two categories: demand feeders and automatic feeders. Automatic feeders can then be split into three classes: electric, pneumatic, and hydraulic.

Pneumatic feeders shoot feed by means of compressed air. The units usually get their air supply from a central air compressor system, but control can be done either from a central electrical system or using individually installed systems.
(Inland Aquaculture Engineering, 1983)

Pneumatic feeders use blasts of compressed air to launch feed in a spread out manner over a fish enclosure. The amount of feed ejected during each firing sequence depends on the diameter of the distribution pipe and the hopper outlet, as well as the length of time that the blast of air is allowed to pass through the distribution pipe. (New, 1987)

3.3 Existing Automated Fish Feeders

The main purpose of the project is to help people who spend much time away from home keep their fishes regularly fed and healthy. Accurately set feeding times will be used. An LCD monitor serves as the main user interface to control the device. A relay is used as a switch to toggle the DC motor on and off. This design will be installed in aquariums and will be operated and controlled by a PIC microcontroller. (Baniqued, et. al., 2009)

The feeding operation begins when the feed silo empties into a feed dosing auger. The auger moves the feed into a funnel that ensures that the feed goes into the airlock and then into the main transport pipe. An air blower blows into the distribution valve, where it is then directed into individual feed pipes.

The operation of the system is controlled using a PLC (Programmable Logic Computer). Programmed software is used to interface between the software and the hardware portions of the system. The software controls the specifics of the feeding operations, such as feed amount, meal times, feed types, etc. (VAKI Feeding System, 2012)

Chapter 4 - Methodology/Methods & Materials

4.1 Theoretical Framework

4.1.1 Technologies

For the development of the system, the following will be utilized: HTML, CSS, JavaScript, Bootstrap, Jquery, MySQL, XAMPP, Arduino, Diafaan, and NodeJS, with the following NodeJS modules: NPM, Express, Body-parser, mysql, sha256.

HTML (Hypertext Markup Language) is a text-based approach to describing how content contained within an HTML file is structured. This markup tells a web browser how to display the text, images and other forms of multimedia on a webpage (What is HTML, 2018).

Stands for "Cascading Style Sheet." Cascading style sheets are used to format the layout of Web pages. They can be used to define text styles, table sizes, and other aspects of Web pages that previously could only be defined in a page's HTML (CSS Definition, 2005).

JavaScript is a programming language commonly used in web development. It was originally developed by Netscape as a means to add dynamic and interactive elements to websites (Javascript Definition, 2014).

Bootstrap is also a popular web development framework used for creating websites. It was developed by a team at Twitter and has been an open source project since 2011. The Bootstrap framework includes CSS styles, JavaScript libraries, and HTML files. Bootstrap provides a way for developers to easily build responsive websites rather than designing them from scratch (Bootstrap Definition, 2016).

jQuery is a JavaScript library that allows web developers to add extra functionality to their websites. It is open source and provided for free under the MIT license (jQuery Definition, 2013).

MySQL, pronounced either "My S-Q-L" or "My Sequel," is an open source relational database management system. It is based on the structure query language (SQL), which is used for adding, removing, and modifying information in the database. Standard SQL commands, such as ADD, DROP, INSERT, and UPDATE can be used with MySQL (MySQL Definition, 2007).

XAMPP (or) is a free and open source cross-platform web server solution stack package developed by Apache Friends, consisting mainly of the Apache HTTP Server, MariaDB database, and interpreters for scripts written in the PHP and Perl programming languages. XAMPP stands for Cross-Platform (X), Apache (A), MariaDB (M), PHP (P) and Perl (P) (What is XAMPP, 2016).

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a

Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online (What is Arduino?, 2006).

A breadboard is a solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate (Breadboard\Wiring, 2010).

The TowerPro MG995 Servo Motor is a 180 degree digitally-controlled metal gear high torque servo motor. It is TowerPro's most famous and most widely-used servo motor (MG995, 2018).

The SIM900A GPRS module is a breakout board and minimum system of SIM900 Quad-band/SIM900A Dual-band GSM/GPRS module. It can communicate with controllers via AT commands (GSM 07.07 ,07.05 and SIMCOM enhanced AT Commands). This module supports software power on and reset (SIM900/SIM900A GSM/GPRS Minimum System Module, 2016).

The 4-Channel 5V Relay Module is a 5V 4-channel relay interface board. Each channel needs a 15-20mA driver current. It can be used to control various appliances and equipments that use large currents. It is equipped with high-current relays that work with AC250V 10A or DC30V 10A. It has a standard interface that can be controlled directly by microcontroller (4 Channel 5V Relay Module, 2017).

The 12V Portable Car Air Compressor is a portable air compressor unit that is powered via an automobile's 12V cigarette lighter socket. It is lightweight, portable, and features multiple attachable nozzles for different air valve types. It includes a built-in pressure gauge that reads in both lb/in and kg/cm (120W Portable Car/Auto 12V Mini Air Compressor Electric Tire Inflator Pump, 2013).

The ZE-4F180 12V Water Solenoid Valve is a normally closed water solenoid valve with a diameter of ½ inches. When not powered, water (or air) cannot pass through. If powered with enough current and voltage, an electromagnet opens the valve within a quarter of a second, allowing water and air to flow through (ZE-4F180 12V Water Solenoid Valve, 2016).

The Universal Laptop/Netbook AC Power Adapter is a power converter that converts the standard 110V-220V output of a power outlet into either 12V, 15V, 16V, 18V, 19V, 20V, or 24V (Best Universal Adapter 96w Ac Power Supply Adapter Charger For Notebook Laptop Netbook).

Diafaan SMS Server is a text message software solution for Windows. It can be installed on a Windows server or on a PC or laptop to send and receive SMS messages with 4G/3G/GSM modems, Android phones, all online SMS services that support the SMPP

standard and the HTTP API SMS services of BulkSMS, ClickSend, Clickatell, Esendex, MessageBird, Nexmo and Twilio (SMS Software for Windows, 2015).

Node.js (Node) is an open source development platform for executing JavaScript code server-side. Node is useful for developing applications that require a persistent connection from the browser to the server and is often used for real-time applications such as chat, news feeds and web push notifications (What is Node.js?, 2012).

Express is a minimal, open source and flexible Node.js web app framework designed to make developing websites, web apps, & API's much easier. Supports multiple templating engines to simplify generating HTML. HTTP requests can be sent as GET/POST/PUT/DELETE, etc (THE BEGINNER'S GUIDE: Understanding Node.js & Express.js fundamentals, 2017).
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Node.js body parsing middleware. Parse incoming request bodies in a middleware before your handlers, available under the req.body property (Body-parser, 2018).

NPM is the package manager for JavaScript and the world's largest software registry. Discover packages of reusable code — and assemble them in powerful new ways (What is npm?, 2010).

Mysql is a node.js driver for mysql. It is written in JavaScript, does not require compiling, and is 100% MIT licensed (mysql, 2018).

SHA-256 is one of the successor hash functions to SHA-1 (collectively referred to as SHA-2), and is one of the strongest hash functions available. SHA-256 is not much more complex to code than SHA-1, and has not yet been compromised in any way (SHA-256 Cryptographic Hash Algorithm implemented in JavaScript, 2017) .

4.1.2 Software Development Life Cycle

Software Development Life Cycle (SDLC) is a process used by the software industry to design, develop and test high quality softwares. The SDLC aims to produce a high-quality software that meets or exceeds customer expectations, reaches completion within times and cost estimates (SDLC Overview, 2013).

4.1.3 Test Driven Development

Test-Driven Development is a process that relies on the repetition of very short development cycle. It is based on the test-first concept of Extreme Programming (XP) that encourages simple design with high level of confidence.

The procedure of doing TDD is following:

Write a test
Run all tests
Write the implementation code
Run all tests
Refactor

This procedure is often called Red-Green-Refactor.

While writing tests we are in the red state. Since test is written before the actual implementation, it is supposed to fail. If it doesn't, test is wrong. It describes something that already exists or it was written incorrectly. Being in green while writing tests is a sign of false positive. Tests like that should be removed or refactored.

Next comes the green state. When the implementation of the last test is finished, all tests should pass. If they don't, implementation is wrong and should be corrected.

The idea is not to make the implementation final, but to provide just enough code for tests to pass. Once everything is green we can proceed to refactor the existing code. That means that we are making the code more optimum without introducing new features. While refactoring is in place, all tests should be passing all the time. If one of them fails, refactor broke an existing functionality. Refactoring should not include new tests (Test-Driven Development, 2014).

4.2 Methods

In the development of the system, Test Driven Development (TDD) will be used in the development process. Since the features for the system were already clarified beforehand, and TDD helps in creating a more scalable product, it was deemed the most suited development method.

4.2.1 Develop a general outline

Conceptualization of the system marked the beginning of the system development. In this phase, the list of functions, capabilities, features, and limitations were set.

4.2.2 Design

After developing the general outline of the system, each section was made more detailed, clearly defining each design, function, and how they will interact with the rest of the system. The tools and other technologies will be specified during this stage.

4.2.3 TDD Implementation

In this phase, the development and implementation of both the field unit and server units will begin. The development will start from the most foundational and necessary features from each of the two main components. The field unit and server unit will be developed independent of each other, while at the same time fitting the specified requirements in inter-component communication, and at the end of the development period, will be integrated with complete system testing.

4.2.4 Automated Fishpond Feeder Field Unit Setup

The device will make use of an Arduino Uno microcontroller. It will be powered via a USB cord and a USB to 220V adapter. Attached to the Arduino will be a breadboard module, a SIM900A module, a TowerPro MG995 servo motor, and a 4-channel 5V relay module. Attached to the relay module will be the 12V portable car air compressor and the ZE-4F180 12V water solenoid valve. These two parts will be powered using a universal laptop/netbook AC power adapter set to its 12V conversion setting.

All these electronics, except for the solenoid valve and servo motor, will be safely stored within a wooden casing that also serves as a stable base for the feeder. The cannon is to be mounted on top using a triangular wooden frame. On the right side of the base will be a wooden beam that supports the feed hopper setup.

The cannon itself will be composed of three main sections: the air tank, the solenoid valve, and the barrel. The air tank will be made from a section of 2 inch PVC pipe, two 2 inch PVC pipe end caps, a schrader air valve, and a ½ inch PVC threaded adaptor. The barrel will be composed of a ½ inch to 1½ inch bushing, a 1½ inch male to female PVC adapter, a 1½ inch PVC coupling, and a modified funnel.

Attached to the funnel will be the feed hopper setup. It will be composed of a small wooden platform, a servo motor, and a feed container that hangs from a support beam.

4.2.5 Automated Fishpond Feeder Server Setup

The server's development covers HTML, CSS, JavaScript, Bootstrap, Jquery, MySQL, XAMPP, Diafaan, and NodeJS. The server is run via Nodejs, using Express and Body-parser as its HTTP modules. The website will be built with HTML, Bootstrap, and Jquery, and the data updated by Ajax requests. It will contain various information like the field unit's label, the species of fish that it contains, the current settings for its scheduled feeding - set with Start, Interval (in hours), and End times, the amount of feed per session, phone number, feeding history, fish sampling history - to measure fish growth over time, and the amount of feeds it has left on its hopper.

All of these functions will be guaranteed security by use of the classic user-password combo, but with the added hashing of the passwords using SHA256, to be stored in the MySQL

database. The user will be allowed to add a new field unit in the server that is automatically linked to their account, but will require the assistance of the researchers to fully set up the field unit in the user's fishpond area.

4.2.6 Integration With SIM900A and Diafaan for Server-Field Unit communication

After the field unit and server are finished being developed individually, the researchers will link them together by use of the field unit's SIM900A module, and the server's Diafaan software. It will be in this level of development that will give the users the ability to fully interact with the system via SMS. In every text, the sender's phone number will be validated, and if it is linked to an account, will be allowed to look at the related information of the field units that are bound to that account. The user will also be able to manually trigger the feed command by texting the server, and the server will act as a relay to forward the message towards the field unit.

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