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The Future in Fishfarms: an Ocean of Technologies to Explore

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Abstract. We present the potential application of Machine Learning (ML) to fish farm in a similar approach used in agriculture to control crop growing and predict diseases. The agriculture concept of Precision Agriculture is now applied to fish farm by applying control-engineering principles to fish production; Precision Fish Farming (PFF) aims to improve the farmer's ability to monitor, control, and document biological processes. PFF can help the industry because it takes into consideration the boundary conditions and potentials that are unique to farming operations in the aquatic environment. The proposed solution improves commercial aquaculture and makes it possible to transition to knowledge-based production regime as opposed to experience-based. We apply a data mining approach to identify and evaluate the impact on the growth and mortality of fish in hatcheries. The use of ML techniques, combined with regulation, can increase the productivity and welfare of aquaculture living organisms.
Keywords: Machine Learning, Precision Fish Farming, Data Analytics, IoT, Water Quality

1 Introduction

One of the largest industries on the globe, seafood accounts for 12% of all global livelihoods. One in ten people on the earth makes their living from seafood and aquaculture. Humans eat more fish than ever before. In the last 50 years, the world's per-capita consumption has doubled (FAO 1, 2018). Total market size estimates are in excess of $500 billion USD. The marine ecosystems are under heavy pressure.
It is expected that the world population reaches 9,6 billion people in 2050, which translates into a need for 69% more food [36]. Food consumption and waste have significant environmental, economic, and social implications, and it is estimated that at least 30% of the food is wasted globally. Fishing was reached its exploratory maximum, so it is important to consider other options more sustainable, like fishfarms production (FAO 2, 2018). New technologies can potentially improve the sustainability of fresh fish species, helping commercial aquaculture transition to a

knowledge-based production regime [7]. Fish farming presents benefits: their feed conversion rate (lower than in other species) [15], the possibility of restoring populations that may have been decimated by ecological catastrophes or overfishing and his contribution to develop rural areas with no aptitude for agriculture, and the ability to produce a lot of food on a small area, leading to new populations settling in [11]. On the other hand, generates pollution through excretion products or medical treatments, the activity dependent on the conditions of the environment in which it operates, and even environmental impact factors such as food scraps, the introduction of new species, genetic alteration in wild stocks, etc. [18].

New technologies (eg, ML) create control-engineering concepts for increasing fish productivity as well as the processes and results in this industry. information to keep track of and control the biological production process, more advanced technical solutions will be required; Sizes and designs of fish cages alter as fish farms expand and become more complex, and new site types are used [7]. By keeping an eye on the variables that affect fish growth, the aquaculture sector and researchers aim to develop tactics that optimize biomass production.
In this line of work, the use of data from farms can offer some correlation between features and identify which ones are directly connected with mortality. A definition of which factors the mortality depends the most can help the farms to know where they should be the focus on, where to intervene, and how to give better answers to their daily problems.
Artificial intelligence is used in machine learning (ML) to enable systems to learn from experience and advance without explicit programming. The development of computer programs that can access data and utilize it to learn for themselves is the main goal of this technology. Its main benefit is the quick processing of massive amounts of data with a time-saving checkpoint [12] [20]. Direct observation is a difficult way to evaluate the animals and gather information on the population's health, because fishfarms are made up of millions of different creatures that reside underwater [7]. For example, through the creation of an algorithm, we can compare historical data from previous delousing processes, providing a recommendation of whether the operation should be continued, halted or aborted.

The paper is structured in 3 sections: 1. State of the Art; 2. CRISP-DM methodology (presentation and demonstration of the application of the concept through the various phases of the process); 3. Conclusion.

2 State of Art

2.1 Methodology

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Methodology was employed to carry out a thorough literature review., and the following research question was used: “Which are the most related factors with mortality in fishfarms and how to prevent or monitoring them?”. The research was carried out through September 2022, and the paper repositories Scopus and the Web of Science Core Collection (WoSCC) were searched. The only acceptable results were journal papers, articles, or reviews that were released between 2017 and 2022. According to the study's name and abstract, the initial selection of articles was made. The questions took into account the "target population" and the "idea" being investigated. The following terms were utilized as screening criteria: "Fishfarm" and "Technology" or "Machine learning," as concept, resulting in 361914 documents; When searching for the target population, we used the term "Fishfarm," excluding the term "aquaculture," because it is more generic and includes the production of other living beings besides fish; for the study's context, we used the keywords "predict" or "mortality" or "monitoring", because these are the topics in which our study was situated. Data extraction and synthesis: Microsoft Excel and Zotero were used to handle and store the data. Title, author, year, journal, subject area, keywords, and abstract were among the fields considered. The duplicates and works that were not pertinent to the domain were first removed. The whole document was analyzed when the title and abstract were deemed insufficient to evaluate the paper's suitability.

In the beginning of our search 47 documents were found. An in-depth analysis was done on these 47 publications. Twelve of the studies were omitted because they were deemed to be outside the analysis's purview. The majority of papers emphasize "water quality" and/or "sustainability." There is a dearth of research publications that describe the main causes of death in fish farms as well as potential solutions. We have seen an upsurge in publications about this industry throughout the years, along with a few research about the circumstances and some suggestions for real historical issues. The majority of the papers reflects that the water quality may be the main reason for mainly diseases and death in this type of production. This leads us to conclude that there is a gap in knowledge into fully understand the origin of the problems and how to solve it. There are already some data analyses being done, but it is important to compare the results between farms, and not to make an isolated study.

In addition, we also access to FAO (Food and Agriculture Organization of the United Nations) to provide some statics about the fishfarms.

2.2 Literature review

The fish farm industry shows an unparalleled exponential growth in the last years but still faces substantial obstacles, as the excessive new water use, heavy chemical use that harms the environment and animals, and the lack of knowledge about the management of fish farm [15].
Fish growth, development, reproduction, and survival are all directly impacted by water quality. It really makes a difference when aquaculture production monitors it. Some fish farm facilities currently assess the water quality manually, either through the practice of manually collecting water samples for lab analysis, others have automatic sensors and other have both manually and automatic analysis of the water [5] [8]. Typically, are used numerical simulation, physical model tests, and field observations to examine the hydrodynamics of a fish cage. However, these conventional research techniques are inefficient and time-consuming [3] [11]. Imbalance and large discrepancies between the measurement and the optimal range of water quality affects fish behavior and growth, which also increases the risk of fish mortality if the conditions persist for a long time. Fish performance and food consumption decrease when they are stressed, which is influenced by the quality of the water [15]. For example, the pH scale is used to determine how basic or acidic a system is. An aquatic organism may not be able to survive if the pH changes since different kinds of aquatic organisms prefer distinct pH ranges to thrive in [10] [20].

To enhance productivity and prevent fish losses, aquaculture facilities must maintain adequate water quality. The first step to boosting fish output and health in these facilities appears to be autonomous and continuous monitoring of water quality [8]. Poor water quality impacts not only aquatic life but also the local ecology. Technology must be used in order to exploit the environment in a way that maximizes efficiency while having the least detrimental effect on water resources [18] [19].

There is an urgence in create a system for digitally monitoring fish farms [2]. Machine learning has emerged as a crucial technique for analyzing the data collected by using monitoring networks and modeling the water pond's dynamics. In general, it gives fish farmers the ability to make better decisions and increase their prodution. Datasets gathered automatically are widely used to build machine learning algorithms, utilizing minute or hourly-based time resolutions on acquisition devices [20]. Systems based on computer vision have been created for a variety of applications in aquaculture and can offer non-invasive monitoring methods as the estimation of fish body length and fish counting; Underwater photos are clearly one approach for achieving the goal of smart aquaculture [1] [4]. In order to cut down on labor costs for farmers, aerial drones have been used to collect data on the water quality of aquaculture ponds, especially when it comes to covering areas of considerable size [6] [14].

These techniques are low-cost, non-invasive, and trustworthy. By monitoring themselves fish behavior, they help to minimize physical fish handling, preventing stress and disturbance [16] [17].

2.2.1 Precision Fish Farming

The intimate connection between farmer and animal has served as the foundation for much of human history's understanding of animal husbandry. Direct observation makes it almost impossible to evaluate the animals and collect information on the population's health, especially when the population is made up countless millions of animals that reside underwater. Due to the current trend of moving aquaculture operations to more environmentally vulnerable locations, farmers have limited access to the farms, only amplifying this challenge. For the reasons listed above, it appears that a system based purely on direct observation could not be sufficient to produce the levels of knowledge, monitoring, and control required to address the issues with modern fish farming. The modern large-scale fish farming industry instead needs technical capabilities that allow remote monitoring of big fish populations in a way that produces data that can be used to change daily operations and adjust them to maximize the development and survival of the fish [7].

Through to the agricultural context, various technologies are being employed in this setting to lessen risks to the environment: that lead to the Precision Agriculture/Fish Farming (PA/PFF) management concept. The PA is focused on seeing, measuring, and reacting to productions' spatial and temporal variability. The goal is to improve monitoring, management, and documentation by using production-level control engineering principles to analyze biological processes in the fish farming industry. Farmers can now discern field differences and administer treatments at a variable rate with a much greater degree of accuracy thanks to PA technologies [1].

2.2.2 Precision Livestock Farming

Precision Livestock Farming (PLF) mission is to offer commercially viable techniques and equipment to enhance animal health and welfare, as well as improve outputs, productivity, and environmental sustainability. Generally speaking, these objectives could be accomplished by combining hardware with artificial intelligence [1].

Although the process and manufacturing industries can directly apply the general principle of the precision on industrial production through technology and automation to PLF, the shift in attention from inert products (such as vegetables) to live animals presents further difficulties: animals can display complicated behavior, making observation and monitoring more difficult because they can move, making the adoption of automated activities more challenging [7].

The urge to keep track and regulate the production process is highlighted by current industry trends that show farms producing larger quantities and rising production employee at each fish farm. Utilizing technical tools effectively will be essential in overcoming these obstacles, and the PLF idea aims to take advantage of this potential by providing a framework within which technologically based approaches to fish farming might be developed. PFF will increase confidence in the utility and effectiveness of commercially accessible technologies by providing scientific documentation.

One strategy would be to concentrate this work on particular use cases, implying that the goal is to address real-world problems in the business using a PFF strategy. To better understand biological systems in fish, it will be necessary to conduct some basic research. This may not have as strong of an immediate industrial appeal, but it will have a bigger long-term impact by laying the groundwork for the creation of new techniques [7].

3 CRISP-DM Process

CRISP-DM is an analytics model for data-mining that as its unique methodology and neutral application.

The methodology evolves 6 phases: Business Understanding, Data Understanding, Data Preparation, Modeling, Evaluation, and Deployment. Figure 1 shows our methodology.

3.1 Business Understanding

The main problem we wish to attend is to discover which factors are more related to mortality in fishfarms. Some companies that have more than one location shows different numbers of mortality even though they are using the same procedures and machines. The differences in our data are the source of water they use in early stages. With the understanding of how the recirculation of water influences the mortality, the industry can really improve its business.

3.2 Data Understanding

In this phase starts the analyze of data, to find patterns and errors within. First, we import the libraries needed and the file with the data. From here it is possible to visualize some information from data, so we can describe and classify the variables, to make it easier to understand them. The variables used are pH, nitrogen, temperature, growth, and death, among others. The visualization of the descriptive data statistics, as frequencies, averages, maximum and minimum, helps to have a perception of possible errors in data.

3.3 Data Preparation

Data Preparation is fundamental to have good results; The cleaning and treatment of data makes them ready for modeling. To accomplish this task, we have to do a serie of steps: a) identify and erase duplicated records, b) decide what to do with missing values (erase or substitute them – if so, how), c) discover outliers and validate which ones makes sense in the context, d) create new variables with the data that improves their analyze, e) erase variables that don’t contribute for the study.

3.4 Modelling

The data can now be used to make some visualization and modelling the predictive model. Through graphics like histograms, heat or correlations maps, we can perceive the variables that influence the most our target variable - mortality. Concluded the exploratory data analysis we have enough information to create the predictive model. The identification of the independent variables is fundamental to choose which should be used in tests with different algorithms, always keeping in mind that variables with big correlations may have a collinearity problem, and that some are more and others less related with the target. Before implementing any algorithm, the dataset must be divided in two parts: the first part, with 70%/80% of the data, to train the algorithms; the second part, with 30%/20% of the data, to evaluate the predicted results. The algorithms to use depends on the target variable, as Logistic Regression, KNN, Support Vector Machine, Naïve Bayes, Decision Tree, Random Forest, etc. A good study must use more than one algorithm to achieve better results and, after testing them, the ones which adjusted better to the data set, can be improved.

3.5 Evaluation

The errors reflect how effective or accurate the selected model was, and this section presents the final results of the algorithms and their improvements. It is crucial to specify an error cause measurement because it informs the user whether or not they can be certain of the outcomes.

3.6 Deployment

In the final phase, the results are presented in a way that is both useful and understandable, because what is valuable and understandable will differ depending on the user.

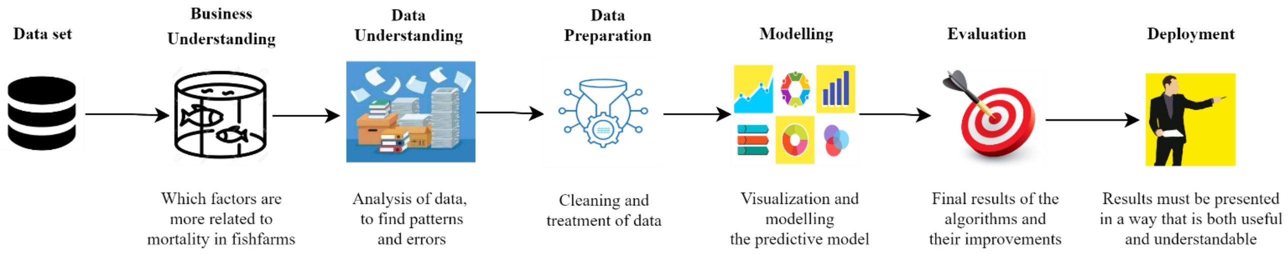

Fig. 1. - Crisp-DM application on our study

4 Conclusions

A significant source of marine protein for human consumption is industrial fish farming [15]. The sector aims to meet the increased demand for seafood brought on by an expanding global population. This challenge is probably impossible to overcome by simply scaling up production volumes and using current production regimes. Factors like the deed raw materials are becoming scarcer, there are fewer farming locations available that are technologically advanced, there are more demands for eco-friendliness, and there are conflicts with other industries (such as fisheries, oil and gas, tourism, windmills, protection, and shipping) over space use. Therefore, to better optimize output, the industry will need to transition to knowledge-driven from experience-driven approaches, which will need more sophisticated and intelligent fish farming techniques.

The urge to monitor and regulate the production process is highlighted by current industry trends that show farms generating bigger quantities and productivity per worker growing on each fish farm. The use of technical tools will be essential in overcoming these obstacles, and the PFF idea aims to take use of this potential by establishing a foundation for the development of technology based on fish farming techniques. Prior to being put on the market, PFF best practice mandates that procedures be Gold Standard certified. There are currently few laws or regulations governing the introduction of new technology into the fish farming industry, and no official or regulatory requirements for validation prior to release exist.

Information on fish size and mass at various growth stages is crucial for accurate management of feeding regimes, calculations of oxygen consumption, antibiotic prescription, and increasing fish welfare, as well as to make judgments about grading, harvesting, and the best time to harvest [17].

Researchers are interested in machine vision systems, a non-invasive method for evaluating fish mass and size, because in-tank monitoring prevents stress and injury. The key is to develop a mass-farming fish estimation technique that is low-cost, non-intrusive, remote, and automatic. The next step may potentially involve the creation and identification of further machine learning methods for forecasting fish mass [17]. The technology of ML has already been used in numerous case studies presenting high accuracy rates.

The ambient environmental conditions are a major determinant of the fish exposure to outside stressors, such as illnesses, parasites, chemical pollutants, and microplastics, and are partly beyond human control. Therefore, it is crucial that the industry strives to track and manage these issues' consequences in order to prevent potentially worsening issues when production is scaled up [9].

Future aquaculture will help create what are known as "smart factories". On the Internet of Things (IoT), cyber-physical systems collaborate and communicate value chain participants offer and use services in real time both inside and outside of their own organizations. It is becoming ever more crucial to monitor and regulate the manufacturing process in order to boost productivity, improve the quality of fish products, and improve animal welfare [1]. Utilizing cutting-edge technology to ensure zero water discharge, good water quality, low energy consumption, and high biosecurity constitutes a smart fish farm. This includes monitoring and automation [15].

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