Journal of Data Acquisition and Processing
ISSN: 1004-9037
https://sjcjycl.cn/
DOI: 10.5281/zenodo.7648743

ARTIFICIAL INTELLIGENCE AND BIG DATA SCIENCE FOR OCEANOGRAPHIC RESEARCH IN BANGLADESH: PREPARING FOR THE FUTURE

Shafiqul Islam Shafiq
Data Analyst, Bangladesh Oceanographic Research Institute, Cox's Bazar-4730, Bangladesh.
E-mail: sishafiq19@gmail.com

Abstract: *Utilizing marine resources wisely is crucial for less developed or emerging nations like Bangladesh, which has the sea in their geographical boundaries. 95% of the world's ocean resources are still unexplored to us. Although it is a challenging task to integrate this untapped resource into the nation's economy, we can currently open the door to our blue economy by applying cutting-edge technologies like artificial intelligence, machine learning, and big data science. With the help of these data-driven, cutting-edge technologies, ocean researchers can examine the seasonal variation of physico-chemical parameters such as sea surface temperature (SST), salinity, pH, dissolved oxygen (DO), conductivity, total dissolved solids (TDS), suitability of specific sites for aquaculture, monitor erosion (turbidity), analyze sea level rise, validate sensitive bleaching zones, and prioritize biodiverse areas. Specifically, identifying and managing ocean resources (such as possible fishing zones, seafood, fuel, renewable energy, minerals, etc.)* ***research*** *and modeling closely* ***related*** *to the blue economy.*
Keywords: artificial intelligence (AI), big data, oceanography, blue economy, SDGs.

1. Introduction

The world is now experiencing the 4th industrial revolution. Global technological change happens every day. The world's most powerful countries compete to create and use advanced technologies such as artificial intelligence and big data science. Artificial intelligence (artificial intelligence, n.d.). AI and big data science have also generated significant interest in research opportunities in the study, identification, modeling and management of marine resources. The technology is also used to understand the causes of global warming and climate change, which are also closely related to the vast ocean. One of Earth's most important natural resources is the ocean. About 200 billion pounds of fish and shellfish are caught here for food each year. Marine resources are economically vital and provide goods, services and jobs to billions of people around the world. Food, fuel, renewable energy, minerals, sand, gravel and tourism are just a few of the resources (Lotus Arise, 2022). The blue economy is concerned with the sustainable use of marine resources and the health of marine ecosystems for economic development, improved lives and livelihoods, and job creation. The blue economy emphasizes social cohesion and the marine economy emphasizes sustainable growth (Smith-Godfrey, 2016; Lee et al. 2020). Sustainable Development Goal (SDG) 14 addresses and reflects the conservation and sustainable use of the seas and marine resources for sustainable development (Patil et al. 2018). AI and big data domains have now also entered marine conservation (Lamba et al. 2019). The wise use of marine resources through advanced technologies is of great importance to ocean science, and this is the main objective of this study. In addition to traditional approaches to organizing, storing, analyzing, transforming, and modeling huge potential ocean science data, it also works with computationally efficient data-driven models (Logares et al. 2021). Where can I get more accurate research results? In light of this, several applications of AI and big data science have been highlighted in this study. Therefore, the enormous potential of marine resources can significantly boost local economies. As you can see in the picture. 1, AI covers a wide range of related fields and technologies, including robotics, machine learning, deep learning, neural networks, and natural language processing. However, the development and use of new technologies in marine research is associated with technical difficulties and risks. This requires marine researchers to have appropriate training and practical knowledge. Following this trend, these innovative technologies enable marine researchers to use monitoring systems to prioritize biodiversity and evaluate post-cyclone relief, coastal restoration, and future sustainable development projects (Munim et al. 2020). They also measure sea surface temperature (SST), salinity, pH, dissolved oxygen (DO), electrical conductivity, total dissolved solids (TDS), and suitability of a site for aquaculture, erosion (cloudiness) monitoring, sea level rise analysis and identification of sensitive areas of bleaching.

2. Research Objectives and Methodology

To explore more possibilities of the blue economy, this study aims to clarify the idea of integrating artificial intelligence (AI) and big data science into ocean science research. The following are some of the specific objectives of the study:

- To improve further oceanography research in Bangladesh using artificial intelligence applications.
- To leveraging data-driven innovations such as artificial intelligence (AI) and big data science in ocean research to expand ocean research, conserve marine ecosystems, and provide open access to ocean resources for humanity.

The appendix is based on the method of descriptive analysis, which extrapolates the prior literature in a critical theoretical and analytic manner to answer key research questions according to the purpose of the study.

3. Research Questions

The key question of this research paper is "How can AI applications be used to improve marine research?" What does artificial intelligence entail? What is an Application? What are the most important applications of artificial intelligence in marine science? What does “big data science”, “data integration” and “data mining” entail and how can they be applied to increase the potential of ocean research?

4. Background and Definition

4.1 Artificial Intelligence (AI)

In the face of the Fourth Industrial Revolution and the 21st century, artificial intelligence (AI) is one of the most exciting and rapidly developing fields worldwide. The term “artificial intelligence" (AI) was first used by mathematician Alan Turing, who created the first modern computer. However, the characteristics of human intelligence, such as critical thinking, interaction, understanding and thinking, should also belong to computers. Around the 1950s, his work became widely known, giving rise to the concept of "universal AI" (Sisodia et al., 2020). AI is a computer program that thinks and behaves like a human using algorithms developed by humans. It's already generating over $1 trillion in annual revenue.

"The term 'artificial intelligence' means a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments." ***-NATIONAL ARTIFICIAL INTELLIGENCE ACT OF 2020***

According to AI scientist Kai Fu Lee, its effects will be "more than anything in the history of mankind." (Russell et al., 2021). A vast range of subfields within AI exists today, from the everyday to any intellectual endeavors. Examples include face recognition, virtual assistants, reasoning, transportation management, perception, computer games, demonstrating mathematical theorems, picture analysis, producing poems and articles, handwriting detection, companion robots, full self-driving, making any medical diagnostic and nursing, weather forecasting, predicting any competitive sport, structural analysis, integrated structural control design, real-world assumptions and many more. It is therefore genuinely a global area for all pertinent intellectual efforts. As seen in figure 1, AI encompasses a wide range of related fields and technologies, including machine learning, deep learning, natural language processing, robotics, augmented reality (AR), computer vision, and data mining.

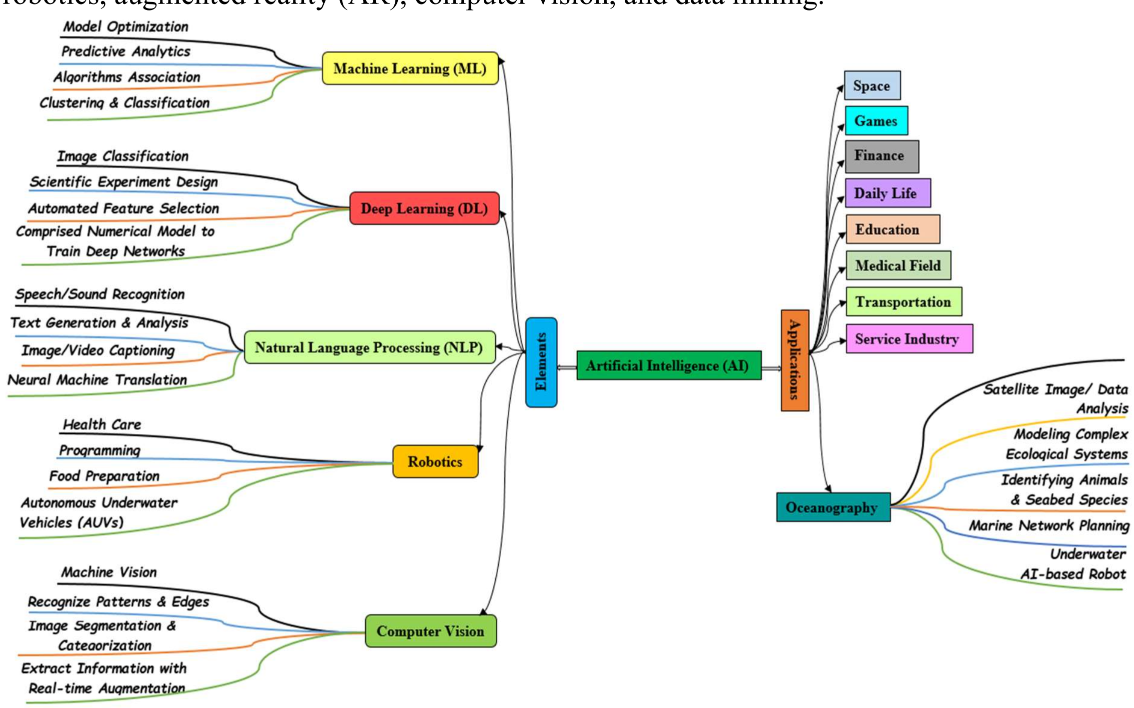

***Fig 1**: Elements & Applications Mind Map of AI*

4.2 Big Data Science

Today, fascinating things are occurring that were never previously feasible and are being fueled by data. Big data is pervasive, provides techniques to extract insights and information from large datasets and supports organizations all around the world that are attempting to profit from it (Chengcheng et al. 2018).

It's a specialized field that uses models, tools, and methods from scientific programming to process large amounts of data. External data from the financial industry, space, land, social media, weather, marine information, topographical information, scientific research, and more are frequently incorporated into big data systems (Stedman, C. 2022).Big data is a collection of structured, semi-structured, and unstructured data that can be used for advanced analytics applications such as predictive modeling, machine learning, and data mining to extract information. The relationship between various forms of data is examined using big data to see whether there is a correlation. The three V's are often used to describe big data. Namely, volume, variety and speed. Big data is often defined by the amount of data in different environments, the different types of data frequently stored in big data systems, and the speed at which most data is created, collected, and processed. In addition to the 3 Vs of big data, other aspects of big data have been mentioned: validity, value, and variability (and complexity) (Gandomi et al. 2015). This characteristic was first identified in 2001 by Doug Laney, then an analyst at the consulting firm Meta Group Inc. Gartner popularized it after acquiring the Meta Group in 2005. Big data has been discovered, defined and studied by researchers and practitioners according to its characteristics. For the main characteristics of big data, some people mentioned 4V (Logares et al. 2021), some people mentioned 5V (Hadi et al. 2015), and some people mentioned 7V. These parameters increase over time (currently 42V exists) and will continue to increase as big data advances (Farooqi et al. 2019). The field of oceanography makes extensive use of big data. Advance marine research by effectively collecting, managing, organizing, and analyzing marine big data.

5. Applications of Artificial Intelligence to Advance Oceanography Research

According to some experts, the marine industry will likely we will be the people most affected by the huge changes brought about by the 4th Industrial Revolution. The direct extraction of insights, hypotheses or quantitative relationships from multivariate data sets using automated methods is a prime example of a new research trend in oceanography (Goldstein et al., 2019). There are two ways researchers can serve analytics users. Either build it all yourself from scratch or include advanced analytics in your program. The areas of artificial intelligence (AI) that can be used for complex marine research in Bangladesh are outlined below with examples.

5.1 Machine Learning Techniques for Oceanographic Research

Machine learning is a subset of artificial intelligence, but can be divided into three categories: supervised learning, unsupervised learning, and reinforcement learning (Zaidi et al., 2018). All three paradigms are widely used to drive intelligent applications, and machine

learning has many algorithms [Figure 1]. 2], the algorithm learns from examples or instances, so it can evaluate past data and learn from previous experience (Mitchell). et al., 1997). Machine learning is primarily used in oceanography to process sensor data for multiple nested sensor arrays (temperature, salinity, flow rate, etc.). The modeling aspect is the secondary use of ML (a good example is the tsunami monitoring and warning system). The key benefit of ML is generating trustworthy findings considerably faster than with arduous manual monitoring. Among the many applications of machine learning are the automatic detection and classification of fish in unregulated underwater marine environments, coral classification, species identification, Oil spill mapping and detection, Satellite image processing, coastal morphological and morphodynamic modeling (Ahmad, H., 2019), sediment analysis, wind and wave modeling, weather forecasting, ocean pollution, Modeling of surface gravity waves, equation of state computations, and local sea-level variations, beach erosion, and resource management (Goldstein et al., 2019; Beyan et al., 2020; Valera et al., 2020). Dynamic models are implemented through machine learning (ML) using computer algorithms, leading to data-driven decision making (Goldstein et al., 2019; Ahmad, H., 2019). In particular, ML has been shown to be a successful method for predicting hypoxic conditions and occurrence of harmful algae using marine environmental data (section, time, depth temperature, salinity, dissolved oxygen, flow rate, etc.), which are important measurements. . In terms of monitoring marine ecology (Valera et al., 2020), we discuss how animals adapt to environmental changes such as rising temperatures and pollution (Sadaiappan et al., 2022). Specifically, echo clicks from whales and dolphins have been used to identify cetacean noises using a variety of detection and classification techniques developed in machine learning (Caruso et al., 2020; Soldevilla et al., 2008; Roch et al., 2011 , 2015; Giorli et al., 2016, 2017, Hildebrand et al., 2019). The advantage of these algorithms is that they can efficiently and reliably evaluate huge amounts of data and produce standardized measures of sound properties that can be used for statistical analysis and prediction. As the concentration of dissolved oxygen (DO) changes, certain microorganisms are released, and in some cases, so-called hypoxic conditions can lead to mass mortality of fish and invertebrates, which is important for economic and environmental reasons (Pena et al., 2010). . Machine learning models use classification methods to reduce complex phenomena such as DO in marine data.
The ability to analyze data at larger temporal and spatial scales is a key component of scientific discovery using ML. A solid understanding of machine learning is required to apply to different places or epochs in order to resolve various scales (Ellenson, A.,2021) like image classification, coral classification, coastal morphological and morphodynamic modeling, sediment analysis, wind and wave modeling, weather forecasting, ocean pollution, and Modeling of surface gravity waves, it may be sufficient to adopt methods from other fields, but when dealing with large scale data types (satellite or raw) and problems that are more particular to ocean sciences, interdisciplinary approaches are needed, and scientists need to understand both machine learning and the relevant skills like Oceanography, Statistical Analysis, Big Data Science

(Malde et al., 2020).

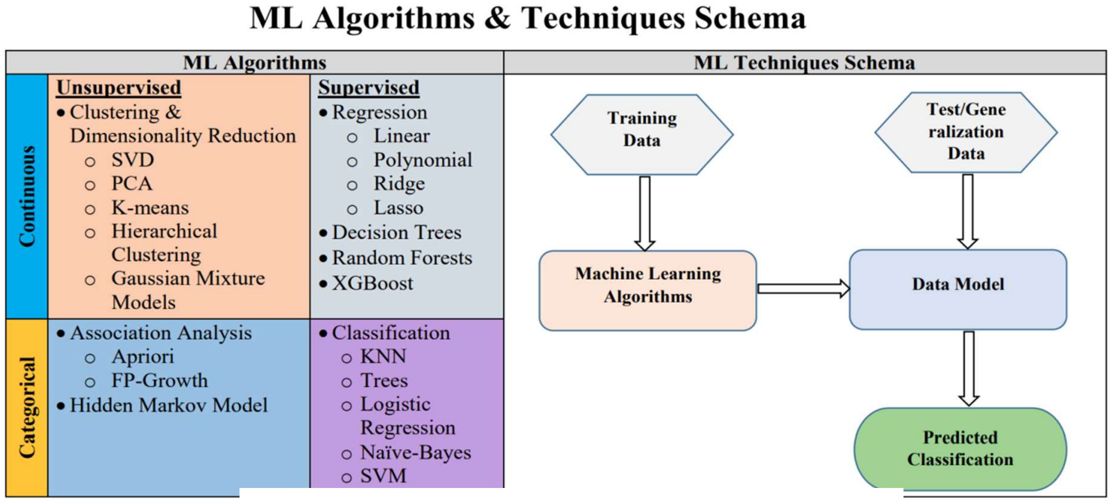

Fig 2: *ML Algorithms & Techniques Schema*

5.2 Deep Learning Techniques for Oceanographic Research

A relatively new field, deep learning performs classification tasks directly from images, text, marine remote sensing applications, or speech and belongs to the broad field of machine learning (Li et al., 2020). Recurrent Neural Networks, Convolutional Neural Networks, and Deep Persuasion Networks are some of the most well-known neural network algorithms used in deep learning. The map is rendered using a deep convolutional neural network (CNN) that can generate low-resolution input images and high-resolution output images (Dong et al., 2015). Each deep neural network will have at least three types of layers [Fig. three]. It should be emphasized that neural networks can contain many hidden layers. These neural networks are used to classify data and predict output. Additionally, it is an automated feature extractor that makes patterns more obvious and automatically reduces data complexity so that researchers can more easily understand how algorithms function. Oceanography is a difficult field that generates a lot of data, satellites, and autonomous drones are gathering a lot of various kinds of data on the ocean. Deep learning techniques are absolutely necessary when using these cutting-edge data systems to study, monitor, and manage marine creatures and ecosystems, and typhoon forecast models (Jiang et al., 2018). To keep up with the rapid advancement of ocean research, existing oceanographic data sets can be upscaled, extrapolated, or information extracted through cutting-edge technology (Bolton et al., 2019), deep learning, machine learning, and robotics.

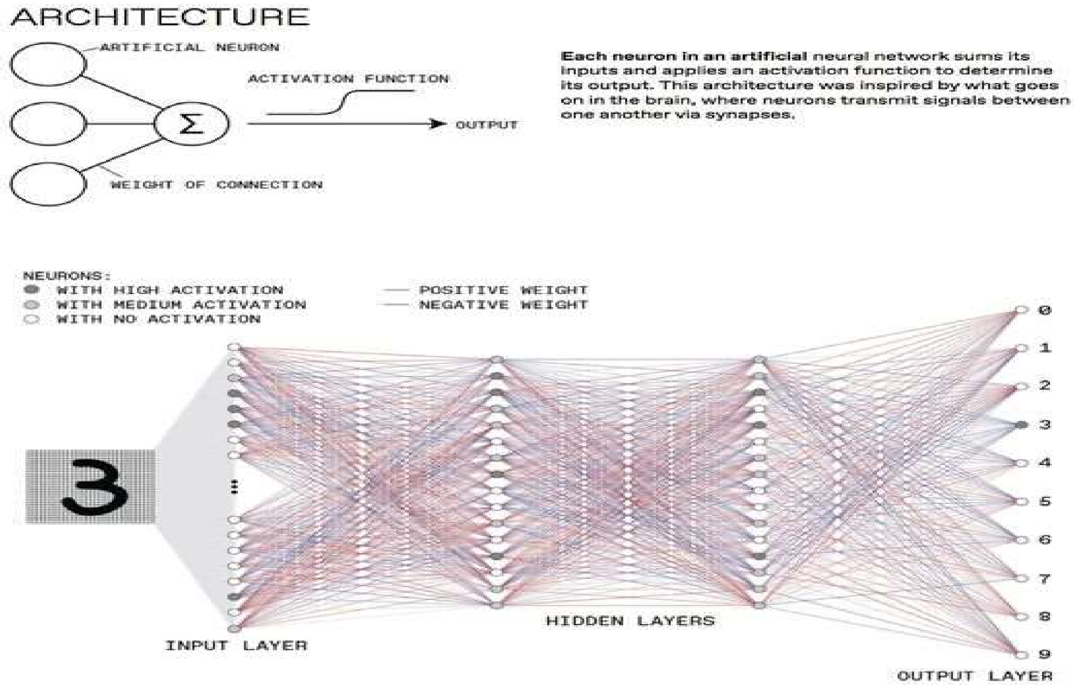

Fig 3: *Deep Learning Layers (*Moore et al. & Strickland, E., 2021)

5.3 Natural Language Processing for Oceanographic Research

Natural language processing (NLP) is a subfield of artificial intelligence (AI). This is a very new and successful method, so it is very much needed in modern artificial intelligence technology. The use of applied probability and statistical methods such as machine learning and data mining has increased significantly over the past decade as a result of dramatic changes in NLP research. Currently, most speech/acoustic recognition systems use HMM (Hidden Markov Model) (Jain et al., (2018); Immberger et al., (1987). Natural language processing is critical to oceanography research because these statistical models perform mathematical calculations to determine what factors should be taken into account when translating marine animal sounds into text (Nadkarni et al., 2011). NLP is much easier to implement. NLP uses computer algorithms to convert artificial language used by computers into text, which can then be used to generate audible speech using text-to-speech technology (Wilson et al., 2020). It is used in question answering software (Survey Analytics) for information retrieval, analytic reasoning, knowledge representation, and information synthesis. A natural language processing (NLP) technique known as named object recognition (NER), also known as object identification or object extraction, automatically recognizes named objects in text, groups them into specified categories, and has wide applications for identifying water . body. plants, corals, fish and marine life.

5.4 Robotics for Oceanographic Research

The usage of marine autonomous AI-based robotic systems is now crucial for ocean modeling, monitoring, simulating, and making use of the ocean in the age of the fourth industrial revolution. These platforms alter the monitoring capacity by utilizing both unmanned aerial vehicles (UAVs), and autonomous underwater vehicles (AUVs) (Ferreira et al., 2019) together to adaptive, and persistent observations from the ocean's surface to its deepest levels and farthest reaches. Ocean vehicles such as underwater gliders, wave gliders, and multipurpose hybrid gliders are examples of gliding robots. These gliding robot technologies have great potential for the advancement of oceanographic research, and they will serve as a model for the creation of novel Autonomous Ocean Observation Platforms (AOOPs) and the choice of applications based on carrying various sensors (Tian et al., 2022). Scientists and engineers are currently working to deploy numerous networks of robotic ocean observatories that expand in the context of geology and geophysics, biology, seafloor mapping, habitat, light transmission, primary productivity, and algae distribution (Barker et al., 2020). Fish migration patterns in diverse marine ecosystems, quantity and quality of data available to scientists and the global public (Bachmayer et al., 1998). The marine environment provides a sophisticated laboratory for robotics researchers to develop and evaluate new sensing, actuation and autonomous control methods.

5.5 Computer Vision for Oceanographic Research

Normally we don’t go to witness the really complex procedures that take place behind the water. Computer vision is a branch of artificial intelligence (AI) that trains and equips machines to understand the visual world. It focuses on simulating human vision so that machines can recognize and process objects in a human-like way. Computers can use digital images (such as photos or movies) and deep learning models to accurately identify, classify, and respond to objects. The goal of computer vision is to teach computers to analyze and understand images individually, pixel by pixel. These applications include a wide range of topics, including baseline and environmental effects in relation to industry, geophysical descriptions of seabed habitat, biological descriptions of the water column and seafloor biogeochemistry, biodiversity, and ecology. The mining of the seafloor, carbon capture and storage, and oil and gas are some of these industrial areas. High-resolution image data are now regularly collected by satellite, robotic platforms from Autonomous Underwater Vehicles (AUVs), and Remotely Operated Vehicles (ROVs) from the shelf to deep seas. Many tools now exist for machine learning and automated annotation of images for complex scenes (Moschos et al. 2023). Image classification is a technique used in computer vision to determine what an image is (bird species, fish species, coral reefs, etc.). In particular, it can be firmly asserted that image inputs fit into certain categories. HD digital camera photo sequences recorded from fixed underwater stations can be used to analyze fish activity in their natural habitat, such as the number of Hills fish and their abundance in different locations. This allows you to use computer vision to find potential fishing areas. The various methods used to obtain numerical or symbolic information by recognizing objects in digital photographs and extracting multidimensional data from the physical environment are called computer vision algorithms. Object recognition in images includes many other computer vision techniques. Common examples include: (1) Classification of objects. What are the main categories of objects shown in this photo? (2) Entity Identification. What types of objects are in this photo? (3) Object Detection - Where are the objects in the photo? (4) Object segmentation. Which pixels belong to objects in the image? (5) Object Check - Is there an object in the photo? (6) object recognition. What objects are in this picture and where are they located? (7) Object landmark detection. What is the key point of the subject in this photo?

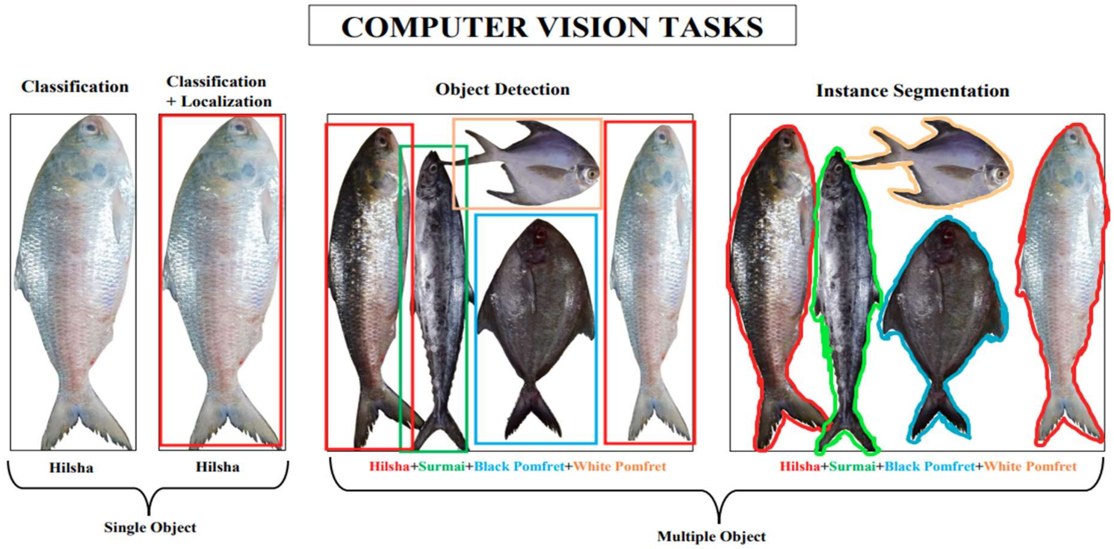

Fig 4: *Computer vision tasks*

6. Big Data Integration & Data Mining for Oceanographic Research

Data is critical to economic development. This setup increases the amount and variety of data. Advances in ocean observation technology have benefited primarily from large-scale ocean data collection techniques (Fichaut et al., 2012). Exploring pervasive and interdisciplinary features of ocean science in major ocean sciences, such as physics, chemistry, biology, and geology, by utilizing marine big data. Marine surveillance capabilities now include real-time, 3D and diversification. In order to effectively utilize big data technologies in marine research and better support economic development, it is essential to integrate the needs of industrial development, use science-based data algorithms, and connect different types of data with information based on them (Liu, Y., 2020). Oceanographic vessels, buoys, submersibles, remote sensing, and finally the development of the Argo ocean observing network have all demonstrated how determined and wise humanity continues to explore the oceans (Chengcheng et al., 2018). After collecting large-scale marine data, most of the reservoirs are located in the midstream, which is often difficult to study or visualize due to their vastness and high measurement accuracy (Healey et al., 1998). Theory, data mining, representational visualization, and big data storage management are examples of analytic approaches. Various data mining methods based on statistics, machine learning, neural networks, classification, Bayesian methods, decision trees, support vector machines, etc. have been created to perform different types of analysis (Frawley et al., 1992). Applications and big data are closely intertwined, and the main goal of logical analysis and sound judgment is professional labeling of data. Whether it is scientific observational or experimental data, it is marked by experts in the field. Because big data research and development has implications for national security, life and health, climate change, geological exploration, and disaster prevention and mitigation (Shuliang et al., 2013).

7. Finding and recommendations

ML is used in applications such as automatic fish detection and classification, sediment analysis, weather forecasting, ocean pollution, and whale and dolphin echolocation click analysis. Using machine learning models helps to reduce complex phenomena such as dissolved oxygen (DO) from ocean data. The ability to analyze data at larger temporal and spatial scales is critical to scientific discovery using ML. Applying ML to different scales and problems in the ocean sciences requires a thorough understanding of machine learning and relevant skills such as oceanography, statistical analysis, and big data science.

Deep learning is a branch of machine learning and deals with categorization tasks such as image recognition, text analysis, ocean remote sensing, and voice recognition. Algorithms commonly used in deep learning include recurrent neural networks, convolutional neural networks, and deep trust networks. Deep convolutional neural networks (CNNs) are used to map and take low-resolution input images to produce high-resolution output images. Deep neural networks have three types of layers: input, hidden, and output layers, and can have multiple hidden layers. Deep learning is used to classify and make predictions on data in a variety of fields. Deep learning is an automated feature extraction tool that simplifies data complexity.

Deep learning is needed to study, monitor and manage marine ecosystems as well as hurricane forecasting models. Deep learning, machine learning, and robotics can be used to augment, estimate, and extract information from existing marine data sets.

NLP is a field of artificial intelligence that uses applied probability and statistical methods such as machine learning and data mining. The use of NLP has grown significantly over the past decade. Hidden Markov Models (HMMs) are commonly used in speech/acoustic recognition systems.

NLP is essential for oceanography research to translate the sounds of marine animals into text. NLP algorithms convert artificial language into text usable by text-to-speech technology. NLP is used in question answering software for information retrieval, analytic reasoning, and information summarization. Named Object Recognition (NER) is an NLP technique that automatically recognizes and classifies named objects in text. NER has a wide range of applications for the identification of aquatic plants, corals, fish and marine life. Gliding robots such as underwater gliders, wave fronts, and hybrid gliders have great potential to advance oceanographic research and serve as a model for creating AOOP. Work is underway to deploy connected robotic ocean observatories to study various aspects of marine ecosystems such as geology and geophysics, biology, seabed mapping, light transmission, primary productivity, algal distribution, fish migration patterns, etc. The ocean environment is a challenging laboratory for researchers in robotics to develop and evaluate new techniques in sensing, control and autonomous driving.

Applications of computer vision in underwater research include the analysis of various aspects such as geophysical descriptions, biogeochemistry, biodiversity and ecology. High-resolution images are collected from various sources and analyzed using machine learning algorithms for object recognition and high-dimensional data extraction. Technologies used to recognize objects in images include object classification, identification, detection, segmentation, validation, recognition, and landmark detection. In underwater research, computer vision can be used to analyze fish activity, locate potential fishing areas, and identify objects in digital images.

8. Conclusion

This study discussed how the enormous potential of Artificial Intelligence (AI) and Big Data Science technology can be exploited to further oceanography research. There is a wide scope for conducting separate studies on each field of Artificial Intelligence and Big Data Science to explore marine resources. However, a significant obstacle to applying these cutting-edge technology in oceanography is the dearth of professionals. In order to develop marine resources for humankind in a way that is appropriate, we require a team of highly qualified individuals with in-depth knowledge of these technologies. Conducting all these technologies, the more the doors of ocean research can be opened, the more the country's economy can be contributed through the blue economy, and the more likely it will be to meet the SDGs.

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