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Analysis of Various Underwater Rock and Mine Detection Techniques- A Typical Review

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Abstract—*The seas are one of the most valuable ecosystems on Earth. Submarines are vessels used by the armed forces to conduct underwater reconnaissance and attack enemy vessels. Submarine movement is the best time to undertake precise identification of underwater obstructions. Among the challenges associated with deciding where to put a facility so that it best fits the requirements laid forth for it is finding an appropriate location. The detection of undersea rock and mines is complicated because of the wide variety of possible approaches and technologies. In this paper, we provide a comprehensive overview of the current techniques used to detect, track, and alert underwater target objects, including machine learning (ML), deep learning (DL), and image processing. We also discuss underwater internet communication networks and GPS navigation processing techniques.*
Keywords— *Underwater, Machine Learning, Deep Learning, Sonar, GPS,*

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I. INTRODUCTION

Various underwater object detection researches have a greater impact on many commercial applications. The ocean's habitats are being observed by such automated, remotely operated underwater vehicles. This research gives a recent literature assessment of existing methods for deep learning for automatic object classification utilizing underwater sonar data for littoral water surveillance. The focus of this work is on creating accurate automatic rock and mine categorization methods for underwater sensor data.

The emphasis on characteristics reveals five primary approaches used in the current literature: detection of rock and mine; classification of rock and mine; alerting system; object tracking; underwater internet communication. All these strategies were implemented by various technologies like deep learning, image processing, underwater sonar, and the Internet of Things.

II. RELATED WORK

A. Underwater SONAR

Sound Navigation and Ranging System is the name of the technology. Sonar is typically used to identify acoustic objects, and it works best underwater. This is accomplished by sending sound waves across the water. Sonar typically operates between 20 and 40 kHz [1]. For activities that are based on the water in low visibility environments, sonars are a more reliable sensing modality.

For underwater activities in low, visibility, sonars are a more reliable sensing modality. The basic idea behind sonar is to trace an object using acoustic waves. These sonar acoustic waves cause mechanical vibrations in a specific medium and return the echo [12]. Sonar waves spread faster underwater than in the air. Level, temperature, ionic strength, and saline are the variables that speed up this process [12]. According to calculations, the sound intensity in water varies from 1405 to 1550 m/s. [12]. The response of the target depends on the frequencies emitted into the water. The two types of sonar are active sonar and passive sonar. The passive sonar will receive the frequency through sound made by water vessels, and the active sonar emits the sound waves and takes the echoes as the output.

III. ROCK AND MINE DETECTION

B. Based on Sonar

A sound wave from the transmitter propagates and reflects an echo when it reaches the target [1]. We use the frequencies collected by active sonar at 60 different angles to figure out if the target in this case is a mine or a rock [1].

Forward-scan In contrast to optical imaging, sonar imaging aids in processing echo data from an acoustic signal coming from the water. Prior to retrieving and tracking submerged objects with the Kalman filter, the Gabor filter is applied to enhance the quality of sonar images [21].

The automatic target recognition (ATR) method is rearealized a forward-looking sonar system, the Echoscope. For feature extraction and recognition in Echoscope sonar images, an Echo Net was created [18]. This system demonstrated the enormous potential of sonar imaging and DCNNs, this feature helps vehicles underwater comprehend their environment and navigate on their own [18].

C. Based on deep neural Networks

The input image is pre-processed using a clipping operation, and the aspect ratio is adjusted by resizing and reshaping before being sent to the system's pre-trained model [2]. In the pre-trained model, the ResNet-50 is used. For the purpose of detecting the target object, they utilised a mask RCNN. The object that might be present in the region of the image is suggested by the mask RCNN that predicts the type of object [2].

On underwater vehicles, side-scan sonar is mounted and used for high resolution. Sonar transmitters send a high frequency acoustic signal. A two-sided sonar image is created by concatenating the backscattered intensities [3]. For the purpose of finding objects in sonar images, they suggested a deep Gabor neural network. Six cutting-edge generic object detectors are compared to the proposed Gabor detector: (1) R-CNN, (2) Fast R-CNN, (3) Faster R-CNN, (4) SSD300, (5) Little YOLOv3, and (6) Full YOLOv3 [3].

A high-precision underwater object identification technique helps to produce clean features for detection by eliminating image blur. The features of the picture are improved by a spatial transformer network. Improved underwater image vision has been employed as a pre-processing step in two different pipelines for underwater object detection tasks as shown in Fig1. This specific design can improve the precision of object identification techniques based on shallow-learning classifiers [10].

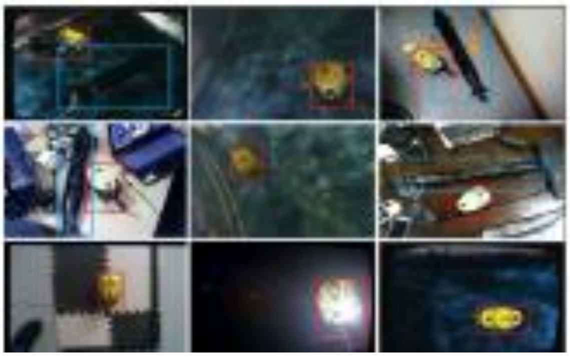

Fig1. Result of object Recognition.

Two groups of object identification techniques based on deep learning exist: one category includes one-stage methods based on regression, and the other category includes two-stage algorithms based on classification [6]. In this paper, ATR (Automatic Target Recognition) and YOLOv5 were used after processing and sampling the images [6].

SSS images can be used to create high-resolution photos, which are often used underwater. Another technique is deep learning, which automatically selects and extracts features. The Generative Adversarial Network (GAN) was also implemented to create SSS target images and helped to enhance the style transfer [8]. Additionally, a novel TR-YOLOv5s network with a down-sampling idea is put forward, an attention mechanism is proposed in the methodology, and these additions help to meet the criteria.

The three most well-known CNN models that significantly influence the image-classification field are AlexNet, VGGnet, and ResNet. Autoencoders (AEs) and generative adversarial networks (GANs), two types of neural networks, are widely used to generate data similar to training data and are used to create automatic categorization of underwater acoustic data [12]. The uniqueness factor is used by the network reduction technique to exclude comparable neurons. The accuracy of the classification job can be improved by reducing the size of the neural network and removing duplicate neurons from it [17]. The uniqueness factor is used by the network reduction technique to exclude comparable neurons. The accuracy of the classification job can be improved by reducing the size of the neural network and removing duplicate neurons from it [17].

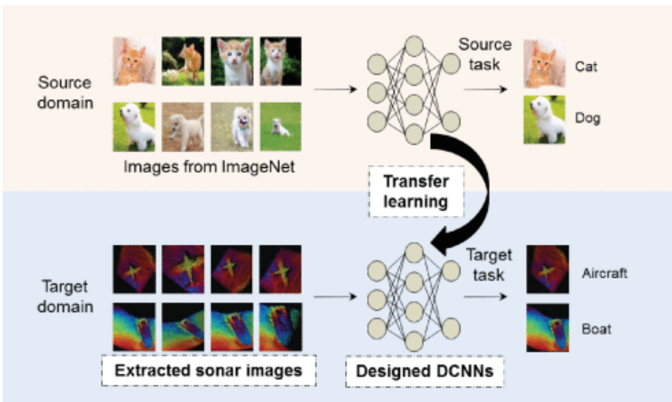

Fig2. Overview of the proposed underwater target recognition method.

A network training method based on transfer learning was developed to address the issue of insufficient training data, and mini-batch gradient descent was used for network optimization. To address the underlying issue of insufficient training data, a machine learning technique known as transfer learning is used. To prevent the EchoNet from overfitting due to the limited number of so-called "so-nar" images accessible, a network training approach based on transfer learning is created [18]. This is shown by moving a deep convolutional neural network (CNN) that has already been trained, like VGG19 as shown in Fig 2, and then fine-tuning the deep CNN on 70% of the real dataset and semi-synthetic data for training [19].

D. Based on Image Processing

Some image processing methods have evolved to automatically detect and track underwater objects. Deep learning algorithms that are appropriate are found to be convolutional neural network techniques. For the input device, they employed a 3.5-metre inspection tube camera to record the items from the underwater environment setup [5]. They are trained using a dataset of objects in various underwater environments with the goal of finding and tracking these objects in the water so they may be recovered. Analysis of the data reveals that the convolutional neural network produced the greatest outcomes. Consequently, YOLO is the preferred approach for accurately detecting and tracking objects [5]. In order to classify undersea targets for synthetic-aperture sonar (SAS) imagery, deep convolutional neural networks were employed [13]. Algorithm fusion involves integrating the detection and classification results from two or more techniques. The chance of detection and accurate classification of mine is increased by combining two or more algorithms [13]. Image sequences retrieved by underwater recordings using the statistical gradient coordinate model, the ADA-boost-based optimization approach, and the Gaussian mixture model are proposed to detect underwater objects [14].

The research proposed an article on a monocular vision-based technique for object detection underwater. A framework is created where, in the first phase, ROI detection takes place, followed by segmentation [4]. The transmission information provided by the approach, in addition to the often-utilised colour and intensity information, increases the accuracy of underwater object detection [4]. The optical surroundings underwater can become extremely contaminated when artificial lighting is used, making the dark channel-based model erroneous in some circumstances.

As a next step, the Convolutional Neutral Network (CNN) technique is implemented for underwater images [8]. Image processing is the process of training the mapping relationship to attain the illumination map. Following that, a deep CNN approach is used for classification, and underwater detection is proposed, which yields accurate results [8].

Current pose estimation techniques, which are based on point clouds and are required for manual manipulation of object point clouds, are inaccurate, time-consuming, and inefficient. A unique approach based on point cloud registration and convolutional neural networks (CNN) has been developed to address this issue. CNN is used to find the object, identify its centre and range, and then extract its point cloud [9].

A semi-synthetic data generation method that uses optical pictures as input and combines image segmentation with intensity distribution simulation of different regions to produce sonar images of planes and drowning victims [19]. To determine whether an object is mine or not, the image classification model uses the FRCNN (Fast Region Convolutional Neural Network) technique. The cloud platform is used to monitor the mine, and as soon as changes are detected, the Android application will update.

IV. OBJECT TRACKING

Although tracking and detection of objects are similar, they are not the same, Tracking is the advanced version. In contrast to object tracking, which involves finding the object(s) in a video stream, object detection entails finding the item in a single frame. A robotic vision-based heuristic tracking system can optimise noise dilation and occlusion approaches as part of the basic framework for tracking a single object under dynamic settings [23].

E. Alerting system

In order to create a more affordable and intelligent alert system in emergency situations, the system integrates IOT and alarm system functionality. It employs radio frequency (RF) detectors to pick up the distinctive confluence of RF signals sent by widely accessible RF emitters. With the aid of this, signals are processed, and alerts are produced [6].

V. GPS UNDERWATER NAVIGATION

A prototype GPS diving computer that supports both GSM communication and underwater navigation was created. This tool offered a realistic 3D depiction of the dive profile as well as the capacity to reasonably georeferenced still images. Even though this approach is used to navigate efficiently, it would also call for more hardware and computing power [24]. This technology is implemented to provide underwater GPS navigation while diving, and the accuracy of this system depends on the weather conditions.

VI. INTERNET OF THINGS

F. Delivering internet underwater using wireless optical networks

In order to serve modern Internet applications and introduce the Internet to underwater habitats, the system showed the deployment of a low power, small underwater optical wireless system known as Aqua-Fi. To offer bidirectional long-distance communication services with varied constraints, such as low cost and simplicity of implementation, Aqua-Fi uses LED or laser communication [25]. But it is not suitable for a wide range of applications.

In a TDMA frame, the routing strategy of the shortest path is paired with a message- or node-slot-allocation process. Due to the low processing demands placed on the underwater nodes by this scheduling method, both the complexity of the computations and the load on the processors are decreased. However, if real-time priorities like earliest-deadline-first are used, better outcomes could be attained [16].

G. Internet of underwater things (IoUT)

This technical advancement prompted the new scientific concept of IoUT, which is comprised of marine sensors, cameras, hydrophones, and so on. This technology offers numerous new options for research in the areas of gathering subsurface data, data communication, handling big marine data, and data processing of the ocean [22]. Innovative methods for improving protocol upgrades, topology and routing optimization, security, and overall connection dependability were proposed, along with advanced underwater communication models based on electromagnetic, optical, and acoustic technology. Software simulation tools for both channel models and underwater communication protocols have also been developed. These solutions addressed a variety of issues, including sensor, image, and video data sources, maritime geographic data, localization and tracking, open access databases, distributed data processing, and cloud-based services [22].

CONCLUSION

From the literature, deep learning algorithms such as CNN, Regions with CNN (RCNN), and Saptial Pryamid Pooling (SPP) have low detection precision in tough underwater situations. YOLOv3 is one of the quickest of these approaches. However, it struggles with dynamic backdrops. However, the designed binary neural network performed admirably. Several things can have an impact on performance. The underwater internet was created for bidirectional communication using the TCP/IP model, laser communication, and UW-ASN. This UW-ASN can be used in the future, and great accuracy can be provided through this network. Here, the bidirectional communication is done by the shorter delay of TDMA.

The internet of things based on RF technology has been employed in almost all types of systems for alerting.

In this study, deep learning techniques, warning systems, and GPS monitoring were compared to prior generations of traditional image processing. It could help with future research by laying the groundwork for the next set of more complex methods and new ways to identify and group things.

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