University of Strathclyde

MSc Advance Computer Science

Department of Computer and Information Sciences

CS957: Research Proposal

“Underwater Image Processing”

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1. Introduction and Literature Review

1.1 Introduction

Due to its potential uses in numerous domains, including marine biology, environmental monitoring, and underwater exploration, underwater image processing is a developing field that has attracted substantial attention. Now more than ever, underwater photos may be taken with improved resolution and quality thanks to developments in underwater photographic technology. However these images are frequently impacted by several elements like bad illumination, turbulence, and scattering, which provide considerable difficulties for underwater image processing.

This study proposal explores the application of cutting-edge image processing methods to increase the aesthetic appeal and quality of underwater photos. In the proposed study, various strategies for image augmentation, denoising, and segmentation will be examined. These strategies will be used to overcome the difficulties involved in processing underwater images.

1.2 Literature Review

For many years, underwater image processing has been an active topic of study, and many experiments have been carried out to to improve underwater photo quality. The decrease of image quality brought on by the water's absorption and dispersion of light presents a substantial obstacle in the processing of underwater images. To address this issue, a number of methods have been suggested, including Adaptive Histogram Equalization (AHE) [1], a popular method for enhancing contrast in underwater photographs.

If we use picture-denoising techniques is another way to enhance the quality of underwater photos. Picture denoising is the process of taking out the noise from an image while leaving the visual information intact. Wavelet-based denoising [2], one of many suggested image-denoising algorithms, has been demonstrated to be successful at removing noise from underwater photos

If we check at the past one of the crucial steps in the processing of underwater images is segmentation [3], which entails breaking an image up into a number of useful sections. Likewise, there have been other segmentation methods put forth, including the active contour model, which has been proven to be successful at segmenting objects in underwater photos.

The literature study concludes by highlighting the significance of underwater image processing and its difficulties. The review also offers insight into the numerous image processing methods, such as image augmentation, denoising, and segmentation, that have been suggested to improve the grade of underwater photographs. We can see these methods will serve as the foundation for the planned study, which intends to investigate how effective they are at enhancing the calibre of underwater photos.

1.3 Conclusions of the literature review to the research questions presented in Section 2

As per the this, there are direct connections between my study questions and the literature review's results. The study of the literature gives an overview of the many image processing

methods, such as segmentation, denoising, and picture augmentation, that have been recommended to improve the calibre of underwater photographs. The study also emphasizes the obstacles of underwater imaging and the necessity to meet them in order to enhance the calibre of fish underwater photos.

The study questions, therefore, line up with the literature review. The literature review's discussion of various techniques for improving the contrast in underwater photographs, such as Adaptive Histogram Equalization (AHE) and picture augmentation, is pertinent to the first research question (Q1), the purpose of my study is to evaluate how effectively different image enhancement techniques so it might be increase the visual appeal of underwater fish images.

The efficiency of various image-denoising algorithms for reducing noise from fish underwater picture is the subject of the second research question (Q2). This is pertinent to the discussion of approaches like wavelet-based denoising, non-local means denoising, and deep learning-based denoising in the literature review, among others.

The development and evaluation of segmentation algorithms for precisely detecting and outlining fish in underwater photographs is the goal of the third research question (Q3). This is pertinent to the discussion of several segmentation techniques in the literature review, including threshold-based, edge-based, region-based, and machine learning-based segmentation.

2. Research Aim, Objectives, and Research Questions

2.1 Research Aim

The goal of my planned study is to determine if advanced image processing techniques could enlarge the quality of fish underwater photographs with better quality. Actually, the goal of this study is to investigate various image processing methods, such as segmentation, denoising, and picture augmentation, in order to overcome the difficulties associated with underwater imaging. The study seeks to give a more exact and accurate analysis of fish behaviour and environment, as well as to enhance the visual quality of underwater fish photos.

The research goal is aligned with the proposed topic of underwater image processing and the fish is the dataset. In this research objective, which we can investigate and assess the efficacy of image processing approaches for enhancing the quality of underwater fish photos, is clearly stated in the research aim, which is appropriate. The research goal is relevant to the suggested issue of underwater image processing because it can gives the proposed study the appropriate context. Also, the dataset of fish was a wise option because it is a frequent and significant topic of study in marine biology and undersea exploration for the underwater images. However, I choose the topic and dataset show a high alignment and relevance to my research goal.

2.2 Research Objectives

- **O1**: To evaluate the performance of various image enhancement techniques for improving the visual quality of underwater images of fish.

  I wish to evaluate the quality of picture for the better enhancement techniques to improve the visual appeal of fish underwater images so for the further use. The collection of a dataset of fish underwater photographs of diverse quality and the application of various image improvement methods to the dataset are both possible. Also, I want to be able to quantify the visual quality of the augmented pictures both subjectively by human viewers and quantitatively using measures like SNR [4], PSNR [5], and SSIM [6]. Following that, I can compare the results to discover the most successful strategies, and the findings can be confirmed using a second test dataset.

- **O2**: To investigate the effectiveness of different image-denoising algorithms for removing noise from underwater images of fish.

  Due to noise and distortions brought on by the water's medium, underwater photography can be difficult. If I compare the various picture denoising algorithms, they have been suggested to enhance the quality of underwater photographs, but it is unclear how well they work to remove noise from fish images.

  There are a few methods that may be taken into consideration if I want to evaluate how well noise can be removed from underwater fish photos. Creating a collection of fish photos from the ocean with varying degrees of noise and distortion is one method. To enable a quantitative assessment of the denoising techniques, the dataset might be explicit with regard to the ground truth pictures. The dataset may be processed using a variety of picture-denoising algorithms, including classic filters (such as the median filter and bilateral filter), wavelet-based techniques, and deep learning techniques (e.g., autoencoders, and convolutional neural networks) [4]. When comparing the denoised photos to the original images, objective measures like peak signal-to-noise ratio (PSNR) and structural similarity index can be used (SSIM).

- **O3**: To develop and evaluate segmentation algorithms for accurately identifying and delineating fish in underwater images.

  I want to create and assess computer algorithms for correctly classifying and identifying fish in underwater photos as part of my research subject. If I want to measure accurately and identify fish in photographs, these sorts of algorithms could be able to assist me with a variety of tasks, such as monitoring fish populations and analysing fish behaviour. I can confirm that a variety of factors, like accuracy, recall, and F1-score [5], will be used to evaluate the advantages of various algorithms for this purpose.

2.3 Research Questions

Q1: What techniques are most effective for improving the aesthetic attractiveness of fish underwater images?

Due to factors including poor lighting, colour distortion, and cloudiness, it can be challenging to enhance the creative attractiveness of underwater fish images. Nonetheless, there are a variety of ways to improve the creative appeal of these images. Here are some practical methods:

Use a polarizing filter [6], Adjust white balance [7], Increase contrast [8], Use artificial light sources [9], and Post-processing [10].

I can get amazing photographs of the intriguing marine life below the surface and underwater fish with enhanced visual clarity using these approaches.

Q2: How can noise in underwater images of fish be effectively removed using image denoising algorithms?

A per the earlier research I can see that, it can be difficult to eliminate noise from underwater fish photography, despite the fact that it often results from a different of problems, including poor lighting, sometimes the camera has limitations, and the presence of particulate matter in the water like object. But yet, there are various image denoising methods that can be applied in previous years to effectively reduce the noise in these images to get better result. While I was reading I find out different effective method to overcome to this as per follow:

Median filtering [11], Wavelet denoising [12], Non-local means denoising [13], Total variation denoising [14], Deep learning-based denoising [15].

I can effectively reduce noise and enhance the visual quality of your images by applying these variety of denoising algorithms to underwater fish images. So, it is kind of crucial to remember that different denoising algorithms may be more successful for different forms of noise, and it may be required to experiment with numerous ways to acquire the best results.

Q3: What are the most accurate segmentation algorithms for identifying and delineating fish in underwater images?

A variety of segmentation methods have been used to identify and describe fish in underwater images. If I want the clarity of the images, the white lighting, and the characteristics of the fish species being identified with the different behaviours all have an impact on how accurate these algorithms are. Here are some of the commonly used segmentation algorithms for fish identification in underwater images:

Threshold-based segmentation [16], Edge-based segmentation [17], Region-based segmentation [17], Machine learning-based segmentation [17].

The specific traits of the fish species, the picture quality, and the lighting circumstances all affect how well the segmentation algorithm can detect and delineate fish in underwater photographs. Often, researchers combine segmentation algorithms to improve accuracy and decrease mistakes.

3. Research Methods

3.1 Research Methodology

As aspect of my research proposal, I am following below methodology to conduct my research.

Review of the Literature: A thorough analysis of the available research on underwater image processing methods will be carried out. Research papers, scholarly journals, conference proceedings, and other pertinent sources of information on the subject will all need to be thoroughly examined.

Data collection: Reliable sources such as fisheries offices, research centres, or marine parks will be used to gather the fish data set. The size, quality, and relevance of the data collection will all be examined to make sure it is suitable for the study.

Pre-processing: To enhance their quality and get them ready for more analysis, the gathered fish photos will go through pre-processing. Techniques including noise reduction, picture enhancement, and normalization will be used for this.

Feature Extraction: Fish picture features will be extracted to identify the distinctive qualities of the fish. Techniques including edge detection, colour histograms, and texture analysis will be used in this.

Machine Learning: To categorise the fish photos into distinct groups, machine learning methods will be used to the retrieved characteristics. To create models for precise categorization, methods including decision trees, support vector machines, and deep learning will be used.

Evaluation: Suitable performance criteria, such as accuracy, precision, recall, and F1-score, will be used to assess the models. The effectiveness of the models will be evaluated in comparison to previously published techniques.

Conclusion and Future Work: This research results will be outlined and discussed, with an emphasis on the study's contributions, constraints, and potential future directions along with the respective field of marine biology. Also, the study suggested that there are always different environments available underwater so this research will help to get a few of the answers.

Overall, this method is appropriate for the recommended study on underwater image processing with an emphasis on fish data sets. The offered methods are widely used and have been proven effective in studies of a similar nature. Also, it is feasible to effectively categorise fish photographs using machine learning algorithms, which is important for a number of applications like fish identification, counting, and tracking.

3.2 Research Methods

Underwater image processing with an emphasis on fish data sets is the suggested study subject. The study's objective is to create a novel method that will increase the precision and effectiveness of fish species and behavioural identification.

The research will utilize a variety of techniques to accomplish this aim, including a thorough literature analysis to comprehend the state of the field's expertise and any knowledge gaps. Sonar, acoustic sensors, or underwater cameras will be used to gather the fish data set. Fish species and behaviours will be identified using image processing techniques including picture enhancement, segmentation, and classification once the incoming data set has been pre-processed to eliminate any noise or undesired components.

To examine the traits that were retrieved and to comprehend how various fish species and their behaviour relate to one another, statistical techniques will be employed. Using relevant criteria including accuracy, precision, and recall, the proposed underwater image processing system will then be compared to current methods for evaluation.

All of the research techniques have been explained, supported, and determined to be pertinent to the suggested study subject.

3.3 Data Analysis Approaches

The four primary phases of the suggested study approach for processing fish photos taken underwater are pre-processing, feature extraction, classification, and assessment.

Using filters and morphological processes, the noise and artefacts from the fish photos are removed during the pre-processing stage. This action is justified by its capacity to eliminate undesirable components while retaining crucial aspects of the photos.

During the feature extraction stage, pertinent characteristics from the fish photos, such as colour, texture, and form, are extracted. The capacity of this phase to represent the photos in a fashion that can be used for additional analysis serves as the justification for it.

In the classification process, support vector machines, random forests, and neural networks are used to classify the fish photos into several groups based on species, size, and behaviour. Based on its capacity to correctly categorize the fish photos, this step is appropriate.

In the final phase, evaluation, measures like accuracy, recall, and F1-score are used to evaluate how well the classification algorithms performed. Based on its capacity to offer valuable information about the effectiveness of the categorization algorithms, this step is justifiable.

The capacity of these data analysis methods to efficiently process, extract features from, categorize, and assess the fish photos justifies their suitability for underwater image processing of fish images.

4. Research Plan and Deliverables

4.1 Timeline for the Research Activities

4.1.1 Gantt Chart

PROJECT NAME	PROJECT DURATION	PROJECT START DATE	PROJECT END DATE
UNDERWATER IMAGE PROCESSING	85	23-May-23	16-Aug-23

TASK DESCRIPTION	TASK DURATION	START DATE	END DATE
MEETING - 1 WITH SUPERVISOR	1	23-May-23	24-May-23
INTRODUCTION	3	24-May-23	27-May-23
LITERATURE REVIEW	3	27-May-23	30-May-23
FINALIZE THE AIM, OBJECTIVES, QUESTIONS AND DELIVERABLES	5	30-May-23	04-Jun-23
DRAFT LITERATURE REVIEW	5	04-Jun-23	09-Jun-23
MEETING - 2 WITH SUPERVISOR	1	09-Jun-23	10-Jun-23
METHODOLOGY LITERATURE	3	10-Jun-23	13-Jun-23
USE ALGORITHM FOR IMPLEMENTATION	8	13-Jun-23	21-Jun-23
FINAL DRAFT FOR METHODOLOGY	4	21-Jun-23	25-Jun-23
MEETING - 3 WITH SUPERVISOR	1	25-Jun-23	26-Jun-23
ANALYSIS	5	26-Jun-23	01-Jul-23
RESEARCH ON THE ANALYSIS	4	01-Jul-23	05-Jul-23
FINAL DRAFT FOR ANALYSIS	5	05-Jul-23	10-Jul-23
MEETING - 4 WITH SUPERVISOR	1	10-Jul-23	11-Jul-23
CONCLUSION AND RECOMMENDATION	3	11-Jul-23	14-Jul-23
FINAL DRAFT ON RECOMMENDATION	4	14-Jul-23	18-Jul-23
MEETING - 5 WITH SUPERVISOR	1	18-Jul-23	19-Jul-23
COMPLETE REMAINING PROJECT	9	19-Jul-23	28-Jul-23
FINAL DRAFT ON INTRODUCTION AND ABSTRACT	3	28-Jul-23	31-Jul-23
FINAL DRAFT ON ACKNOWLEDGMENT	2	31-Jul-23	02-Aug-23
TABLE OF CONTENTS AND REFERENCES	1	02-Aug-23	03-Aug-23
SUBMISSION OF FIRST DRAFT TO SUPERVISOR	3	03-Aug-23	06-Aug-23
AWAIT FEEDBACK FROM SUPERVISOR	1	06-Aug-23	07-Aug-23
REVISE SUGGESTION FROM THE SUPERVISOR ON FIRST DRAFT	2	07-Aug-23	09-Aug-23
FINALIZE THE REPORT	3	09-Aug-23	12-Aug-23
REVISE AND CHECK THE REPORT BEFORE FINAL SUBMISSION	2	12-Aug-23	14-Aug-23
SUBMIT THE REPORT	2	14-Aug-23	16-Aug-23

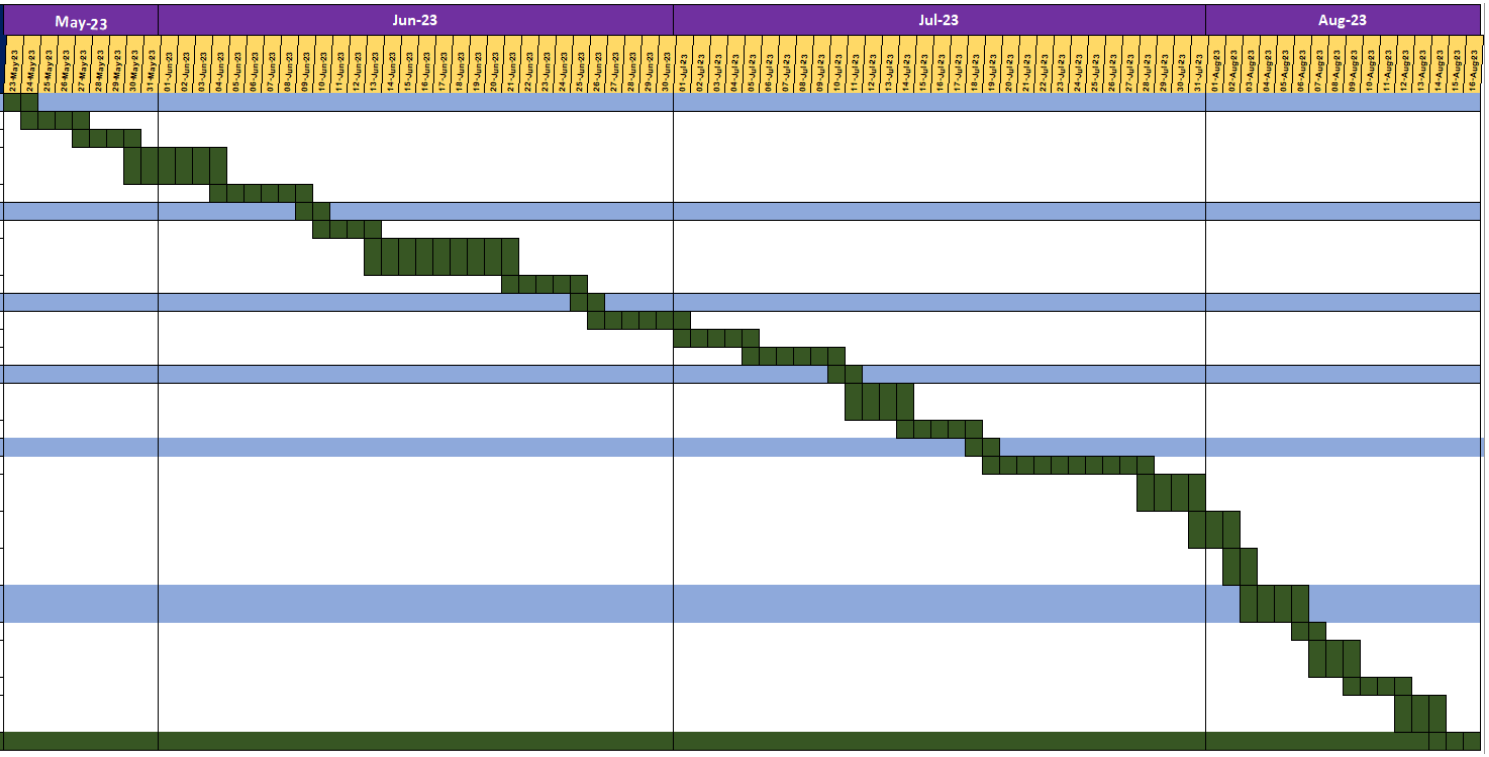

Figure 1 - Gantt Chart

It is anticipated that my project will take around 3 months and 25 days, beginning on May 23, 2023, and concluding on August 16, 2023. Several responsibilities are listed in the project plan, including meetings with supervisors, literature reviews, technique creation, algorithm implementation, data analysis, and report writing.

Each task's start and finish dates are specified in the Gantt chart, which also offers a clear schedule for each work. A number of meetings with the supervisor are also included in the project plan to make sure everything is going according to schedule.

The project's timetable begins on May 23, 2023, with a meeting with Supervisor 1, and it finishes on August 16, 2023, with the submission of the final report. Each work is given a time limit in the project plan; however, some activities take longer than others. For example, the tasks "Use Algorithm for Implementation" and "Finish Remaining Project" take 8 and 9 days, respectively.

Ultimately, I can efficiently manage my time and finish the project within the allotted time limit thanks to the Gantt chart's handy visual depiction of my project plan.

4.2 Key Milestone

SR NO	DATES	MILESTONES	DESCRIPTIONS
1	04 June 2023	Finalize the Aim, Objectives, Questions, and Deliverables	This milestone involves the finalization of the aim, objectives, questions, and deliverables of the project. These provide the direction and focus of the project, and their finalization marks a significant step towards the completion of the project.
2	21 June 2023	Use Algorithm for Implementation	This milestone involves the implementation of algorithms for processing the underwater images. The successful implementation of the algorithms is crucial for the analysis and interpretation of the dataset.
3	18 July 2023	Final Draft on Recommendation	This milestone involves the completion of the final draft on recommendations, which is an important part of the report. The recommendations provide suggestions for further research, improvements, and future direction of the project.
4	03 August 2023	Submission of First Draft to Supervisor	This milestone involves the submission of the first draft of the report to the supervisor. This milestone marks the halfway point of the project and provides an opportunity for the project team to receive feedback and make any necessary changes before the final submission.
5	16 August 2023	Final Submission of the Report	This is the final milestone of the project, marking the completion and submission of the report to the supervisor. The report includes all the findings, analysis, and recommendations of the project, and the successful completion of this milestone indicates the successful completion of the project.

Figure 2 – Milestone

4.3 Risk Analysis

Risk	Risk Description	Likelihood	Potential Impact	Risk Severity	Risk Management Activity
R1	Data quality issues	Medium	High	High	Regularly check and validate data quality and use quality control measures during data collection
R2	Algorithm failure	Low	High	Medium	Develop and test multiple algorithms, and have backup plans in place in case of algorithm failure
R3	Inadequate resources	High	High	High	Identify resource requirements early and allocate resources efficiently, seek additional resources if necessary
R4	Changes in project requirements	Medium	High	High	Regularly communicate with supervisor and obtain feedback, make necessary adjustments as early as possible
R5	Technical challenges	High	High	High	Plan for additional time for technical challenges, collaborate with experts, and conduct thorough testing
R6	Scope creep	Low	Medium	Low	Monitor project scope closely and communicate changes to supervisor, manage expectations and prioritize deliverables
R7	Communication issues	Medium	Medium	Medium	Establish clear communication channels, ensure regular communication with supervisor, and manage expectations
R8	Time constraints	High	High	High	Plan project schedule carefully, prioritize tasks, allocate resources efficiently, and manage supervisor' expectations
R9	Security and privacy issues	Low	High	Medium	Develop and implement security and privacy measures, adhere to relevant regulations and standards

Figure 3 – Risk Register

4.4 Ethical Consideration

In carrying out research using a fish dataset, it is imperative to take ethical considerations into account. These consist of maintaining data security and privacy, abiding by ethical reporting guidelines, guaranteeing fair usage, and obtaining informed consent from all stakeholders. To avoid injury or suffering to the fish during data collection, researchers must employ non-intrusive methods and secure handling and release practices.

To guarantee that data collecting is carried out in a moral, legal, and transparent manner, approval from competent authorities and ethical review boards is required. To further secure data privacy, robust cybersecurity measures, and anonymization are necessary. Researchers may ensure that their study is conducted in a way that respects the welfare of the fish and other research participants by taking these ethical considerations into account.

4.5 Research Deliverables

A literature review, methodology, processed fish dataset, experimental findings, and a research report are suitable deliverables for a three-month study on underwater image processing utilising a fish dataset. The methodology will guarantee that the study is carried out ethically and responsibly while the literature evaluation will serve as the research's theoretical underpinning.

While the experimental findings should be provided in a clear and straightforward way with statistical analysis, the processed fish dataset should be annotated with pertinent metadata to enable for analysis and interpretation of the data. The final study report should include an ethical concerns section in addition to a summary of the research questions, methods, findings, and conclusions. Together, these deliverables will give a thorough overview of the research study during the three-month time frame. These deliverables are crucial for a good research conclusion.

5. Summary

Exploring underwater image processing methods in particular for fish image collections is the goal of the research project. There is a need for effective ways to analyse photos obtained from underwater habitats due to the growing interest in underwater exploration. Although fish play a significant role in marine ecosystems and are frequently investigated for conservation efforts, this study will concentrate on fish picture databases.

Fish picture files will be gathered for the study from a variety of sources, including databases for fisheries, scientific investigations, and underwater cameras. To guarantee consistency and correctness, the datasets will be pre-processed and annotated. To examine the

fish photos, a number of image processing methods will be investigated, including feature extraction, segmentation, and classification.

Also, the study will consider how convolutional neural networks (CNNs), a sort of deep learning strategy, may be used to more precisely and successfully identify fish photos. In order to preserve marine biodiversity and make fish population monitoring easier, the suggested study would help develop automated fish recognition systems.

6. Appendix

1. **Use a polarizing filter:** Employ a polarising filter to cut down on glare and reflections from the water's surface. Images taken underwater may become more contrasty and clearer as a result.
2. **Adjust white balance:** Since underwater colours could seem distorted, adjust the white balance. To restore more accurate colour tones, the white balance can be changed.
3. **Increase contrast**: Raising contrast may make underwater photographs look fresh and more vivid.
4. **Use artificial light sources:** While photographing fish, using artificial light sources like strobes/searchlights or video lights can help you to improve image clarity and make the fish and its surroundings more visible.
5. **Post-processing:** Last but not least, post-processing methods like colour correction, sharpening, and noise reduction can aid in enhancing the visual appeal of fish underwater photography.
6. **Median filtering:** While I was reading I found out that, median filtering is one of the simple and effective methods for removing noise from images. According to previous research, this method really can help to improve output by replacing each pixel with the median value of its neighbours' or reasonably similar pixels. This method can help to smooth out any random changes in the image.
7. **Wavelet denoising:** Wavelet denoising is a well-liked method for taking out noise from photographs. Based on the noise properties in each band, this method divides the image into various frequency bands and applies varying degrees of filtering to each band.
8. **Non-local means denoising:** One of the complex approaches to remove noise called non-local means denoising compares several areas of a picture to see if there are any similarities. In order to estimate the noise levels in each location and apply the proper filtering to eliminate the noise, the algorithm then makes advantage of these commonalities.
9. **Deep learning-based denoising:** Deep learning-based denoising is a relatively new technique that uses convolutional neural networks (CNNs) to learn a mapping between noisy and noise-free images. This approach has shown promising results when denoising underwater fish photos since it can learn to do so while retaining the tiny features and textures in the image.

10. **Threshold-based segmentation**: Setting a threshold value to distinguish the foreground (fish) from the background is the basis of this strategy (water). Although this approach is straightforward and computationally effective, it might not be appropriate for photographs with varying lighting conditions.
11. **Edge-based segmentation**: This method locates the boundaries of the fish in the picture. For fish with more complex textures or picture shapes, this tactic could be difficult or ineffective, but it works well for fish with clear edges or outlines.
12. **Region-based segmentation**: According on how similar their colours or textures are, this method groups the pixels in the image. Using this approach, discovering fish with distinguishing colours or textures could be achievable, but finding fish with colours or textures that blend in with their surroundings might not
13. **Machine learning-based segmentation**: Based on a pixel's distinctive properties, our programme can detect whether it represents a fish or a backdrop. Although this approach is more accurate than the other three, it might be computationally demanding and need a lot of training data.

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