A purple triangle with a white tree and a red circle

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UNIVERSITI MALAYSIA TERENGGANU

SEMESTER 2 2022/2023

DIGITAL IMAGE PROCESSING CSF3545

DIGITAL IMAGE PROCESSING APPLICATIONS IN CORAL REEFS SURVEY

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1. **Introduction to the Problem to be Solved.**

One of the planet's most diverse and productive ecosystems, coral reefs provide as crucial habitats for a variety of marine animals. However, there are several challenges to coral reefs as well, such as overfishing, pollution, and climate change, which are harming these delicate ecosystems and causing widespread coral bleaching.

Digital image processing tools, which may provide thorough and precise information about the health and condition of coral reefs, are being used by researchers and conservationists to monitor and protect coral reefs. In this setting, digital image processing can be applied to a number of coral reef surveying tasks, including mapping, categorization, and monitoring.

The use of image segmentation for mapping coral reefs, machine learning for coral species classification, and time-lapse imaging for tracking coral growth and recovery are a few of the key applications of digital image processing in coral reef surveying that will be covered in this report.

We will also go through some of the difficulties and potential future paths for digital image processing in coral reef research and conservation, as well as the benefits and drawbacks of these techniques.

1. **Literature Review on the Marine-based Application.**

Digital image processing has been used extensively in marine-based applications for coral reefs surveying, with a focus on mapping, classification, and monitoring. Here, we review some of the recent literature on the use of digital image processing techniques in coral reefs surveying.

1. Mapping Coral Reefs:

Image segmentation has been widely used for mapping coral reefs, as it allows researchers to distinguish between different types of coral, as well as other features such as sand, rocks, and algae. For example, Li et al. (2018) used image segmentation to map coral reefs in the South China Sea, achieving an overall accuracy of 92% in identifying coral, sand, and other features.

1. Classification of Coral Species:

Machine learning techniques have been applied to the classification of coral species, which is an important step in understanding the diversity and distribution of corals in different reef ecosystems. For instance, the work of Huang et al. (2020) utilized convolutional neural networks to classify coral species based on images taken from different locations in the South China Sea, achieving a classification accuracy of over 90%.

1. Monitoring Coral Growth and Recovery:

Time-lapse imaging has been used for monitoring coral growth and recovery after bleaching events, which can provide important information on the health and resilience of coral reefs. For example, the work of DeCarlo et al. (2018) used time-lapse imaging to monitor the growth and recovery of Acropora corals in the Great Barrier Reef after a bleaching event, demonstrating the potential of this technique for long-term monitoring of coral reefs.

1. Advantages and Limitations:

Digital image processing techniques offer many advantages for coral reefs surveying, including the ability to capture detailed and accurate information on the condition and health of coral reefs, as well as the potential for large-scale monitoring. However, there are also some limitations to these techniques, such as the need for high-quality imaging equipment and the requirement for trained personnel to analyze the data.

1. Future Directions:

Future research in this field could focus on the development of new techniques for mapping, classification, and monitoring of coral reefs, as well as the integration of these techniques with other data sources, such as satellite imagery and environmental data. Additionally, there is a need for more standardized protocols and data sharing practices to ensure that the results of digital image processing research are accessible and useful for marine conservation and management.

1. **Problem Statement**

The degradation of coral reefs is a major environmental challenge, with impacts on marine biodiversity, food security, and livelihoods. Monitoring and understanding the condition of coral reefs is essential for effective conservation and management, and digital image processing techniques offer a powerful tool for this purpose.

However, there are several challenges to the use of digital image processing in coral reef surveying. These include the need for high-quality imaging equipment, the requirement for trained personnel to analyze the data, and the limitations of current image processing algorithms in accurately distinguishing between different types of coral and other features.

Furthermore, there is a lack of standardization in data collection and processing protocols, which can make it difficult to compare results from different studies and regions. Finally, there is a need to ensure that the results of digital image processing research are accessible and useful for marine conservation and management, including the development of user-friendly tools for decision-makers and stakeholders.

Therefore, the problem statement for this report is to explore the potential of digital image processing applications in coral reefs surveying, while also identifying the challenges and limitations of these techniques and proposing solutions to address them. By doing so, we aim to contribute to the development of effective strategies for the conservation and management of coral reefs, which are critical to the health of our oceans and the well-being of coastal communities.

1. **The Objective of the Project**

The main objective of this report is to explore the potential of digital image processing applications in coral reefs surveying, with a focus on mapping, classification, and monitoring. To achieve this objective, the following specific objectives will be addressed:

1. To review the literature on the use of digital image processing techniques in coral reefs surveying, including the advantages, limitations, and challenges of these techniques.

2. To identify the key applications of digital image processing in coral reefs surveying, including mapping, classification, and monitoring, and to describe the methods and algorithms used in each application.

3. To evaluate the accuracy and effectiveness of digital image processing techniques for coral reefs surveying, including comparisons with other methods and assessments of the potential for large-scale monitoring.

4. To identify the challenges and limitations of current digital image processing techniques for coral reefs surveying, including issues related to data collection, analysis, and interpretation.

5. To propose solutions to address the challenges and limitations of digital image processing techniques for coral reefs surveying, including the development of standardized protocols and data sharing practices, and the integration of digital image processing with other data sources.

6. To discuss the implications of digital image processing applications in coral reefs surveying for marine conservation and management, including the potential for improved monitoring and decision-making.

By achieving these objectives, this report aims to contribute to the development of effective strategies for the conservation and management of coral reefs, which are essential for the health and well-being of our oceans and coastal communities.

1. **Scope of the Project**

The scope of this report is to explore the potential of digital image processing applications in coral reefs surveying, with a focus on mapping, classification, and monitoring. The report will cover the following topics:

1. A review of the literature on the use of digital image processing techniques in coral reefs surveying, including the advantages, limitations, and challenges of these techniques.

2. The key applications of digital image processing in coral reefs surveying, including mapping, classification, and monitoring, and a description of the methods and algorithms used in each application.

3. An evaluation of the accuracy and effectiveness of digital image processing techniques for coral reefs surveying, including comparisons with other methods and assessments of the potential for large-scale monitoring.

4. The challenges and limitations of current digital image processing techniques for coral reefs surveying, including issues related to data collection, analysis, and interpretation.

5. Proposed solutions to address the challenges and limitations of digital image processing techniques for coral reefs surveying, including the development of standardized protocols and data sharing practices, and the integration of digital image processing with other data sources.

6. The implications of digital image processing applications in coral reefs surveying for marine conservation and management, including the potential for improved monitoring and decision-making.

The report will focus on the current state of digital image processing applications in coral reefs surveying, based on the available literature and research. It will not cover all aspects of coral reef ecology, conservation, or management, nor will it address all possible applications of digital image processing in marine environments. Instead, the report will provide a targeted overview of the potential and limitations of digital image processing techniques in coral reefs surveying, with the aim of informing and guiding future research and management efforts.

1. **Proposed Solution using Digital Image Processing**

There are several proposed solutions for the use of digital image processing in coral reef surveying, which aim to address the challenges and limitations of current techniques. These solutions include:

1. Standardization of data collection protocols: A lack of standardized protocols for data collection and processing can make it difficult to compare results from different studies and regions. To address this issue, researchers and managers could develop standardized protocols for image acquisition and processing, which would ensure that data are collected consistently and can be compared across studies and regions.

2. Development of automated classification algorithms: Current digital image processing techniques rely on manual classification by trained experts, which can be time-consuming and subjective. Developing automated classification algorithms, such as machine learning techniques, could improve the speed and accuracy of classification, while also reducing the need for human intervention

3. Integration with other data sources: Digital image processing techniques can provide valuable information on coral reef conditions, but they are not the only source of data. Integrating digital image processing with other data sources, such as satellite imagery, acoustic monitoring, and in situ sensors, could provide a more comprehensive understanding of coral reef dynamics and improve management decision-making.

4. Improved data sharing practices: Sharing data and methodologies among researchers and stakeholders could improve the accuracy and consistency of digital image processing results. Encouraging open data sharing and collaboration could also facilitate the development of new algorithms and techniques.

5. Development of user-friendly tools for decision-makers: The results of digital image processing research can be complex and technical, making it difficult for decision-makers and stakeholders to interpret and use them. Developing user-friendly tools, such as interactive maps and dashboards, could improve the accessibility and usefulness of digital image processing results for management and conservation decision-making.

By implementing these proposed solutions, digital image processing could become a more effective tool for coral reef surveying, monitoring, and management, leading to improved conservation and management outcomes for these critical ecosystems.

1. **Expected Outcomes**

The expected outcomes of using digital image processing in coral reefs surveying include:

1. Improved accuracy and efficiency: Digital image processing techniques can provide more accurate and efficient methods for mapping, classification, and monitoring of coral reefs, compared to traditional methods. This can improve the quality of data collected and increase the speed and efficiency of data processing and analysis.

2. Standardized data collection and processing: Standardized protocols for data collection and processing can help ensure consistency and comparability across studies and regions. This can improve the ability to track changes in coral reef conditions over time and across locations.

3. Increased spatial coverage: Digital image processing techniques can cover a larger area than traditional survey methods, allowing for more extensive mapping and monitoring of coral reefs.

4. Enhanced understanding of coral reef dynamics: Digital image processing can provide detailed information on coral reef conditions, including changes in species composition, abundance, and health. This can improve our understanding of coral reef dynamics and help identify potential threats and management actions.

5. Improved conservation and management outcomes: By providing more accurate and comprehensive data on coral reef conditions, digital image processing can support evidence-based decision-making for coral reef conservation and management. This can help ensure the long-term health and resilience of these critical ecosystems.

Overall, the use of digital image processing in coral reefs surveying has the potential to provide a range of benefits for both researchers and managers, leading to improved conservation and management outcomes for these important ecosystems.

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