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AI Report

Use of AI to Study Marine Mammals: A Case Study on Dugong Detection

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In today's fast-paced world with constant advances in technology, the use of artificial intelligence (AI) is becoming more integrated into academia, research, and our day-to-day lives. The many current and potential applications of AI are attracting multiple industries to test, adapt, and invest in AI as part of their operations. Healthcare, transport, customer services, education, and many other sectors are already using AI. The technology's proven efficiency and its recently unlocked accessibility through open-source software that anyone can use and adapt has made AI more attractive than ever.

In this paper, we showcase applications of AI in wildlife ecology, including marine research and conservation, and how AI can drive long-term improvements in accuracy, time efficiency, and cost.

Marine biology's deep data pool

Marine biology, having been established as a modern discipline since the late 19th century, has developed a deep and wide pool of data. This includes data sets on variables including temperature, salinity, tides, depths, weather condition, wind speed, surrounding activities, and seasons. The complexity and granularity of this data make it difficult to account for all possible variables using traditional methods of research. Researchers are now looking to AI to overcome these challenges.

> **"As global temperatures rise, better understanding and mitigating their impacts on marine mammals becomes increasingly urgent."**

As global temperatures rise, so does the urgency to better understand and mitigate their impact on marine mammals. AI-based autonomous underwater and aerial vehicles are playing an increasingly important role in these efforts. These vehicles can operate in the most difficult-to-access areas, providing researchers with valuable scientific and technical data. For instance, by being able to navigate currents, AI technologies have already "learned" to measure water temperature, salinity, and pH indexes at different depths and connect this to the dynamics of climate change.

> **"By collecting data from areas ordinarily unreachable by uncrewed vessels, aerial and underwater AI drones and devices provide scientists with valuable facts that can assist in designing more effective conservation solutions."**

AI devices equipped with sensors can detect and process the characteristics of contaminants, such as microplastics and heavy metals. By inspecting the condition of reefs, the technology can provide information around the most appropriate ways to protect these fragile ecosystems.

By exploring these areas of AI enhancement, researchers can better assess the current status of an environment and the factors that impact it – and develop strategies to mitigate negative impacts. Most importantly, AI can detect and study marine wildlife with increasing accuracy and precision, and in the most time-efficient way.

> **"AI can detect and study marine wildlife with advancing accuracy and precision of received data in the most time-efficient way."**

The increasing influence of AI in ecology can be seen in its use to interpret data on marine mammals, including dugongs. These are herbivorous marine mammals, commonly known as "sea cows," which are found in the coastal waters of the Indian and western Pacific Ocean.[1] AI can improve the outcomes of aerial and underwater studies of the unique dugong population, as explored later in this paper.

Overview of different uses of AI in marine biodiversity research

AI is currently being used to research marine biodiversity in several ways, especially using data collected by drones or Unmanned Aerial Vehicles (UAVs). These drones are specifically designed for underwater exploration and have significantly transformed the field of marine conservation by revolutionizing how oceans and seas are monitored and protected. Coupling this technology with AI will further accelerate these transformational benefits.

By using these cutting-edge autonomous technologies, scientists have changed the way they gather data and can explore greater depths and larger distances than ever before. With advanced AI and robotics, modern drones can collect more data with greater precision and on a larger scale than traditional methods. This gives scientists valuable insights into the marine environment.[2]

The potential of autonomous underwater drones to enhance marine conservation methods is immense. For example, they can help to survey critical marine habitats including coral reefs and seagrass beds, both of which are crucial components of marine ecosystems. They also help to detect, track, and monitor the migration patterns of marine wildlife. Drones can also collect data on water quality, giving scientists comprehensive information about the overall health of aquatic environments.

[1] worldworldlife.org

[2] Zhong, Jiageng, et al Real-time marine animal detection using YOLO-based deep learning networks in the coral reef ecosystem, ISPRS, 22 April 2022

AI devices can map the seabed, allowing specialists to learn more about the depths and inhabitants of the world's oceans. These devices reduce costs associated with marine biodiversity conservation as they can be used for extended periods, reducing the number of ocean trips required to collect the data needed.

AI underwater drones can also "scan" a much more extensive area than traditional methods, allowing conservationists to achieve more with less effort and fewer resources.[3]

Applications like these demonstrate the critical influence of AI technology on marine biodiversity research and conservation. For the scientific community, AI is an invaluable tool in their efforts to better understand ocean and sea life and gather critical data to help preserve the planet's marine ecosystems. As AI technologies evolve, the potential to further revolutionize marine conservation grows.

Use of AI in marine mammal study and detection

AI is currently used to analyze images from autonomous aerial and underwater drones. Both types of drones play a crucial role in improving the detection and study of marine mammals. Integrating AI technology offers immense potential for scientists to accurately describe the diverse array of species that inhabit the aquatic environment, including those found on the ocean floor. [4]

This progression is vital, given the growing scale of threats to the entire marine ecosystem. These include global warming, over-exploitation, habitat loss, and threats from human activities, such as industry and agriculture. More data is needed to help scientists assess these threats and explore conservation and biodiversity management solutions. For aerial surveys, AI machine learning brings two key improvements. These are:

01 Further automating the detection of marine species via aerial imagery.

02 Easing the task of reviewing the captured images to extract sightings data. Specifically, species sightings along survey routes recorded by UAVs help scientists determine mammals' distribution and abundance upon manual review of the images.

Unlocking the power of deep convolutional neural networks

Deep convolutional neural networks, or DCNNs, represent one of the progressive "deep learning architecture" advancements in this area. A convolutional neural network, usually abbreviated as CNN or ConvNet, represents a network architecture used in deep learning design. "Deep" refers to the number of layers in the network and enables a scientist or researcher to learn directly from data. This type of architecture dominates other techniques used to recognize objects from an image.

Convolutional networks are particularly useful for detecting image patterns to identify specific objects, their classes, and particular categories.[5]They can also effectively classify audio, time series, and signal data. Deep ConvNet has added to the precision quality of data, allowing more efficient learning and accuracy of mammal detection.[6] By default, the number of layers in the ConvNet is relatively unlimited and can range from a dozen to **100 layers**.

How does DCNN technology work?

In applying AI technology to these convolutional networks, each layer is designed to "learn" and detect distinct features encoded within an image. These layers start with basic attributes such as brightness and edges, and gradually progress to more intricate features. Filters are applied to each training image—images used to train algorithms. The filters target each image's unique, defining characteristics while considering varying resolutions. The output of each convolved image is then used as the input for the subsequent layer in the network.

The term "training images" refers to images where we already know the desired outcome.[7] Specialists put these images into a program for feature analysis. The identified features are then processed through a classification system that determines the optimal weights for each feature. The aim is to achieve results with the highest level of accuracy.

Pioneering advances in marine detection

In their 2015 project, Frederic Maire and colleagues demonstrated the effectiveness of three convolutional layers in improving detection performance. By generating more

[3] Raoult, Vincent, et al, Operational Protocols for the Use of Drones in Marine Animal Research, Drones 4.4, 25 September 2020
[4] Williams, A., Study explores the use of robots and artificial intelligence to understand the deep sea, University of Plymouth, Plymouth.ac.uk, 10 May 2019
[5] Saleh, Alzayat, et al, Applications of Deep Learning in Fish Habitat Monitoring: A Tutorial and Survey, arXiv, 11 June 2022
[6] Maire, Frederic, Luis Mejias Alvarez, and Amanda Hodgson, Automating Marine Mammal Detection in Aerial Images Captured During Wildlife Surveys: A Deep Learning Approach, Advances in Artificial Intelligence: 28th Australasian Joint Conference, 26 October 2015
[7] What are Training Images? MathWorks, 2014

image-based data, researchers gain valuable insights into how to enhance the detection capabilities of AI-powered DCNNs. Instead of analyzing entire high-resolution images, which may have a size of **20 megapixels**, for example, marine biologists now have the option to focus on specific "positively" labeled windows identified by the DCNN detector.[8]

This approach significantly reduces the time needed to extract and process data during aerial surveys of marine areas. The corrected versions of these labeled windows can then be incorporated into the training set database, continuously improving the performance of the detector. The dataset curated by the specialists also enables the scientific community to objectively evaluate research in mammal detection methods, review its attributes, and track its progress.

These methodologies can be applied to other image analysis challenges. The ability to focus on specific windows of interest, rather than analyzing entire images, optimizes efficiency and streamlines data processing. By continually refining and expanding the training dataset, researchers can achieve more accurate and reliable detection results and drive advances in mammal detection methods.

Applications like these highlight the importance of leveraging AI technology, particularly DCNNs, to enhance detection performance in marine mammal research, delivering savings in time and effort while increasing output and precision.

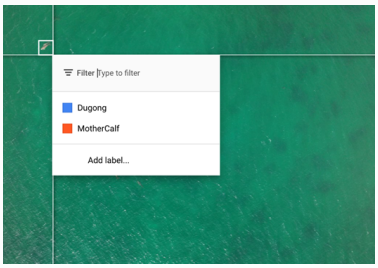

Image 1: Vertex AI, from Google Cloud, is an example of open-source AI machine learning

How AI is helping to collect data on marine mammals

Computer Vision (CV) plays an important role in addressing the human challenges of processing data.[9] Research led by the University of Plymouth into the use of robots and AI to understand the deep sea found that, if enough data is used to train algorithms, animals and specific species can be identified with comparatively high accuracy.

This suggests that a CV system based on AI can potentially revolutionize marine animal and plant studies. For mammal conservation projects and biodiversity crisis management, AI autonomous underwater vehicles (AI-AUVs) can also aid in the substantial accumulation of data and its availability.[10] Animals are already exposed to environmental dangers from human factors—such as fishing nets, collisions with marine transport, and noise pollution—and associated climate change. To protect the marine environment for the future and preserve and restore certain mammal populations scientists must harness AI technology.

Adapting AI applications for Dugong research

The dugong, or Dugong dugon, is an herbivorous marine mammal. The species is mostly found on the coast of the Indian Ocean between eastern Africa and northern Australia. Its forked tail distinguishes the dugong from other marine mammals, particularly manatees, which have a rounded tail flipper.

Image 2: Dugong. Source: iStock Photo by Getty Images (2023)

Dugongs are considered to be vulnerable mammals as they are the only remaining representative of the Dugongidae family, which once had a diversity of genera. Given this backdrop, adapting aerial and underwater devices to incorporate advanced deep learning AI and associated DCNN could serve dugong research well.
The distinctive features of the dugong and our knowledge of where they live help in this regard. For example, researchers at James Cook University in Queensland, Australia fitted **28**

[8] Maire, Frederic, Luis Mejias Alvarez, and Amanda Hodgson, Automating Marine Mammal Detection in Aerial Images Captured During Wildlife Surveys: A Deep Learning Approach, Advances in Artificial Intelligence: 28th Australasian Joint Conference, 26 October 2015

[9] Williams, A., Study Explores the Use of Robots and Artificial Intelligence to Understand the Deep-Sea. University of Plymouth, 10 May 2019.

[10] Cai, Levi, et al, Semi-supervised Visual Tracking of Marine Animals Using Autonomous Underwater Vehicles, International Journal of Computer Vision, 1 March 2023

wild dugongs with GPS satellite transmitters and time-depth recorders. They combined this data with aerial survey data to publish new research on the detection of dugongs in water.[11] Marine ecosystem scientists and developers of AI technology are therefore well-placed to improve the training of algorithms in ecology, and in turn, increase the clarity and precision of research results. AI-automation methods with integrated DCNN advancements can add to the scope and resolution of dugong studies (figure 1).

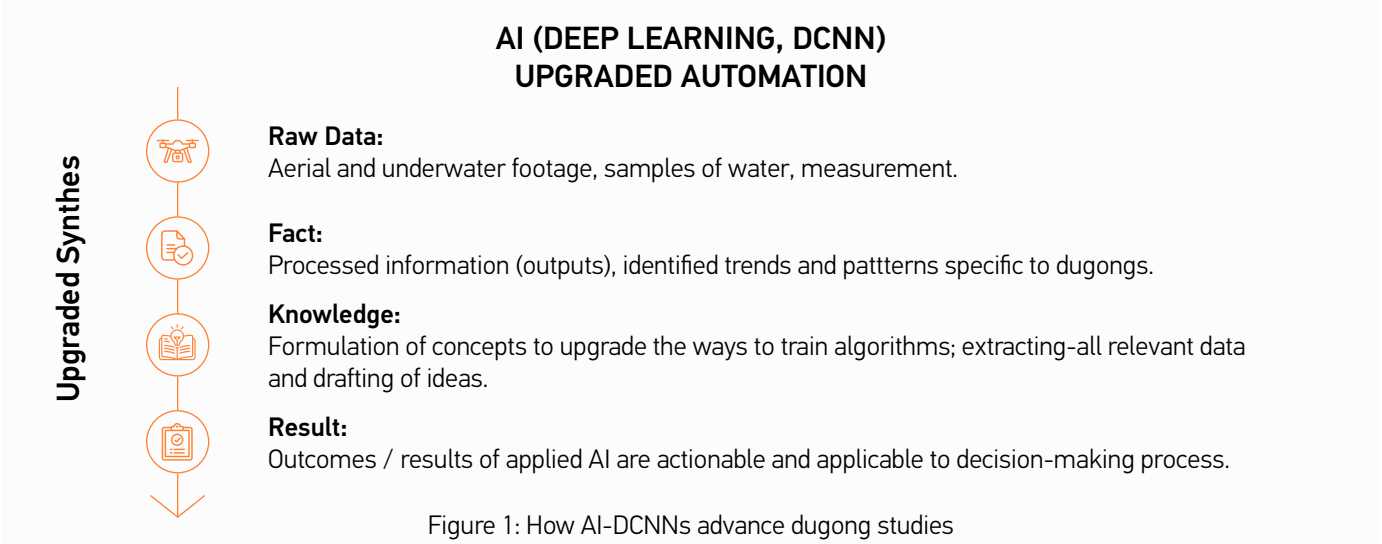

Figure 1: How AI-DCNNs advance dugong studies

Challenges and opportunities for underwater AI drones

Aerial uncrewed devices have already been tested, showing they can quite effectively gather survey data on the number and location of dugongs. The challenge that AI must be trained to manage more efficiently is the turbidity - cloudiness - of waters and wave crests. These factors complicate data analysis and affect the brightness of the images. That said, the existing computer vision systems and AI Deep ConvNet machine learning technologies discussed here have proven to be good "learners" and remain reliable data processing tools with the flexibility to adapt to different sensors and vehicles (chart 1).

> **"AI Deep ConvNet machine learning proved to be a good "learner," remaining a reliable data-processing tool with the flexibility to adapt to different sensors and vehicles."**

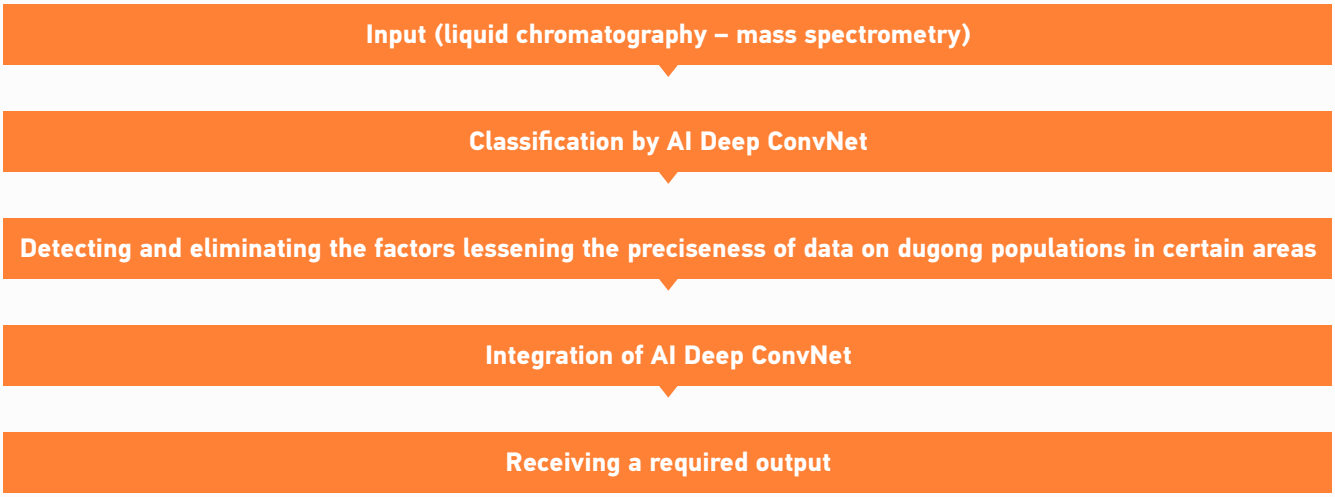

Chart 1: AI Deep ConvNet algorithm to survey dugong populations

[11] Hagihara, Rie, et al, Compensating for geographic variation in detection probability with water depth improves abundance estimates of coastal marine megafauna, PLOS ONE, 25 January 2018

This flexibility is essential given the climatic and infrastructural hardness of the Indian Ocean as a survey space. Advanced underwater AI drones can also help to study dugongs in the context of environmental monitoring and oceanography.[12] For example, these devices can be used not just to take images, but also to examine the quality of water in concentrated dugong habitats. Data like this will help to build a more comprehensive view of the entire marine ecosystem and how its elements are connected.[13] For example, the devices can collect samples of water to analyze in the laboratory in order to detect the presence of any contaminants that might harm the dugongs and endanger their future in marine environments.

Conclusion

Overall, AI technologies are playing an increasingly significant role in analyzing and interpreting data related to marine life, especially data captured through aerial and underwater devices. These advanced technologies are instrumental in producing the outcomes and insights necessary to understand and study marine ecosystems.

Increased preciseness helps to mitigate threats that endanger the existence of diverse marine mammals, including the dugong population. As the last representative of its family, this species is unique. Their specific geographical habitats and identifiable physical features also make the dugong a fitting subject for testing new AI devices for aerial and underwater studies. What we learn in improving dugong research can also be tailored and adapted to deepen our understanding of other marine species.

To achieve this vision, the development of AI technologies—particularly deep learning DCNNs—must be continued. They are vital in helping to detect and recognize mammals. In turn, the data produced can be used to train better algorithms. This means solutions to urgent threats can be designed more accurately and intelligently. By collecting data from areas usually unreachable by uncrewed vessels, aerial and underwater AI drones and devices can venture further than ever before.

For researchers and scientists, this technology is unlocking new possibilities to protect Earth's dugong population—and the marine environment in general.

[12] Butcher, Paul A., et al, The Drone Revolution of Shark Science: A Review, Drone Technology for Wildlife and Human Management, 21 January 2021
[13] Li, Juan, et al, Deep learning for visual recognition and detection of aquatic animals: A review, Reviews in Aquaculture, August 2022