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Using Machine Learning to Detect Suitability of Microalgae for Carbon Capture

Said Al Shibli[1], Omar Al Babele[2], Nusaiba Al Sulaimani[3], Khadija Al Balushi[4],
[1,2,3,4] German University of Technology in Oman (GUtech)
German University of Technology in Oman (GUtech), Halban, Muscat, Oman
Khadija.albalushi@gutech.edu.om ; nusaiba.alsulaimani@gutech.edu.om

Extended Abstract

This study presents a comprehensive investigation into the optimization of microalgae for carbon dioxide (CO_2) capture and the integration of artificial intelligence (AI) techniques for species classification. A microalgae strain (SA_1) was successfully isolated from a freshwater source in Oman and cultivated under controlled laboratory conditions. The research focused on identifying the optimal environmental parameters for enhancing biomass growth and CO_2 sequestration efficiency. Through systematic experimentation, key factors such as salinity, pH, and temperature were varied individually while maintaining other variables constant. The strain exhibited its highest growth and CO_2 absorption efficiency at 0 percent salinity, a pH of 8, and temperatures ranging between 28 and 30 degrees Celsius. Under these optimal conditions, the SA_1 strain achieved a CO_2 capture efficiency of up to 71 percent, demonstrating its potential as a sustainable bio-based solution for atmospheric carbon mitigation.

The growth performance of the strain was monitored daily using spectrophotometry, and CO_2 uptake was measured in real time through a dedicated gas monitoring setup. This included CO_2 regulators and sensors connected to the cultivation system, allowing accurate tracking of gas concentrations in both air and water phases. The results showed a steady increase in CO_2 capture starting from day one, with a notable surge by day three and a stabilization period beginning around day ten. The consistency of these results was supported by triplicate experiments and statistical validation using analysis of variance.

To complement the biological findings, the study also explored the feasibility of employing AI for microalgae classification. Traditional methods for species identification are either time-consuming, reliant on expert interpretation, or cost-intensive due to molecular techniques. As an alternative, image-based classification models were considered. However, the majority of the images obtained in the lab were of insufficient resolution for AI training. To address this, FlowCam imaging technology was identified as a promising tool for capturing high-quality images along with morphological metrics essential for building a robust dataset. Although the dataset is not yet complete, the groundwork has been laid for future training phases.

Two AI models were selected in preparation for the classification task. The first is Support Vector Machine (SVM), a reliable and computationally efficient model suited for small to medium datasets. The second is MobileNet, a lightweight convolutional neural network that performs well on mobile and embedded devices. Additionally, the latest YOLOv9 object detection model was earmarked as a potential method for identifying and classifying microalgae cells based on shape, size, and structure. These models will support the development of an automated classification system once suitable image data becomes available.

This research demonstrates a dual-path strategy combining optimized microalgae cultivation with AI-driven classification to advance carbon capture technology. The biological results provide a strong foundation for scalable CO_2 sequestration, while the integration of AI sets the stage for rapid and accurate species identification. Together, these innovations offer a promising direction for environmentally sustainable solutions to climate change.