🪸 Coral Reef Health Classification

🧩 1. Project Statement

Coral reefs are one of the most diverse and valuable ecosystems on Earth, providing habitats for thousands of marine species and protecting coastal regions from erosion. However, due to **rising sea temperatures, pollution, and ocean acidification**, coral reefs are facing severe degradation through a phenomenon known as **coral bleaching**.

In coral bleaching, corals lose their symbiotic algae (zooxanthellae) because of environmental stress, leading to their pale or white appearance and, if prolonged, death. Monitoring coral health is essential for marine conservation, but traditional field surveys are **time-consuming, labor-intensive, and costly**.

This project aims to develop an **automated image classification system** that can identify whether a coral is **Healthy** or **Bleached** based on underwater images. By applying **Convolutional Neural Networks (CNN)**, this model will assist researchers and organizations in rapidly assessing reef health, thereby supporting **sustainable marine resource management** and conservation efforts.

💡 2. Solution for This Problem

To address the challenge of manual coral health monitoring, this project proposes a **deep learning-based image classification solution** using **CNNs** and **transfer learning**.

🔹 **Key Steps in the Solution:**

1. **Data Collection & Preprocessing:**
    - Use the publicly available **Coral Reefs Images Dataset** from Kaggle, containing labeled images of **Healthy** and **Bleached** corals.
    - Preprocess images (resizing, normalization, augmentation) to handle underwater variations in lighting and color.
2. **Model Development:**
    - Utilize a **pre-trained CNN model** (e.g., EfficientNetB0 or ResNet50) for transfer learning.
    - Replace the final layer to classify images into two categories: *Healthy* and *Bleached*.
    - Apply techniques like dropout and early stopping to avoid overfitting.
3. **Training & Evaluation:**
    - Train the model on a split dataset (e.g., 80% training, 20% validation).
    - Evaluate performance using accuracy, confusion matrix, and F1-score.

4. **Visualization & Interpretation:**
    - Use **Grad-CAM** (Gradient-weighted Class Activation Mapping) to visualize which parts of the coral images influence the model's decision.
    - Plot accuracy and loss curves to analyze model performance trends.
5. **Outcome:**
    - An automated classification model that accurately identifies coral health from images, providing a scalable, cost-effective, and sustainable method for reef monitoring.

📂 3. Dataset

Dataset Name: Coral Reefs Images – Healthy and Bleached
Source: Kaggle Dataset Link
Classes:

- Healthy Coral
- Bleached Coral

Type: Image Classification Dataset
Format: JPEG/PNG underwater images of coral reefs

Purpose: To train a deep learning model to distinguish healthy coral (vibrant colors) from bleached coral (pale or white appearance).

📊 4. About This Dataset

The **Coral Reefs Images dataset** contains a collection of labeled underwater coral reef photographs captured under different lighting and visibility conditions. Each image belongs to one of two categories:

- **Healthy Coral:** These images show corals with normal coloration, indicating a balanced symbiotic relationship with algae and stable environmental conditions.
- **Bleached Coral:** These images show corals that have lost their pigmentation due to stress factors like temperature rise, pollution, or salinity changes.

🔹 **Dataset Characteristics:**

- The dataset is **small to medium-sized**, suitable for fine-tuning pre-trained CNN models.
- Images exhibit **natural underwater variability**, such as light scattering, turbidity, and angle differences, which make it ideal for testing model robustness.
- The dataset is well-labeled, allowing for **supervised learning** and straightforward class separation.

🔹 **Why This Dataset:**

- Freely available for academic and research use on Kaggle.
- Designed specifically for **coral reef health analysis**, making it highly relevant for sustainability and environmental AI projects.
- Supports binary classification tasks (Healthy vs. Bleached), making it efficient for model experimentation and performance visualization.
