

Protocol for beach plastic monitoring using aerial drones

1. Introduction

1.1 Background and Importance

Plastic pollution on beaches is a pressing environmental issue characterized by the accumulation of plastic debris, ranging from bottles and bags to microplastics, along coastal areas worldwide. This pollution not only tarnishes the natural beauty of beaches but also poses significant threats to marine ecosystems, wildlife, and human health.

Monitoring plastic pollution on beaches is crucial for several reasons: Environmental Impact, Human Health Concerns, Economic Impact, Policy and Regulation, Public Awareness. The situation is more crucial for wild beaches with bad accessibility. Technology is used in this context to resolve such problems.

1.2 Objectives

- Identify the most affected areas.
- Quantify plastic pollution on beaches.
- Track pollution trends over time.

2. Materials and Methods

2.1 Equipment

2.1.1 Drone

DJI MAVIC AIR (MAVIC AIR 3 in future).

The DJI Mavic Air is equipped with a high-quality camera with the following specifications:

- **Sensor:** 1/2.3" CMOS, 12 megapixels
- **Lens:** 85° FOV, 24 mm equivalent, f/2.8 aperture
- **Image Resolution:** 12 MP (4056×3040)
- **Video Resolution:**



- 4K: 3840×2160 at 24/25/30 fps
- 2.7K: 2720×1530 at 24/25/30/48/50/60 fps
- FHD: 1920×1080 at 24/25/30/48/50/60/120 fps
- HD: 1280×720 at 24/25/30/48/50/60/120 fps
- **Image Formats:** JPEG, DNG (RAW)
- **Video Formats:** MP4, MOV (H.264)

The DJI Mavic Air has a battery life that supports up to 21 minutes of flight time under optimal conditions. Here are some additional details:

- **Battery Type:** Intelligent Flight Battery
- **Capacity:** 2375 mAh
- **Voltage:** 11.55 V
- **Energy:** 27.43 Wh
- **Weight:** Approximately 140 grams
- **Charging Time:** Approximately 55 minutes using the DJI charger

2.1.2 Software

- **Pilot and flight planning software.**

For piloting and flight planning with the DJI Mavic Air, several software options are available that provide comprehensive control and planning capabilities. we use : **DJI GO 4**

DJI GO 4

Features:

1. **Flight Control:** Real-time video feed, flight telemetry, and aircraft control.
2. **Camera Settings:** Adjust camera settings, including resolution, frame rate, ISO, and more.
3. **Intelligent Flight Modes:** Access to features like ActiveTrack, QuickShots, TapFly, and more.
4. **Flight Data:** View and record flight data, including battery status, GPS signal strength, and flight logs.

Compatibility: Available for both iOS and Android devices.

- **Image analysis software**

Our model IA is designed to detect plastic debris in general. A first improvement is the counting of the number of debris detected and a second improvement is also underway with the knowledge of several types of plastic (bottle, Cap, Goblet, Bag ..).

Label Studio: Open-source tool for data labeling, essential for training ML models. User-friendly interface for annotating text, images, audio, and video. Supports collaboration, automation, and integrates with ML frameworks.

mean Average Precision at 0.5 threshold:

$$mAP@0.5 = 77.03\%$$

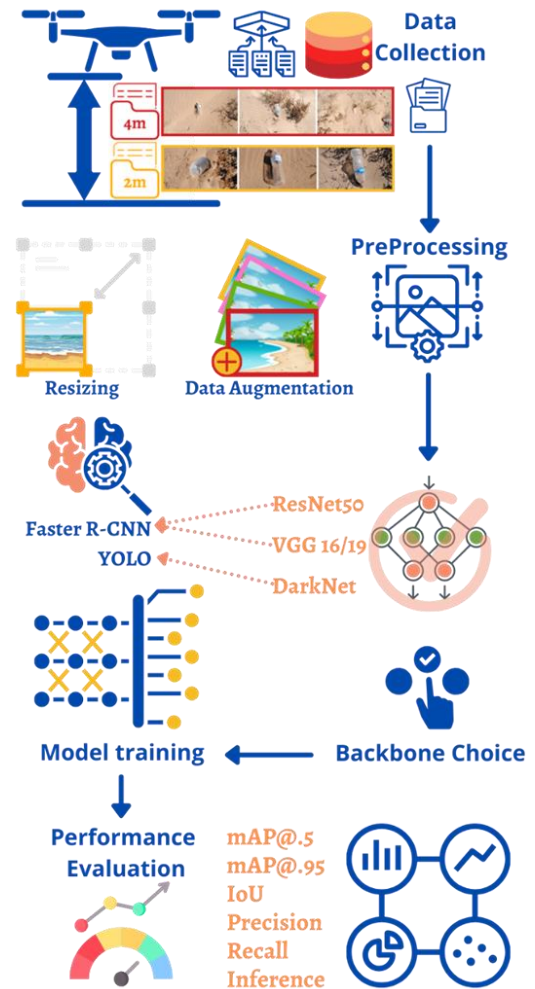
mean Average Precision at 0.95 threshold:

$$mAP@0,95 = 68.17\%$$

Precision = 71.47%

Recall = 78.09%

F1 score =74.63%



Flight Altitude : 4m



Flight Altitude : 2m



Height influences detection accuracy: comparative study confirms this

2.2 Study Area

2.2.1 Location

- **Sadia Beach**, site of biological and ecological interest Moulouya: Eastern Morocco, like all the regions of Morocco, is well known for the diversity of its ecosystems, which include forests, steppes and wetlands .
- Exact location **35.123401, -2.347291**

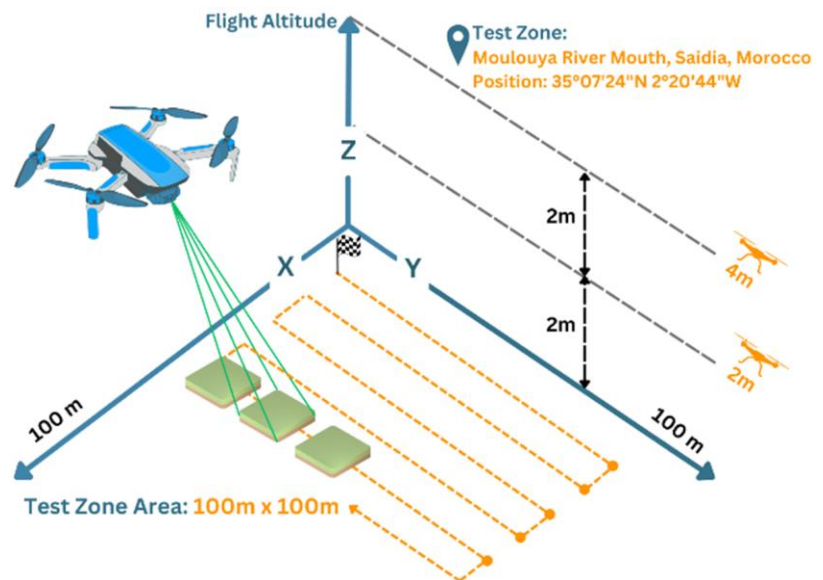
2.2.2 Monitoring Period

- Frequency of flights : **Three months (every time a seasonal survey is made)**
- Maximum Wind Speed for Flight : **Max 5m/s**

2.3 Flight Plan

- Flight altitude : **2m**
- Flight speed : **1m/s** (we can go faster, a study will be carried out to find the optimum speed to maximize flight time and the percentage of detection)
- Image with 20% image overlap for complete coverage.
- Flight path : zigzag flight path with **1m** step (the step size can be increased, but a study must be carried out to find the best step size to minimize flight time, maximize the detection percentage and minimize the overlap area) to cover the monitoring area

At this speed, it takes almost 47 minutes to fly over the 100*28m zone. We have **3 batteries** to cover this zone with this **slowest and most precise mode**.



3. Data Collection

3.1 Pre-flight Preparation

- Drone inspection :
 - Check the Drone Exterior,
 - Inspect the Battery,
 - Inspect the remote controller for any physical damage or loose components,
 - Power on the drone and check the camera and gimbal functionality.
 - Connect the drone to the DJI GO 4 app and verify flight settings such as return-to-home altitude, maximum flight altitude, and intelligent flight modes.
 - Conduct a short test flight in a safe and open area to verify the drone's stability and responsiveness.
- Maximum Wind Speed for Flight : **Max 10m/s (we recommend 5m/s)**

3.2 Flight Execution

- Follow the flight plan to cover the monitoring area.
- Real-time control via laptop screen, but model performance is less reliable given the model's high computational resource requirements
- Record videos of flight coverage of the area for asynchronous analysis on a powerful server video to be uploaded [here](#) with file format: **saidia_30_Nov_2023.avi**

4. Data Analysis

4.1 Image Processing

- Record videos of flight coverage of the area for asynchronous analysis on a powerful server video to be uploaded [here](#) with file format: **saidia_30_Nov_2023.avi**.
- Videos correction.

4.2 Detection and Quantification of Plastic Debris

- The UMP technical team will process the video within 24 to 72 hours and will upload a video with the plastic box waste on the same file. **saidia_30_Nov_2023_Box.avi**.
- Once the counting system is up and running, the resulting video will contain the localized plastic waste and its count. **saidia_30_Nov_2023_Box_Count.avi**.
- In the phase where several plastic classes will be finalized, the resulting video will contain the classes with their cumulative numbers **saidia_30_Nov_2023_Box_Count_Classes.avi**.
- Comparison of automatically detected results with the manually performed operation to calculate model accuracy.

4.3 Mapping Debris

- Create maps showing the spatial distribution of plastic debris.
- Analyze spatio-temporal trends.

5. Reporting and Communication

5.1 Report Writing

- Standardized format for reports.
- Include maps, graphs, and statistics.

5.2 Sharing Results

- With local authorities.
- With local communities.
- Scientific publications and presentations.

6. Safety and Ethics

6.1 Operational Safety

- Compliance with local regulations regarding drone flights.
- Protocols for emergencies (drone failure, adverse weather conditions).

6.2 Ethical Considerations

- Respect the privacy of people on the beaches, a deep learning model is being developed to hide people's faces in recordings
- Minimize the environmental impact of flight operations.

7. Conclusion

- Summary of the objectives and importance of monitoring.
- Future perspectives and recommendations to improve the protocol.

The present protocol was drafted by [MOH](#) and [Infordata](#).

Contributors/Authors: Mounir Grari, Alae-eddine Barkaoui, Marko Petelin, Nicola Zuccato, Samuel Zidaric