Uniquely Identifying African Savanna Elephants from Ground-based Images using YOLOv11, RESNET-50 and Hierarchical Clustering

Estimating an elephant population structure using machine learning

BACKGROUND

- **Monitoring** elephant populations in Southern Africa **supports conservation efforts**, alleviating the risk of misdirected efforts, which can lead to biodiversity loss, habitat degradation, and long-term ecological imbalance
- Traditional methods for uniquely identifying **African savanna elephants** (*Loxodonta africana*) are labour-intensive and time-consuming. Therefore, an automated, integrated solution to improve efficiency and reduce manual workload is needed
- The main objective of this research is to develop a model that can **identify individual elephants** from **ground-based images**, thereby supporting conservation efforts

METHODS

Datasets

- Elephant Images from the Mammal Communication Lab & Conservation Ecology Research Unit (CERU)]

Image pre-processing

- Extract individual elephant using YOLOv11 & Convert images – Gray, Sketch, Edge & ***Local Binary Pattern***

Feature extraction techniques

- Scale Invariant Feature Transform, EfficientNet & ***ResNet***

Elephant identification (clustering) & matching

- Cosine similarities & Euclidean distances heuristics, Lowe's match/ratio of good matches & ***Hierarchical clustering***

Evaluation/validation

- Qualitative – Visualisation & Quantitative – External ELPephant annotated data

Deployment

- Data Annotation Streamlit App

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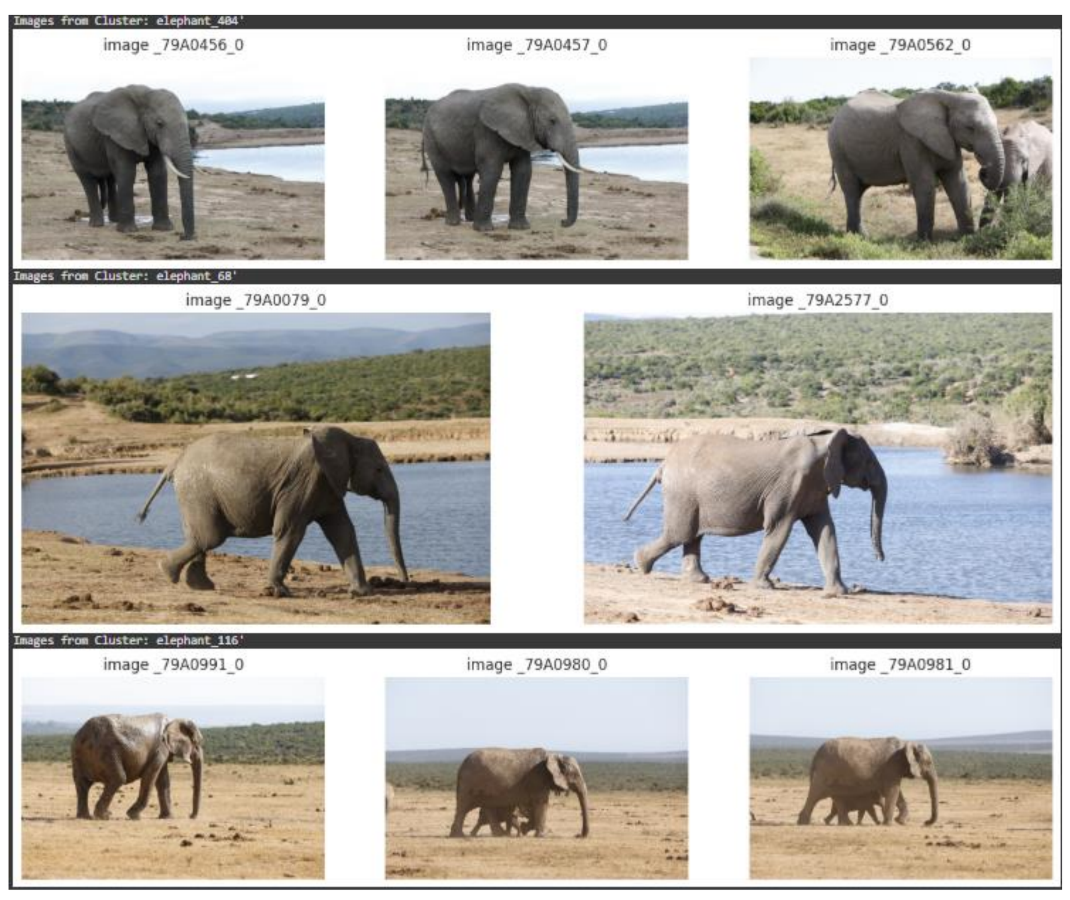
RESULTS

- **Local Binary Pattern** and pre-trained **ResNet-50** technique with **YOLOV11** model performed the best in processing the images and extracting key features for identifying an elephant
- Visual evaluation shows that **approximately 50%** of the observed images are correctly classified. It is also evident that some images within the clusters exhibit greater similarity than others, and that the model is biased towards pose or orientation

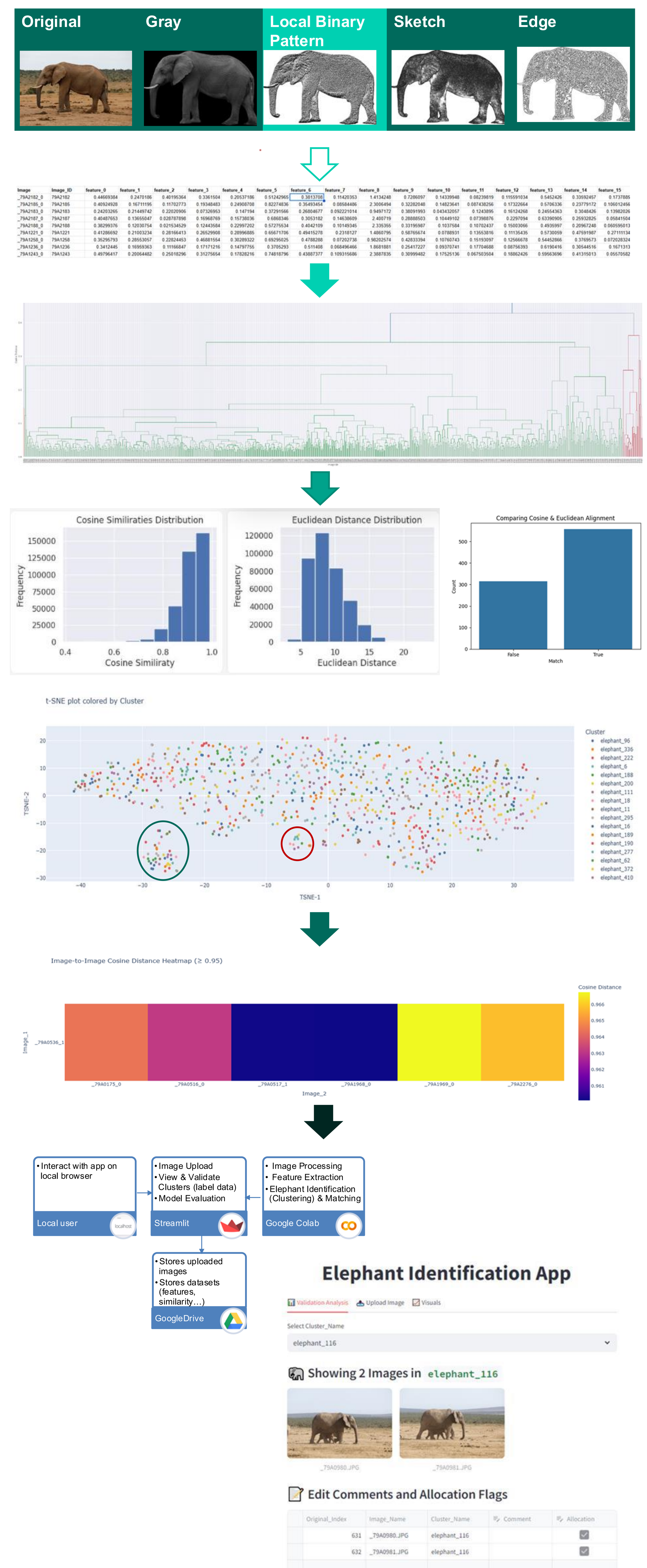


- External ELPephant data shows that the model can classify images with an accuracy of 23%

DISCUSSION

- **Lack of a labelled dataset** limits the evaluation and validation of the model. External labelled data is helpful but introduces subjectivity and inconsistency, especially as the team members lack familiarity. Labelling the current dataset is recommended for fine-tuning and accurate performance evaluation
- **Feedback-driven clustering refinement** can significantly enhance model performance through semi-supervised learning, despite limited ground truth, such as annotated images or the number of captured elephants in the dataset

VISUALISATIONS



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