HAMELEON

Vineyard Leaf Image Analysis for Pest and Disease Detection using Explainable Federated Learning

VIPA-DELF

NTNU

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VIPA-DELF Team @ NTNU

The team involved in VIPA-DELF is part of Multidisciplinary Research group on Privacy and data protection (MR PET)[1]

[1] https://www.ntnu.edu/iik/mrpet#/view/about

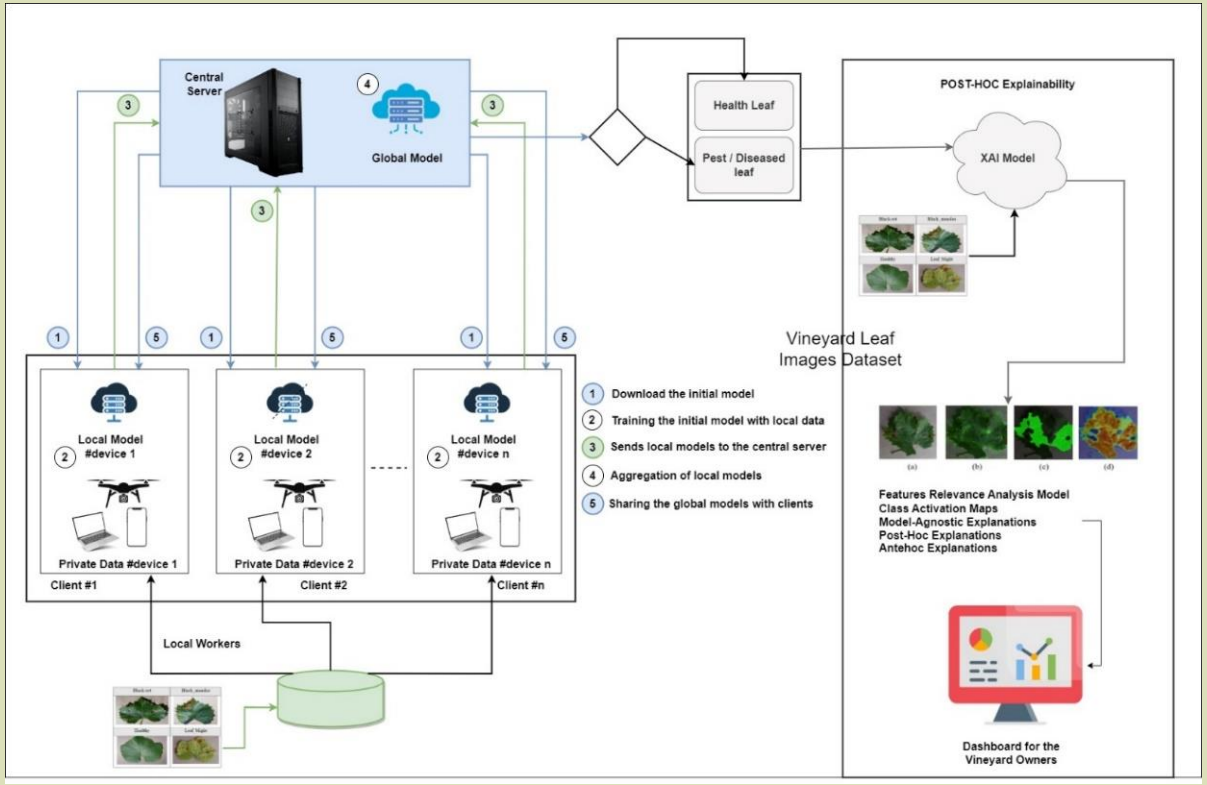
01 VIPA-DELF Team @ NTNU

Sule Yildirim Yayilgan (Professor)	Mohamed Abomhara (Researcher)	Sarang Shaikh (PhD Researcher)
Anne Hilde Ruen Nymoen (Senior Financial Advisor)	Noor E Mobeen (Masters Student)	Livinus Obiora Nweke (Associate Professor)

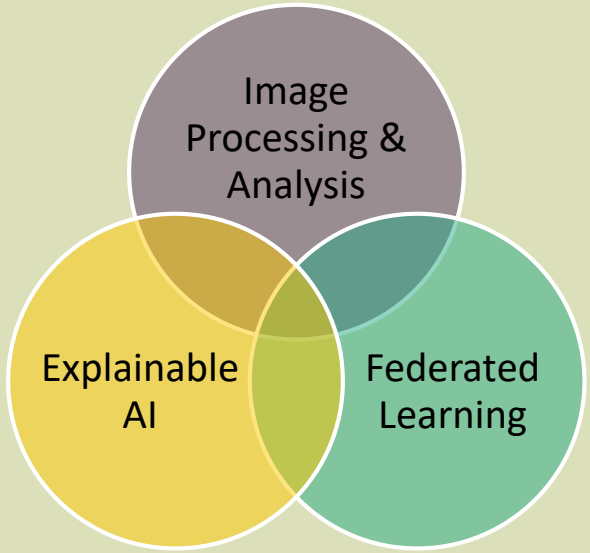
VIPA-DELF Goals & Objectives

02 VIPA-DELF Goals & Objectives

VIPA-DELF employed cutting-edge technical approach that combines computer vision, deep learning, and federated learning while emphasizing transparency and interpretability using explainable AI for vineyard leaf image analysis.



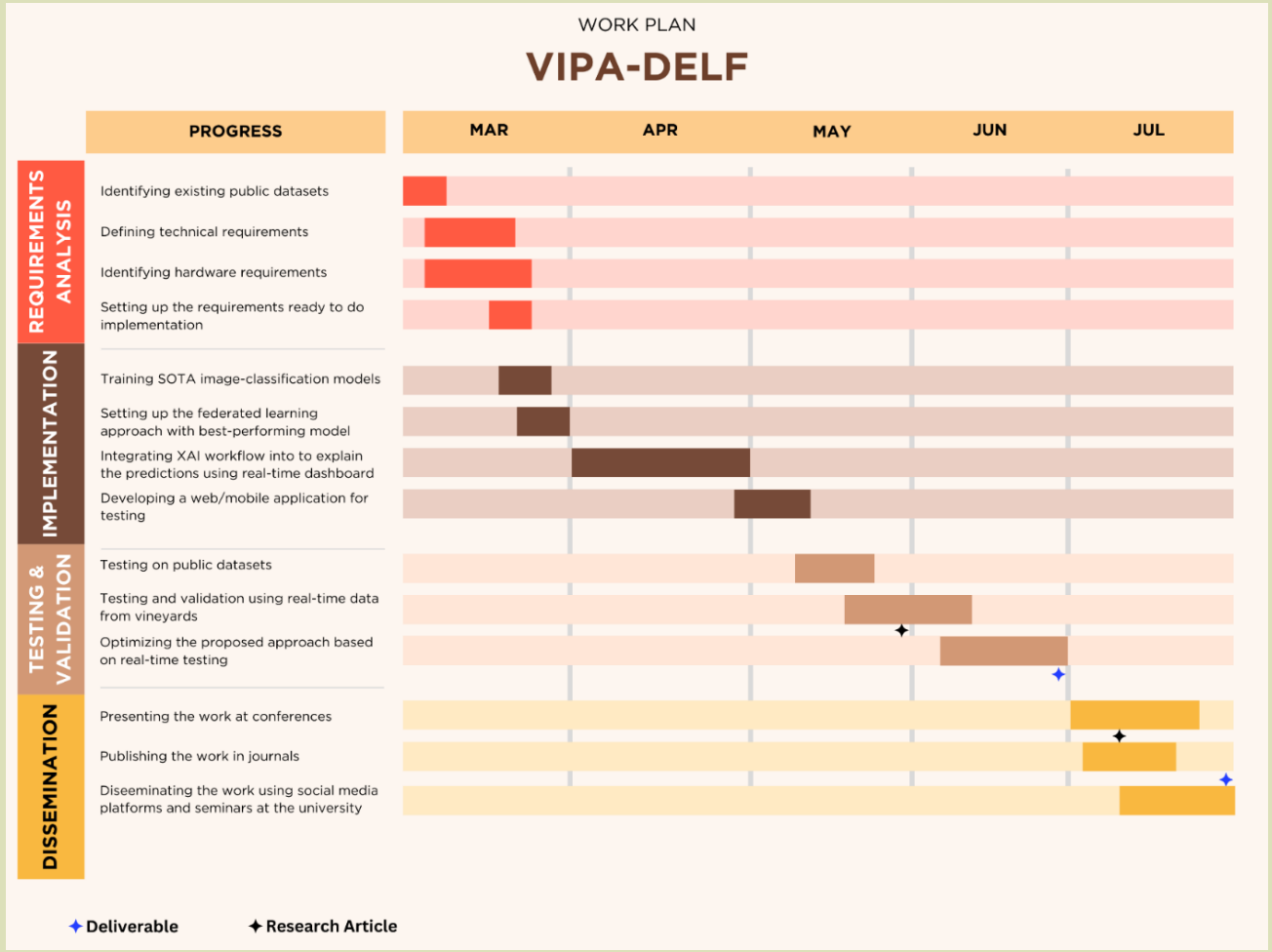
VIPA-DELF Proposed Approach



VIPA-DELF Technical Approach

VIPA-DELF Timeline

03 VIPA-DELF Timeline



VIPA-DELF Datasets

04 VIPA-DELF Datasets

Dataset#1: GrapeVine

- Target disease: Esca
- Dataset accessibility: Public
- Dataset details:
  - a.Total: 1770 images
  - b.Two classes (Healthy, Esca)
  - c.Healthy: 882 images, and Esca: 888 images

Dataset#2a: PlantVillage (Grapes)

- Target diseases: Black rot, Black measles, and Leaf blight
- Dataset accessibility: Public
- Dataset details:
  - a.Total: 7516 images
  - b.Four classes (Black Rot, Black Measles, Leaf Blight, and Healthy)
  - c.Healthy: 783 images, Black rot: 2183 images, Black measles: 2559 images, and Leaf blight:1991 images

Dataset#2b: PlantVillage (Apple)

- Target diseases: Apple scab, Black rot, and Cedar apple rust
- Dataset accessibility: Public
- Dataset details:
  - a.Total: 5867 images
  - b.Four classes (Apple Scab, Black Rot, Cedar Apple Rust, and Healthy)
  - c.Healthy: 3043 images, Apple Scab: 1166 images, Black Rot: 1149 images, and Cedar Apple Rust: 509 images

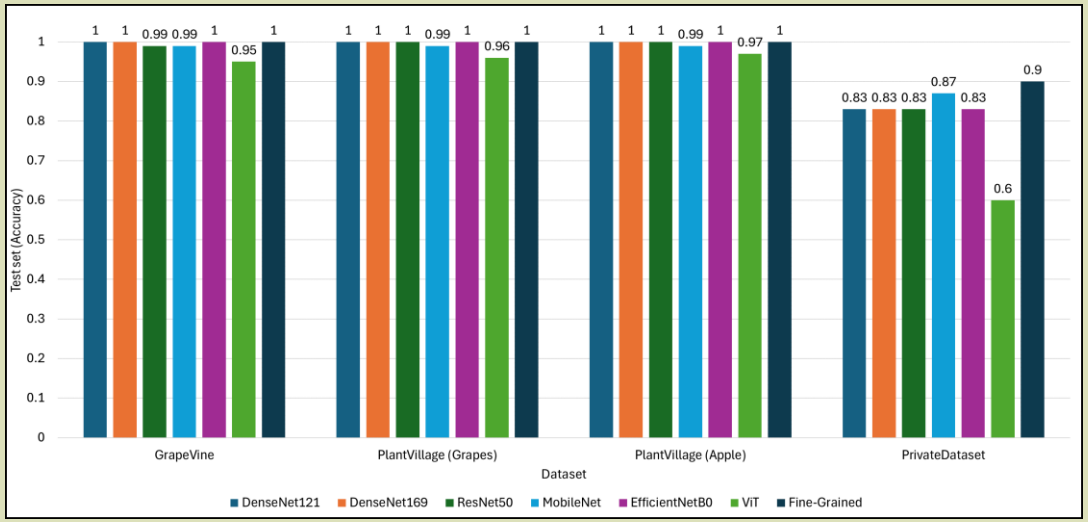
Dataset#3: Private dataset

- Target disease: Plasmopara
- Collected from vineyards of Spain and Norway
  Data accessibility: Private
- Dataset details:
  - a.Total: 281 images
  - b.Two classes (Plasmopara, and Healthy)
  - c.Healthy: 151 images, and Plasmopara: 130 images

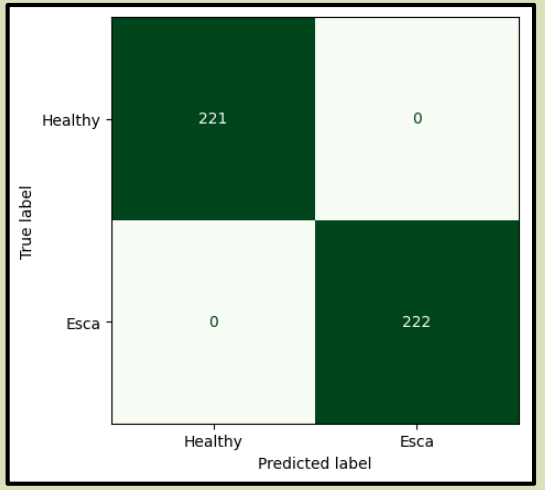
VIPA-DELF Results

05 VIPA-DELF Results

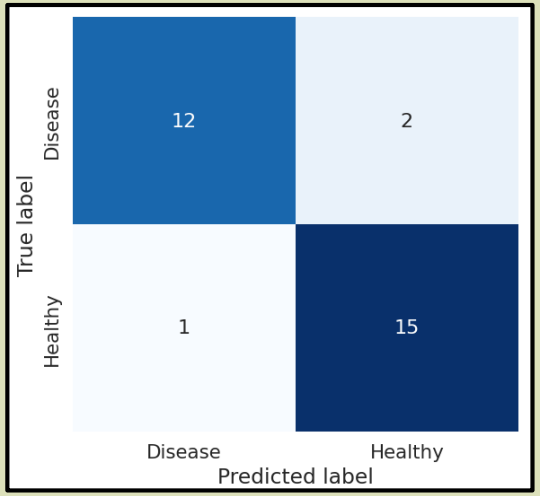
Image Analysis Models results without federated learning



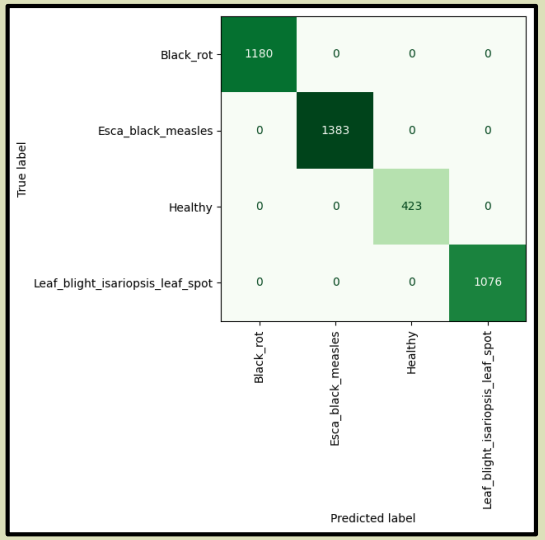
Accuracy comparison of all SOTA models against all the three datasets without Federated Learning



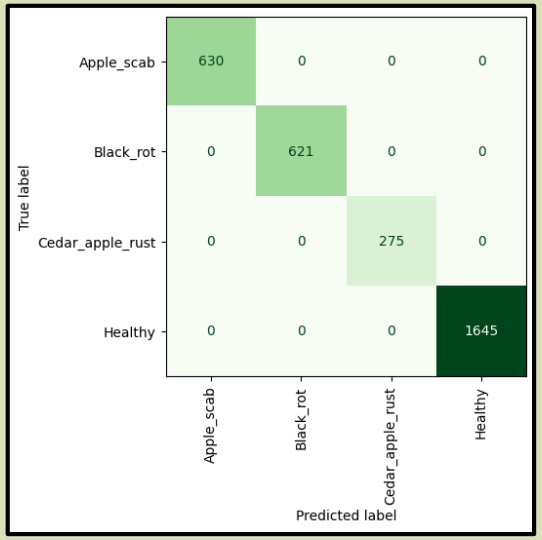
Confusion Matrix (GrapeVine Dataset)



Confusion Matrix (Private Dataset)



Confusion Matrix (PV – Grapes Dataset)



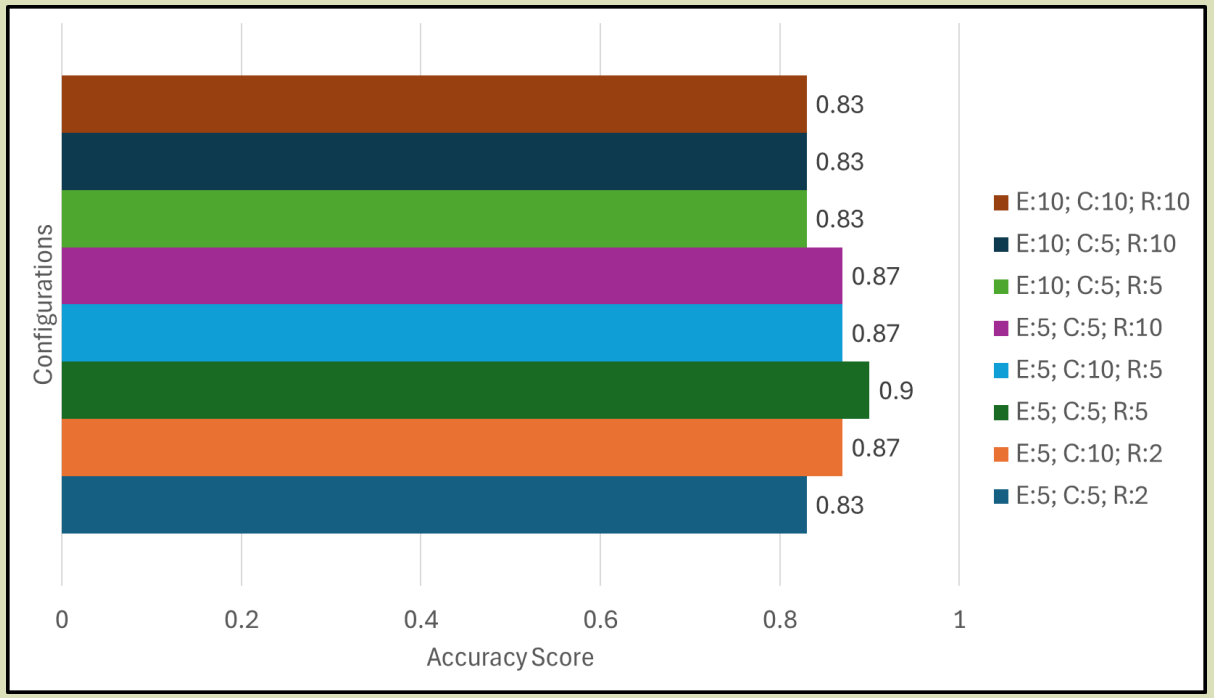
Confusion Matrix (PV – Apple Dataset)

05 VIPA-DELF Results

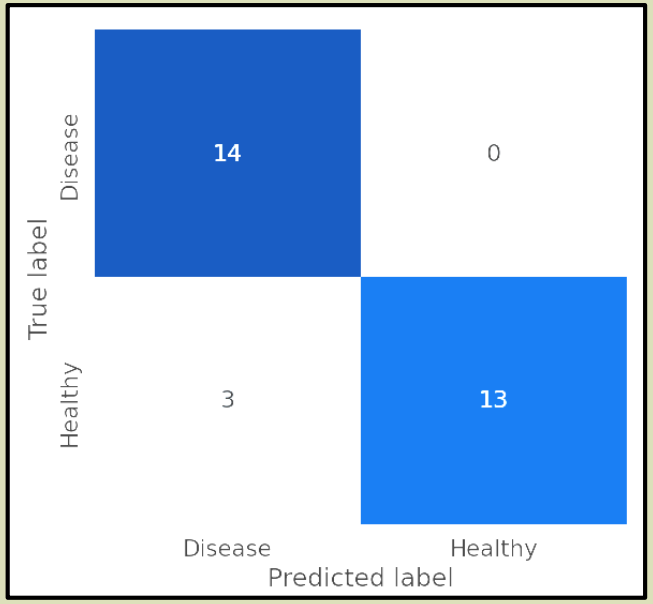
Image Analysis Models results with federated learning

Epochs	Clients	Round
5	5	2
5	10	2
5	5	5
5	10	5
5	5	10
10	5	5
10	5	10
10	10	10

Parameter configurations for VIPA-DELF FL Approac



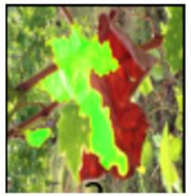
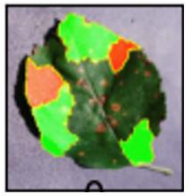
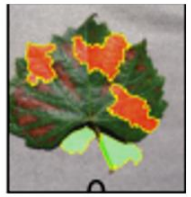
Comparison of fine-grained model; PrivateDataset using FL approach; (E=Epochs; C=Clients; R=Rounds)



Confusion Matrix (PrivateDataset; Federated Learning; Epochs:5; Clients:5; Rounds:5)

05 VIPA-DELF Results

Explainable AI

Dataset	Orignal Image	LIME	Grad-CAM
ESCA			
APPLE			
GRAPES			

05 VIPA-DELF Results

Measured KPIs

KP#1 Early Pest and Disease Detection Rate for vineyard leaves

- Proposed: Achieve a detection rate of more than 80% for diseases in vineyard leaves using the proposed technical approach.
- Outcome: The results shown on slide “” supports the achievement of this KPI.

KPI#2 Data Privacy Compliance

- Proposed: Ensure 100% compliance with privacy and data protection regulations, such as GDPR, by safeguarding sensitive vineyard data using the proposed FL method.
- Outcome: We achieved this KPI in two ways. 1) Data safeguard: Signed the “Non-Disclosure Agreement (NDA)” with the dataset providers from Spain. 2) Implemented FL approach, to maintain the privacy of sensitive data collected from Spanish and Norwegian vineyards during the model training and testing.

KPI#3 Explainability Score

- Proposed: Achieve an explainability score of at least 85% in AI decision-making for pest and disease detection in vineyard leaves using proposed XAI method.
- Outcome: Since, the achievement of this KPI is more kind of qualitative assessment; we achieved this one by sharing our work in the research community by publishing one conference paper.

KPI#4 Publishing research papers

- Proposed: Disseminating the work done in the proposed sub-project by publishing/submitting at least 1 journal and 1 conference paper in the relevant venues between Month 5 and 6 and disseminating the results to vineyard owners and relevant stakeholders in Europe.
- Outcome: 1 conference paper presented, published and 1 journal paper to be started.

VIPA-DELF Dissemination

06 VIPA-DELF Dissemination

Academic publication – Conference

- 4th International Conference on Disruptive Technologies Tech Ethics and Artificial Intelligence **(DiTTEt 2024)** from **July 3-5, 2024.**
- Link to published paper: https://link.springer.com/chapter/10.1007/978-3-031-66635-3_9

Academic publication – Journal

- Plan to publish a journal paper together with the VIPA-DELF mentors' team.
- The target journal for this paper is "Scientific Reports (Q1 journal; impact factor: 3.8)" by Nature publisher.

Open-source code repository

- We have created an online public github code repository to disseminate the code part of our sub-project VIPA-DELF.
- The gitbub repository is available at the link (https://github.com/sarangs-ntnu/VIPA-DELF).

Visit to the vineyard in Norway

- NTNU team visited a vineyard in Norway called "Hofvingard" near Holmstrand Kommune.
- The vineyard is located at Vikevein32. 3090 Hof. with an overall vineyard area of 2.9ha with total 9300 grapevine plants.
- We discussed the VIPA-DELF sub-project with the vineyard owner together with doing some data collection for the grapevine leaves.

CHAMELEON

Thank you for your attention!
Do you have any questions?

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