Title: Implementing Plant Epidemiology Concepts Using Image-Only Rose Leaf Disease Dataset

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Objective

To investigate and simulate plant epidemiological modeling using a rose leaf disease image dataset, by integrating synthetic metadata and statistical analysis into a deep learning classification pipeline.

Current System Overview

- **Dataset**: Contains 350 images each of four disease categories: Healthy, BlackSpot, Yellow Mosaic Virus, and Insect Hole.
- **Model**: Custom CNN trained initially on binary classification (BlackSpot vs Healthy).
- **Goal**: Expand to multiclass classification and simulate disease spread, risk factors, and severity using synthetic metadata.

Concepts of Plant Epidemiology

Plant epidemiology involves studying how plant diseases emerge, spread, and can be predicted or prevented. Key concepts include:

- **Disease Triangle**: Interaction between host, pathogen, and environment.
- **Disease Incidence**: Percentage of infected plants at a given time.
- **Risk Factor**: A variable (e.g., high humidity) associated with increased disease probability.
- **Odds Ratio**: A statistical measure showing association between risk factor and disease.
- **Epidemic Curve**: Graph showing new cases over time.

Adapting Epidemiology to Image-Only Datasets

Although we lack actual spatial-temporal data, synthetic metadata can be simulated to emulate field-like epidemiological scenarios.

Simulated Fields:

Parameter	Type	Description
Date	Temporal	Simulated capture date for each image
Location ID	Spatial	Simulated field grid (e.g., Zone A1, A2...)
Plant ID	Categorical	Simulated identifier per plant
Weather Tag	Categorical	Assigned by class correlation (e.g., BlackSpot = humid)
Label	Categorical	Disease class from manual or model label

Implementation Roadmap

Phase 1: Multiclass Classification

- Extend CNN to support four-class classification.
- Use metrics such as precision, recall, F1-score, and confusion matrix.

Phase 2: Metadata Simulation

- Generate synthetic metadata (date, location, plant ID) for each image.
- Map disease classes to environmental tags (e.g., humidity for BlackSpot).

Phase 3: Epidemiological Analysis

- Calculate synthetic disease incidence over time.
- Visualize trends using epidemic curves.
- Estimate odds ratios between environmental tags and disease occurrence.

Phase 4: Severity and Progression Modeling

- Use CNN confidence scores or Grad-CAM heatmaps to approximate disease severity.
- Simulate repeated image capture to model progression over time.

Phase 5: Dashboard and Visualization

- Build a Streamlit dashboard to:
    - Upload an image and classify disease
    - Display simulated disease incidence and severity plots
    - Provide basic outbreak prediction using trend extrapolation

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Conclusion

Despite limited metadata, plant epidemiology can be meaningfully implemented using image-only datasets through simulation and logical assumptions. This hybrid approach merges AI with epidemiological reasoning, offering a valuable framework for smart agriculture research.

References

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