

Persistent Homology and Fractal Dimension-Based Classification of Retinal Fundus Images

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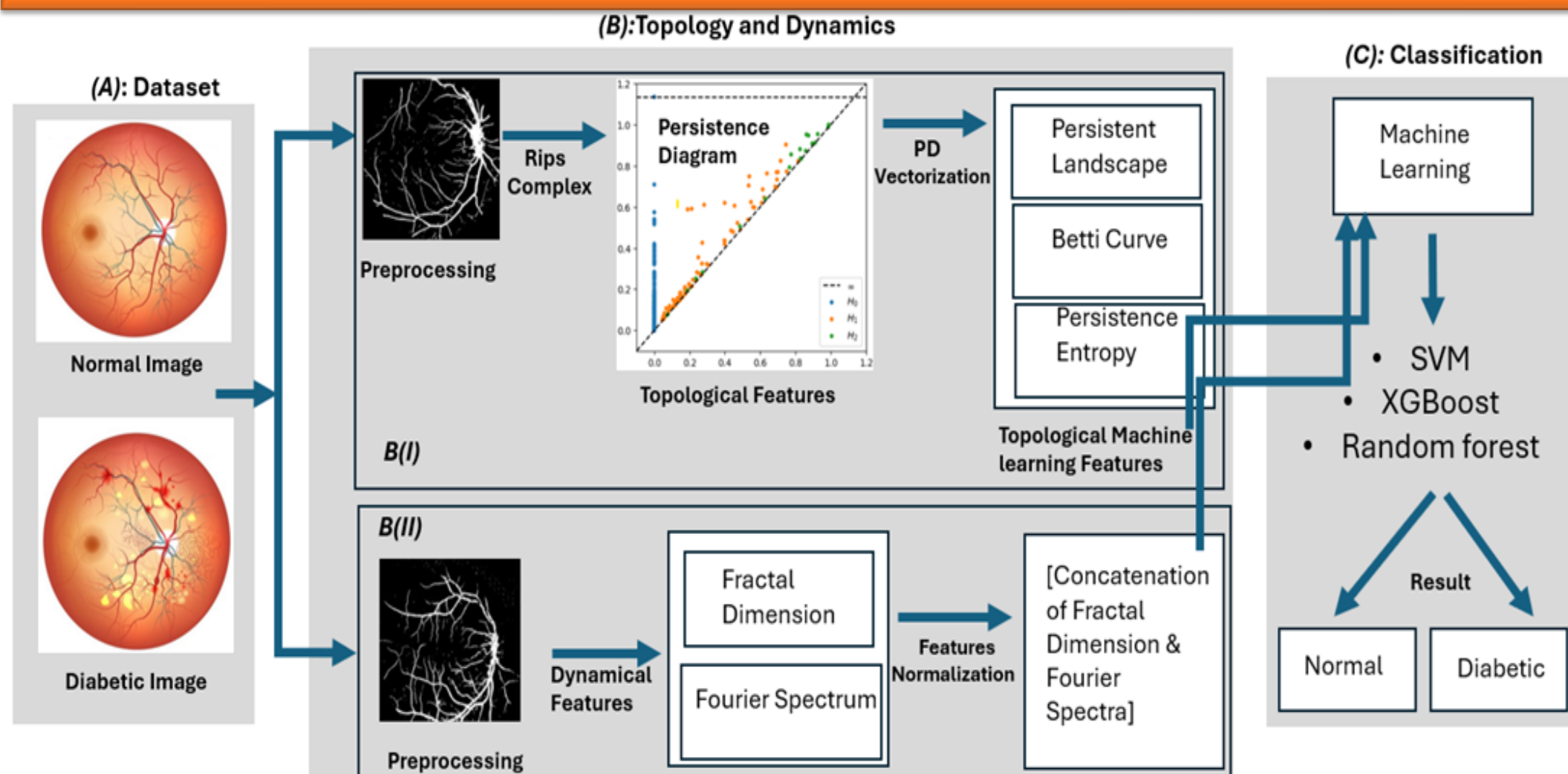
INTRODUCTION & AIM

Diabetic Retinopathy (DR) [1] is a leading cause of vision loss among diabetic patients, making early detection essential for effective treatment. This study presents a hybrid framework that combines Topological Data Analysis (TDA) and nonlinear dynamics [2] to characterize retinal vascular changes associated with DR. Persistent homology was used to extract topological features, while fractal dimension quantified vascular complexity. These features were integrated into a Support Vector Machine (SVM) classifier, achieving 94% classification accuracy. The proposed approach provides an interpretable and robust method for automated DR screening and severity grading.

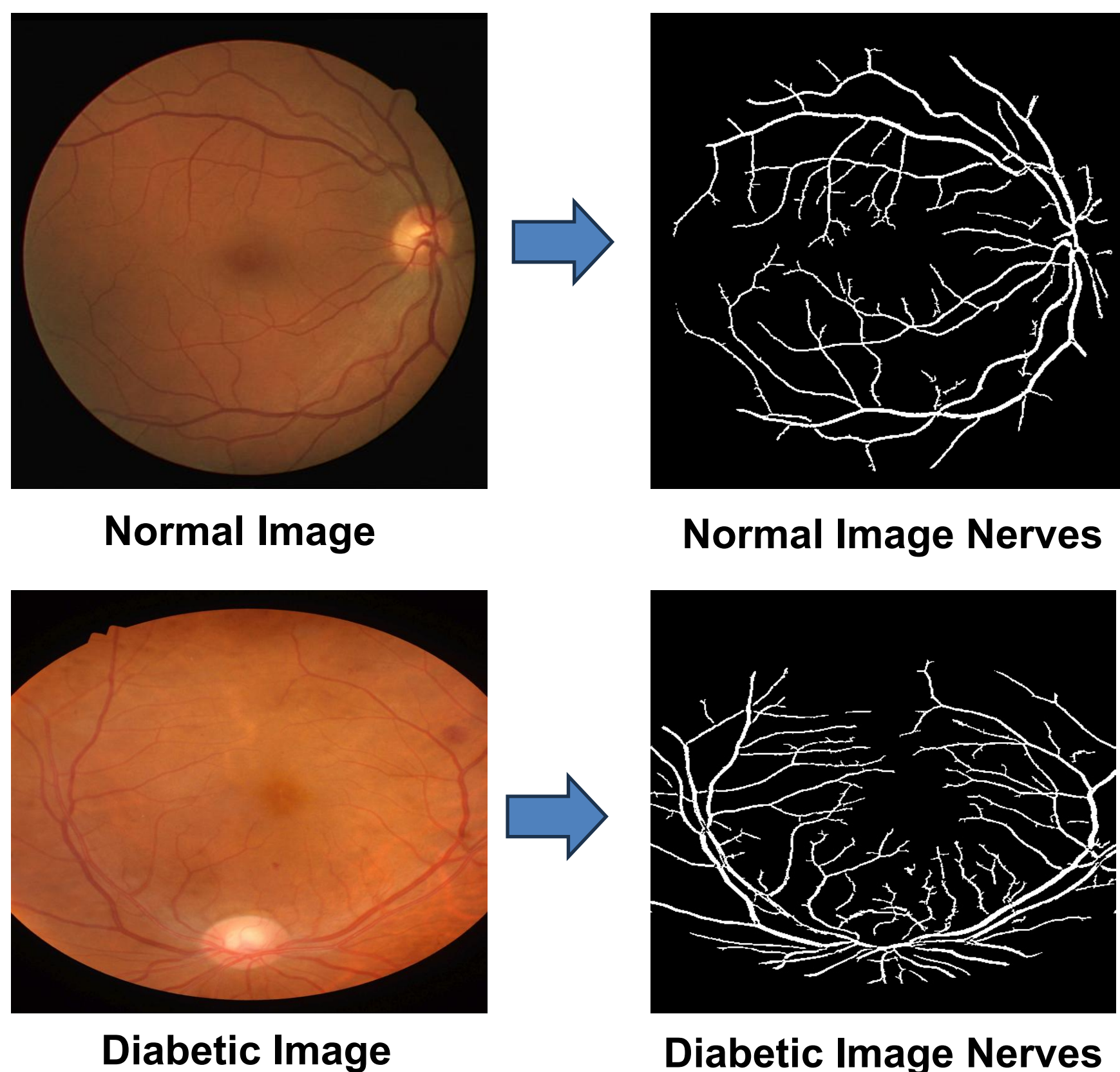
DATASETS

1. Civil Hospital Guadalajara, Guadalajara, Mexico
2. Hospital de la Luz, Mexico City, Mexico
3. Messidor, ADCIS (Publicly available dataset)

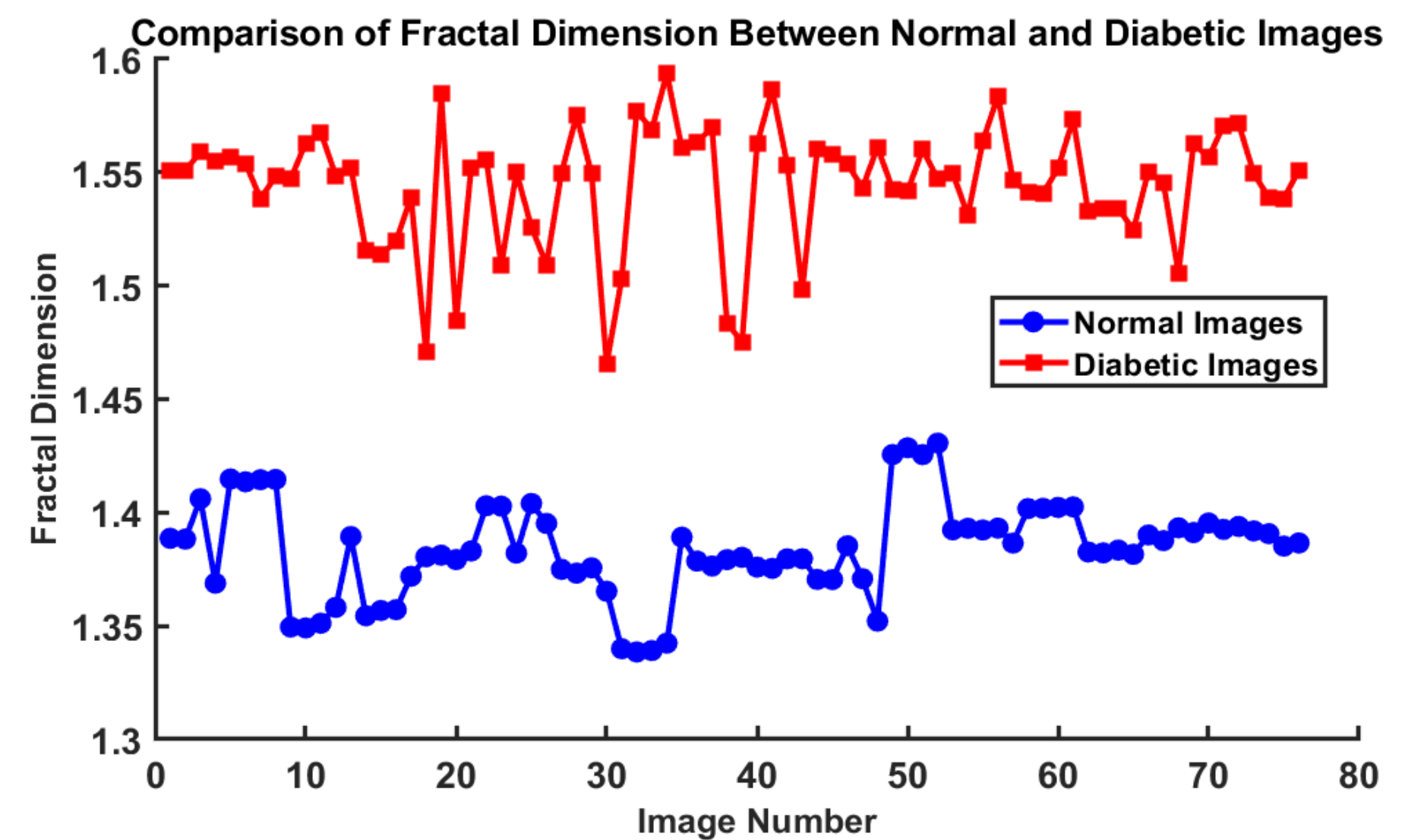
METHODOLOGY



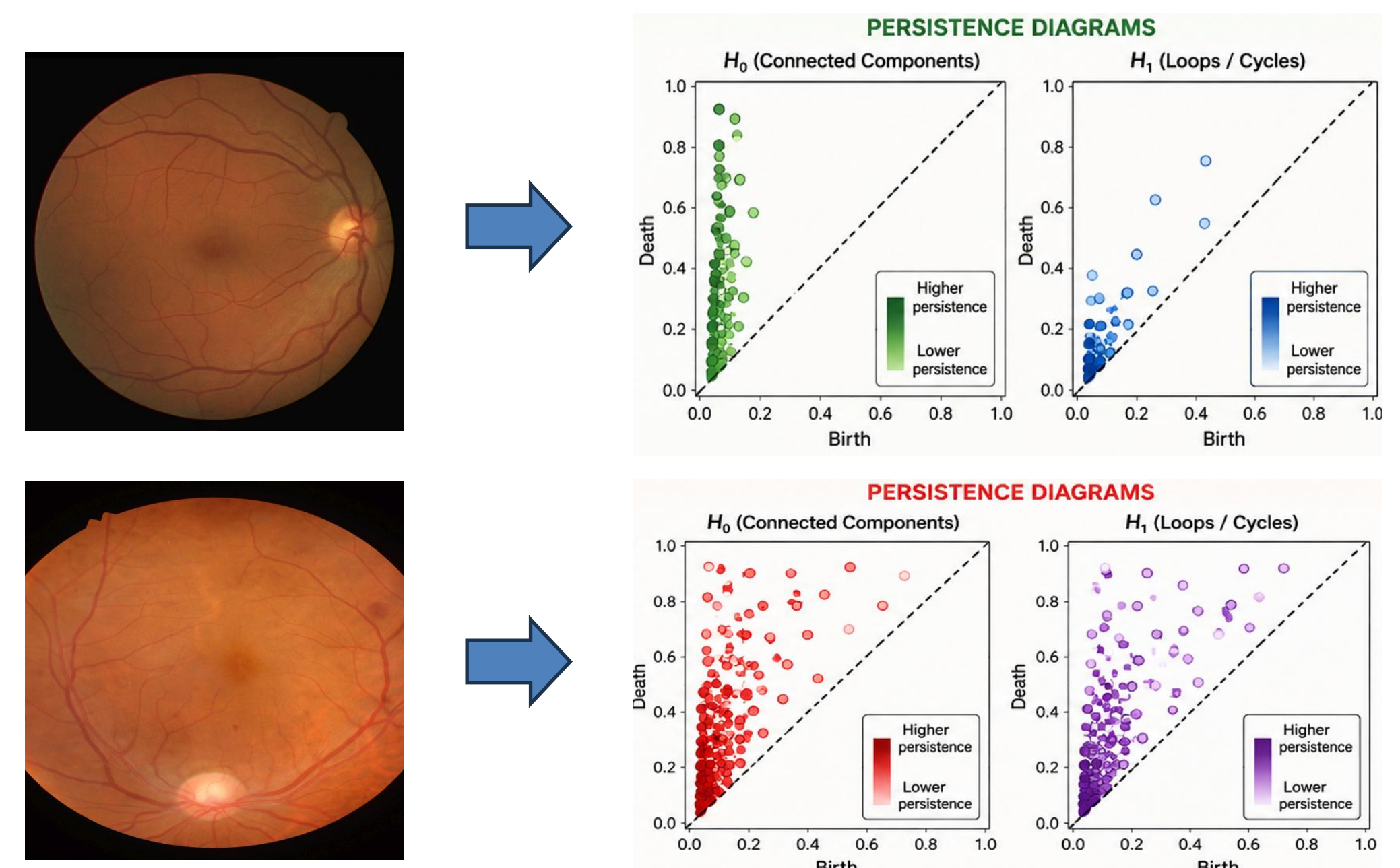
RESULTS (VESSEL EXTRACTION)



RESULTS (FRACTAL DIMENSION)



RESULTS (PERSISTENT HOMOLOGY)



RESULTS (MACHINE LEARNING CLASSIFICATION)

Table: 5-Fold Cross-Validation Accuracy (%)

Fold	SVM	Random Forest	XGBoost
Fold 1	94.8	92.3	93.5
Fold 2	95.6	91.8	94.1
Fold 3	94.3	93.7	93.8
Fold 4	94.2	94.1	94.0
Fold 5	95.1	94.5	94.6
Mean ± SD	94.0 ± 0.5	93.5 ± 0.5	94.8 ± 0.3

CONCLUSION & FUTURE WORK

TDA and nonlinear dynamic features provide a robust and interpretable framework for automated diabetic retinopathy detection, achieving 95% classification accuracy. Extend the framework to DR severity grading and evaluate its performance on larger and more diverse retinal image datasets.

References:

- 1: Yang, Z., Tan, T. E., Shao, Y., Wong, T. Y., & Li, X. (2022). Classification of diabetic retinopathy: Past, present and future. *Frontiers in endocrinology*, 13, 1079217
- 2: Cutting, J.E., & Garvin, J.J. (1987). Fractal curves and complexity. *Perception & psychophysics*, 42(4), 365-370. 21