Fundamentos de Aprendizagem Automática 25/26

Universidade de Aveiro

Brain

TUMOR CLASSIFICATION

Carolina Silva, 113475, MEI

Matilde Teixeira, 108193, MECT

Motivation

01

HIGH mortality:

most dangerous types of cancer when not detected early.

02

Need for Better Diagnostics

ML provides fast, consistent and accurate tumor classification.

03

Importance of MRI:

MRI offers detailed brain imaging (safest, non-invasive method for detecting abnormalities and early-stage tumors).

04

Goal:

Reliable binary classifier capable of distinguishing tumor vs. no-tumor MRI images with high accuracy.

Brain Tumor MRI Dataset (Kaggle)

- Original classes: glioma, meningioma, pituitary, no tumor
    - Merged into: tumor vs. no tumor
    - Total images: 6726
        - Training: 5521
        - Testing: 1205
- Final resolution: 128×128
- Moderately imbalanced dataset

State of the Art

S: Classical ML: SVM, LR, handcrafted features

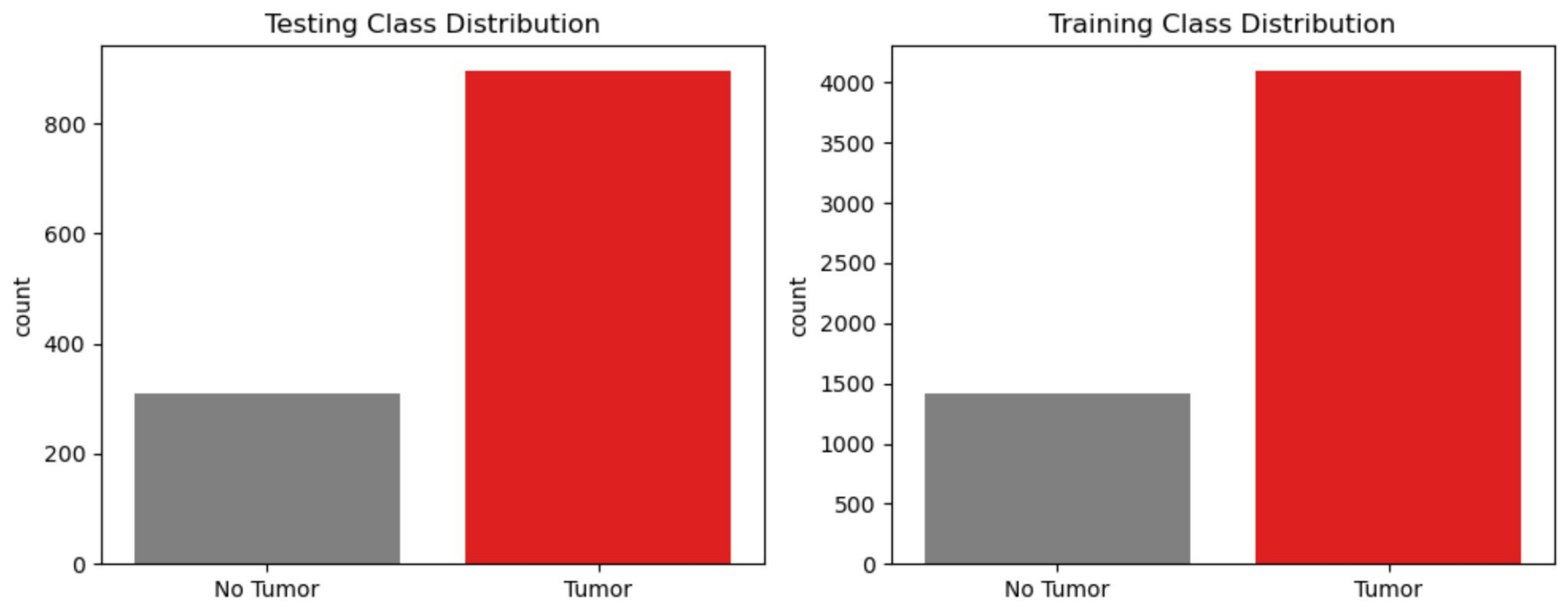
O: Deep learning: CNNs achieve >98–99%

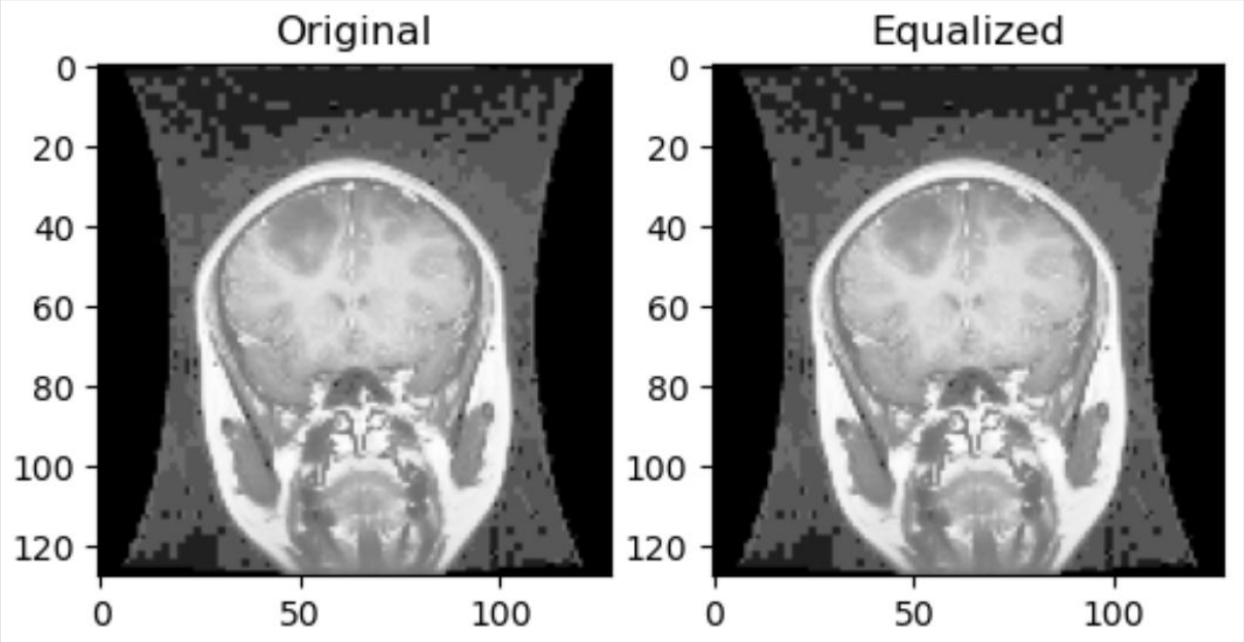
T: Hybrid CNN-SVM models widely used.

A: Challenges: imbalance, interpretability, variability

Pre-processing Pipeline

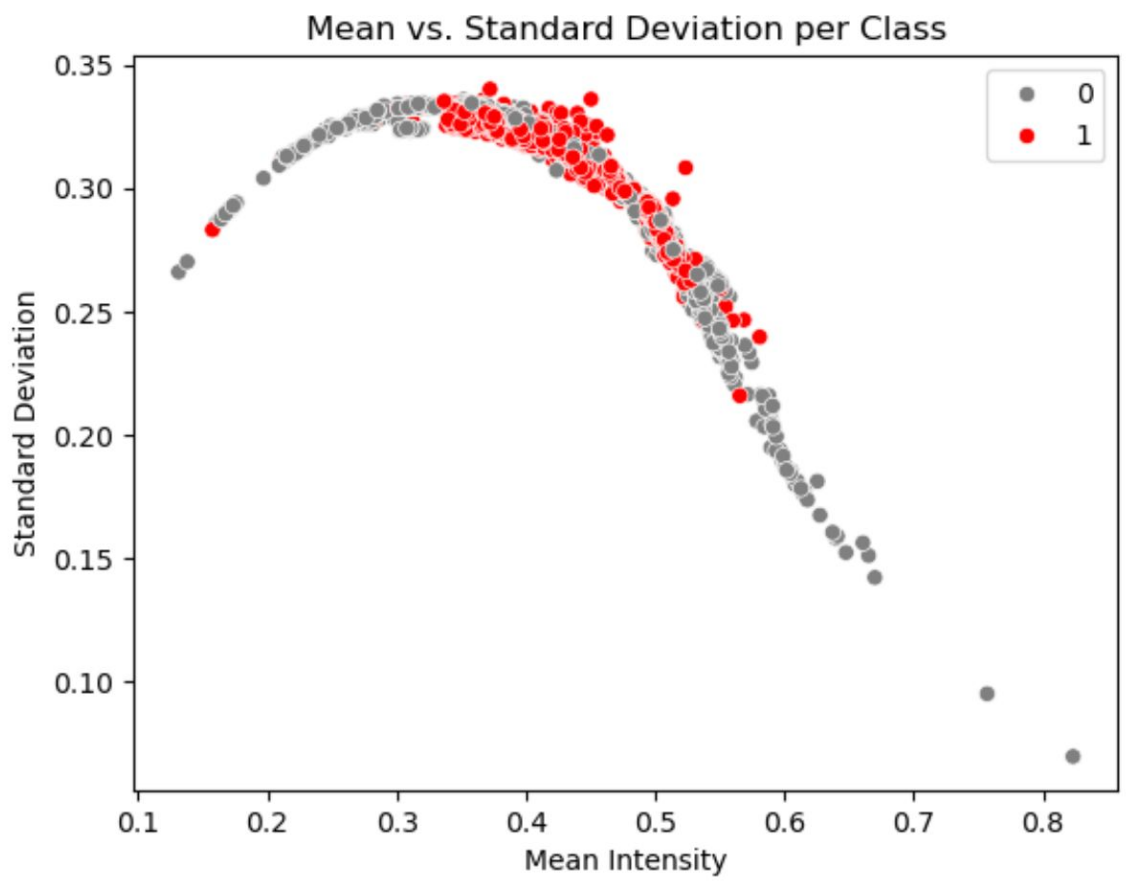
- Duplicate removal (297 images).
- Grayscale conversion.
- Resizing to 128×128.
- Histogram equalization for contrast improvement.
- Min–max normalization to [0,1].



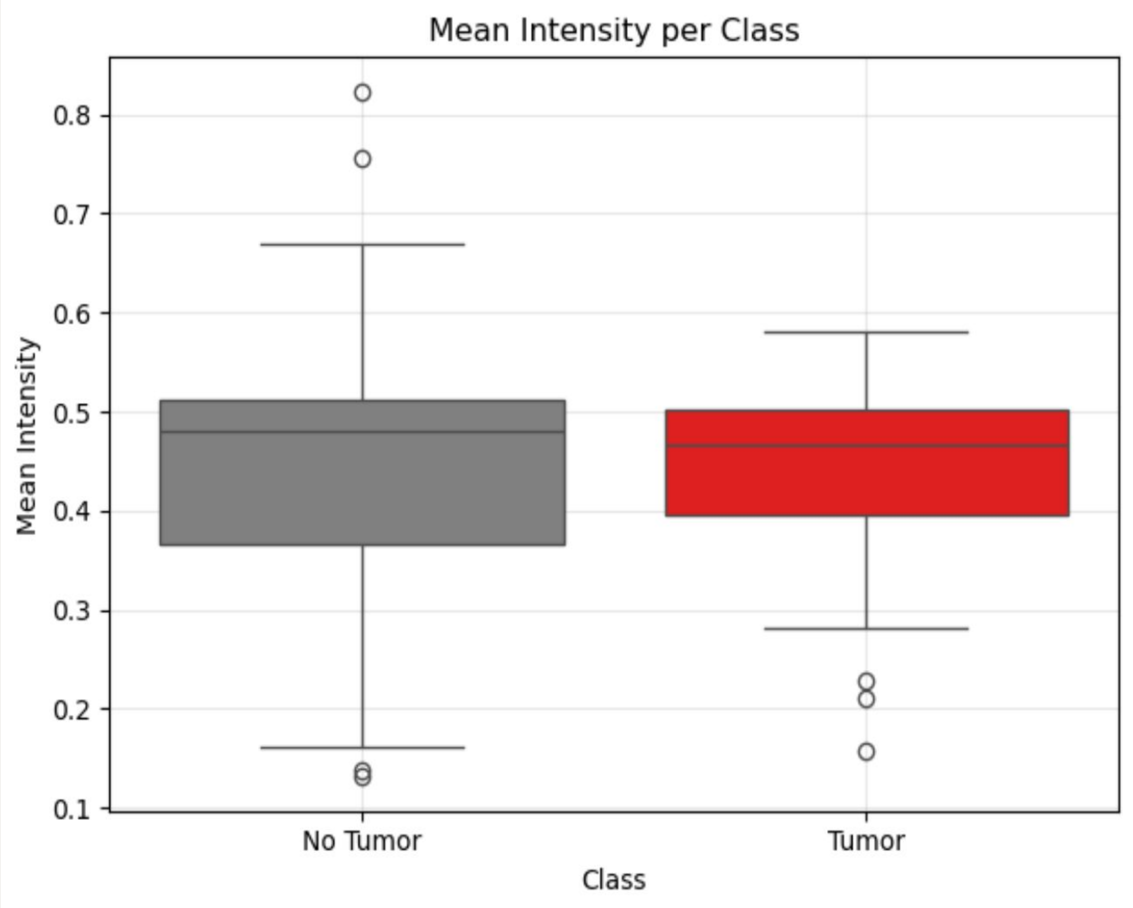


MEAN VS STANDARD DEVIATION

Summary: dataset is consistent and well balanced after processing.



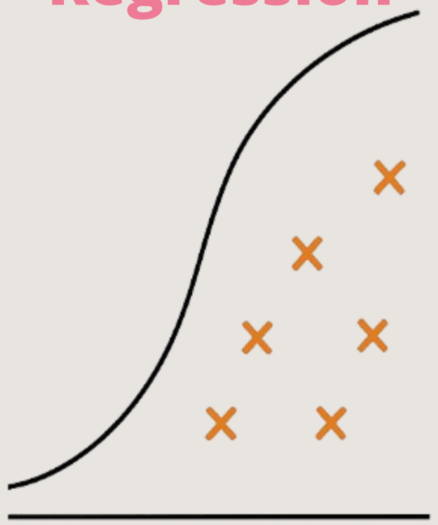
Mean & standard deviation comparison (train/test)



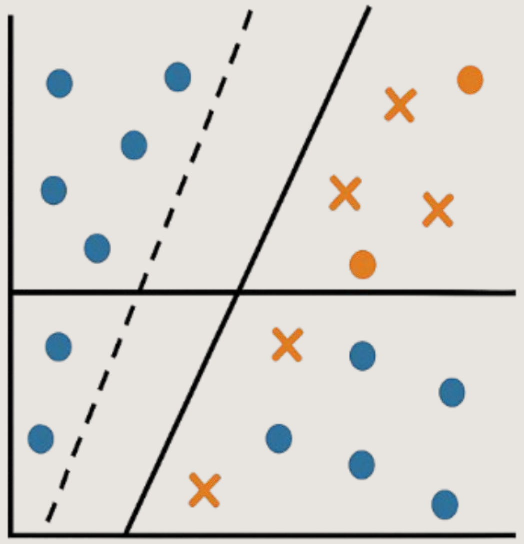
Boxplots and intensity statistics

Models Evaluated

Logistic Regression

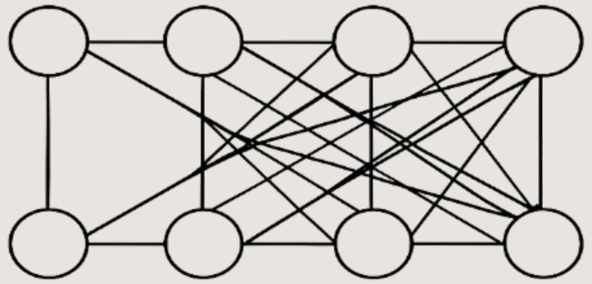


SVM with Polynomial Kernel



Neural Network

(1 hidden layer, 64 units)



Purpose

Compare linear vs. non-linear approaches.

Logistic Regression

Key Features:

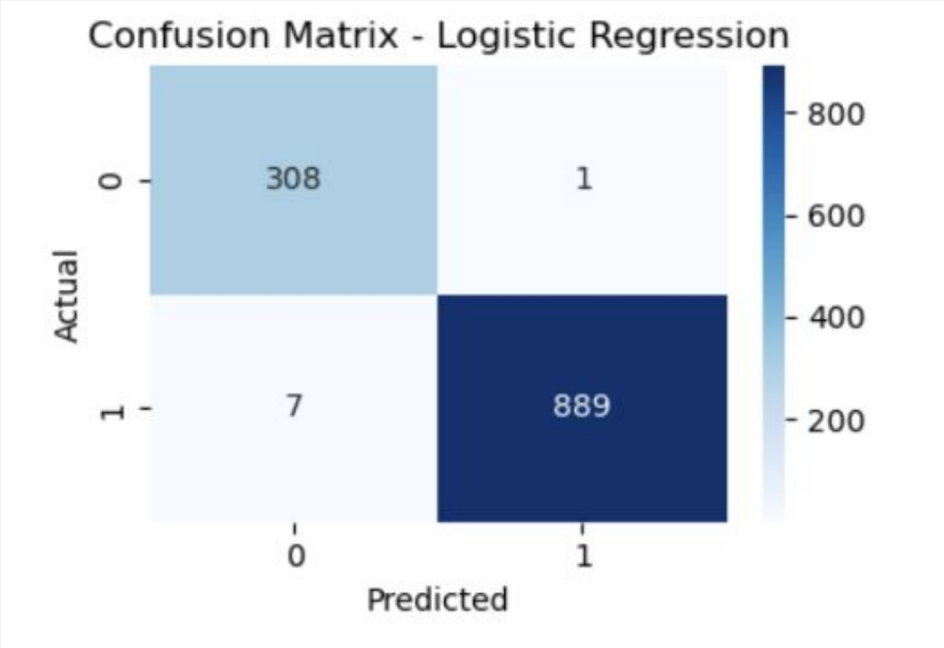
- Linear classifier with L2 regularization
- liblinear solver
- Input features:

Results:

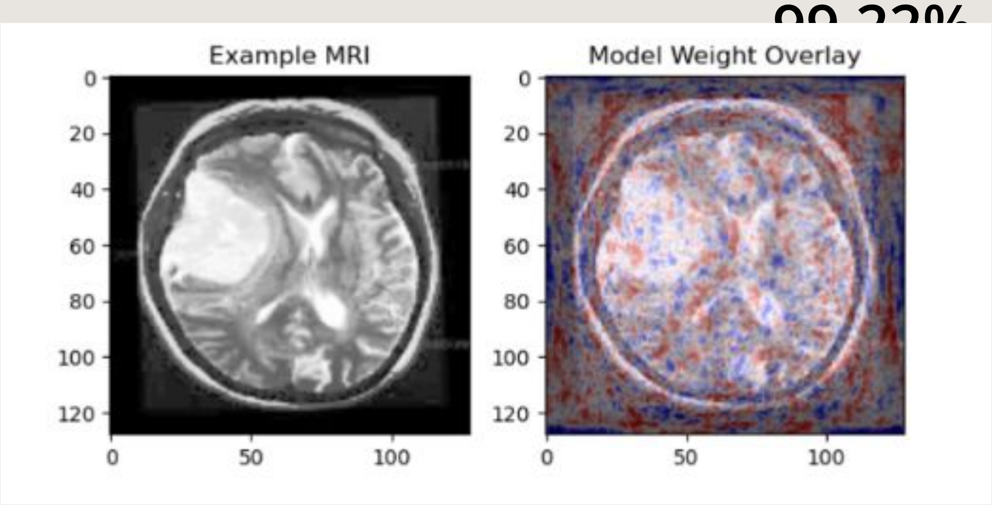
- Accuracy: 99.34%
- Precision: 99.89%
- Recall:

Include:

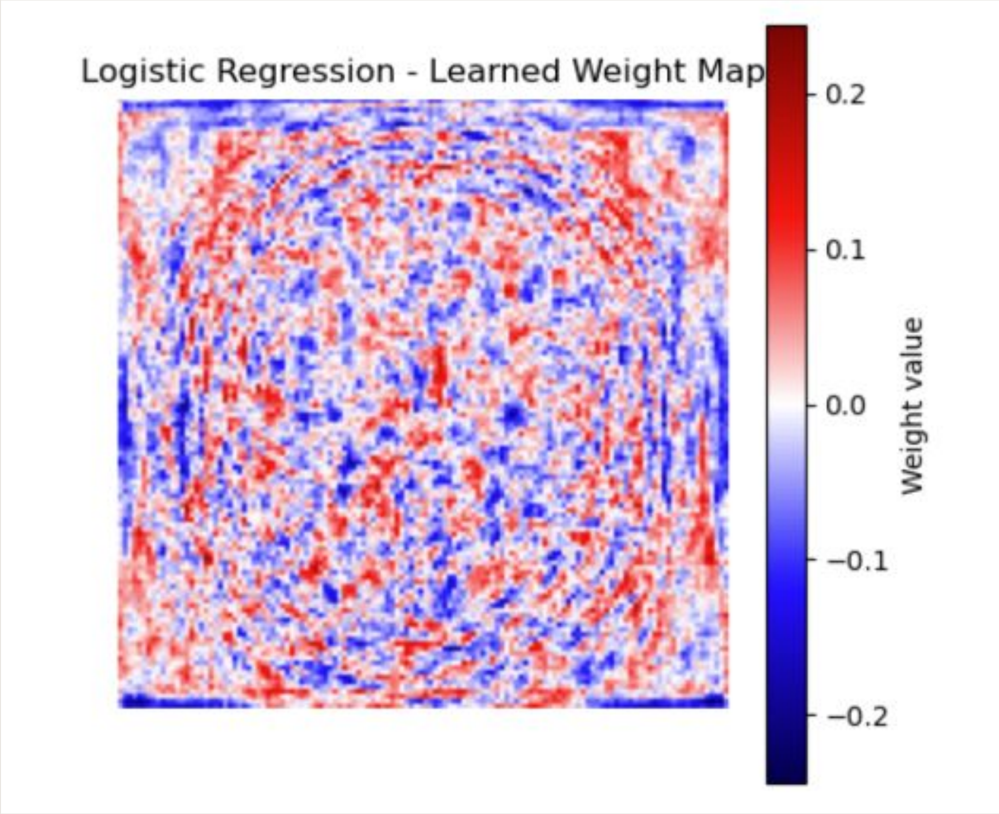
- Confusion matrix
- Weight map & overlay visualization
- Regularization impact chart



Confusion Matrix



Example MRI vs Model Weight Overlay

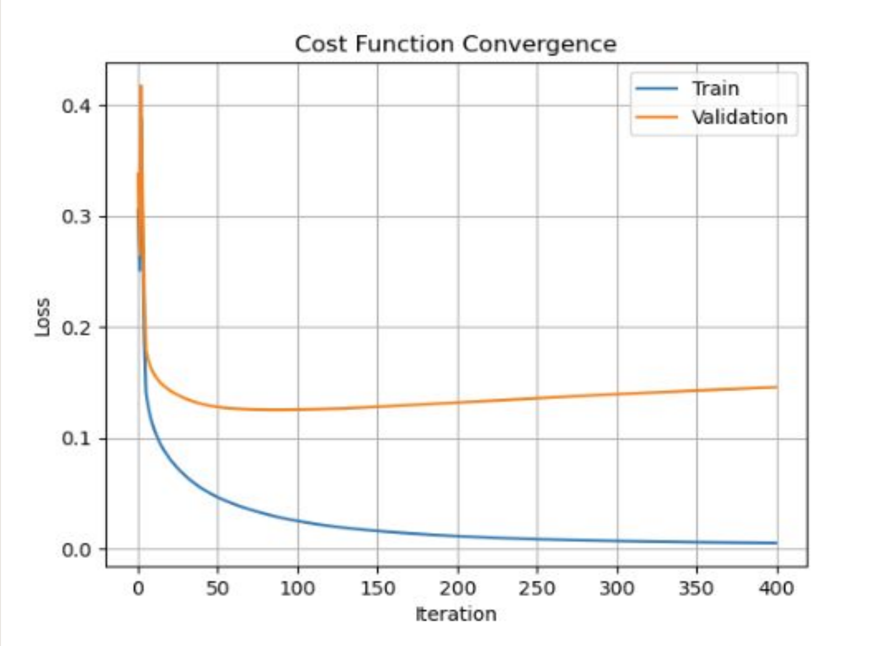


Learned Weight Map

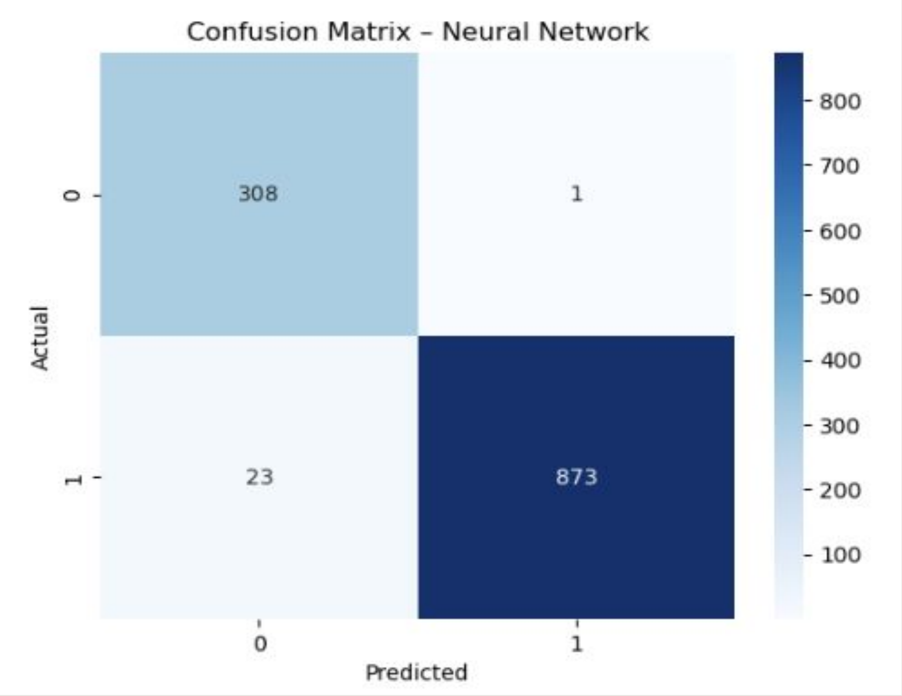
Neural Networks

- **Architecture**
  - Input layer: 16,384 features (flattened 128×128 MRI)
  - Hidden layer: 64 neurons, sigmoid activation
  - Output layer: 1 sigmoid neuron (tumor probability)
  - Implementation: fully built from scratch in NumPy
  - Optimization: batch gradient descent, L2 regularization

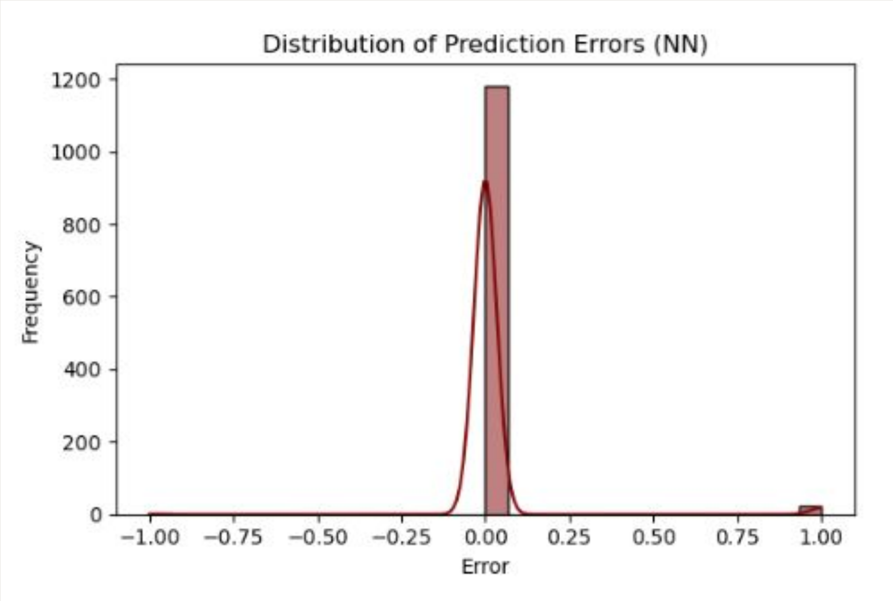
- **Hyperparameters**
  - Learning rate $\alpha = 0.5$
  - Regularization $\lambda = 0.1$
  - Iterations: 400
  - Weight initialization: Xavier



Training and validation loss



Confusion Matrix



Distribution of prediction errors

SVM

Test

Tested Linear, RBF, Polynomial kernels

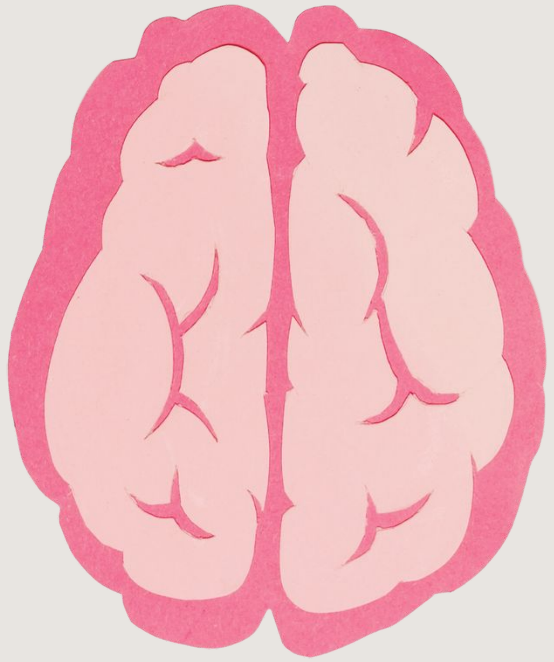
Best

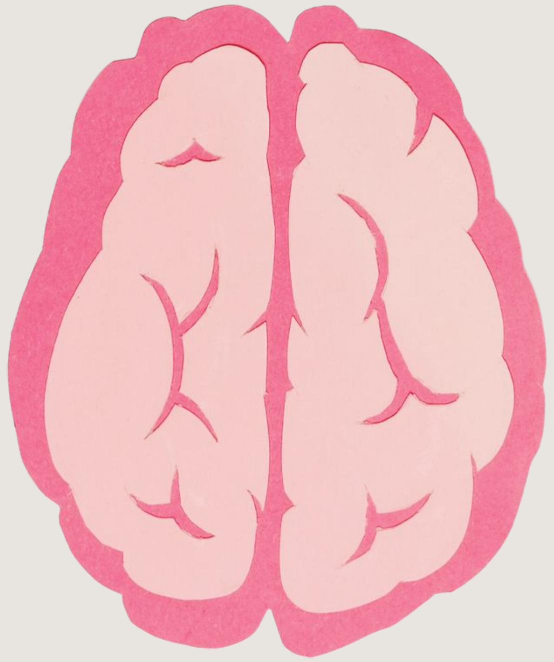
Polynomial (degree 2, C=1, γ=0.01)

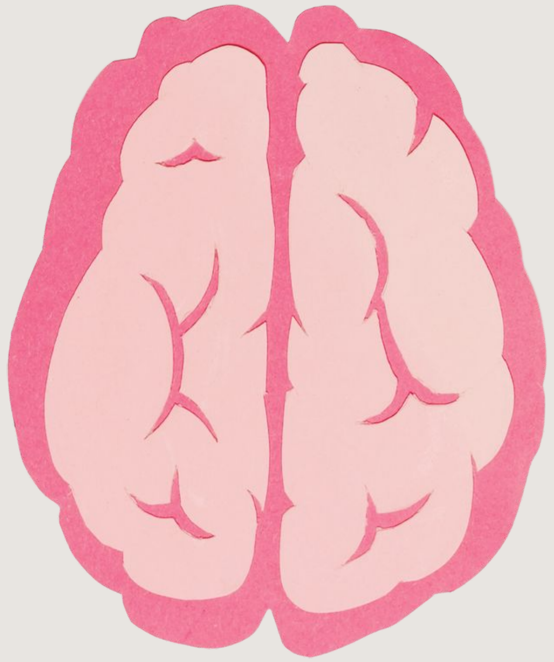
Accuracy

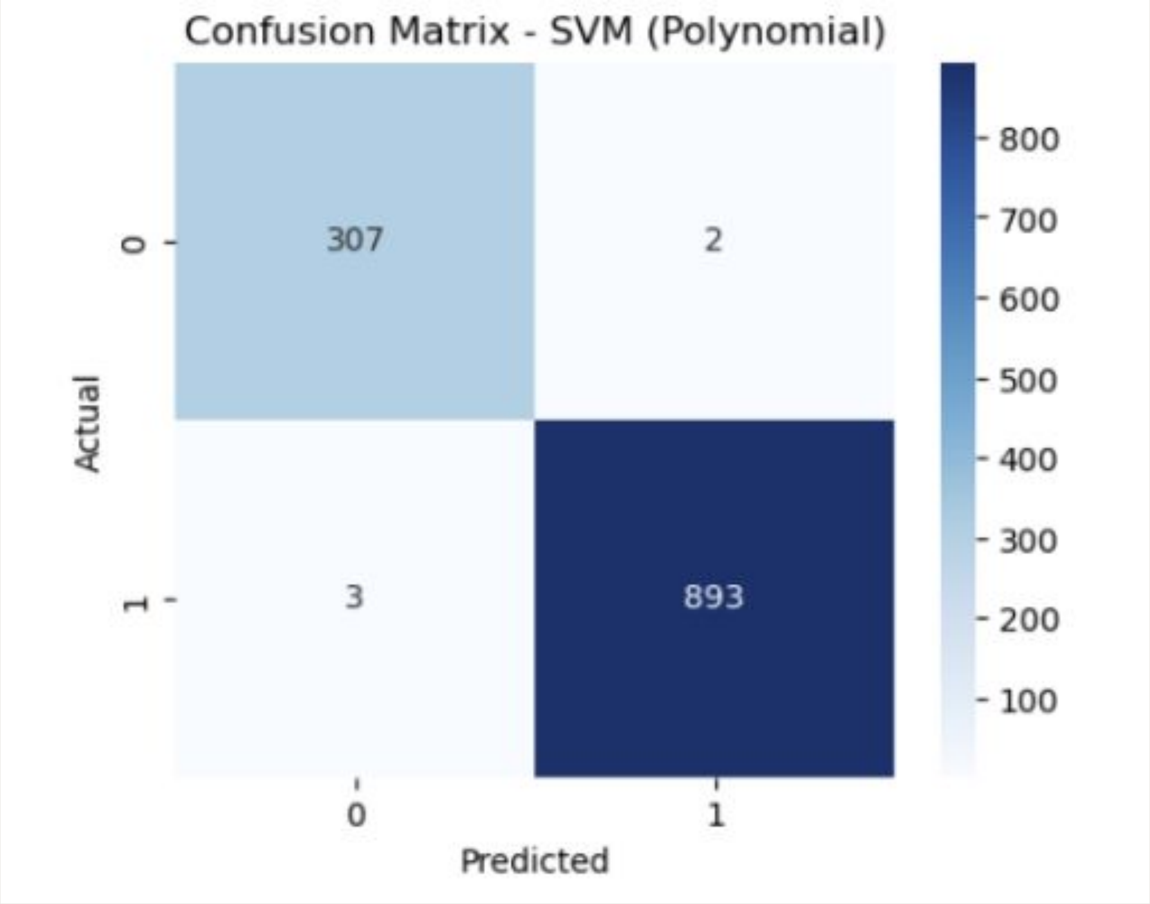
Highest: 99.59%

Strong generalization + low error rate.

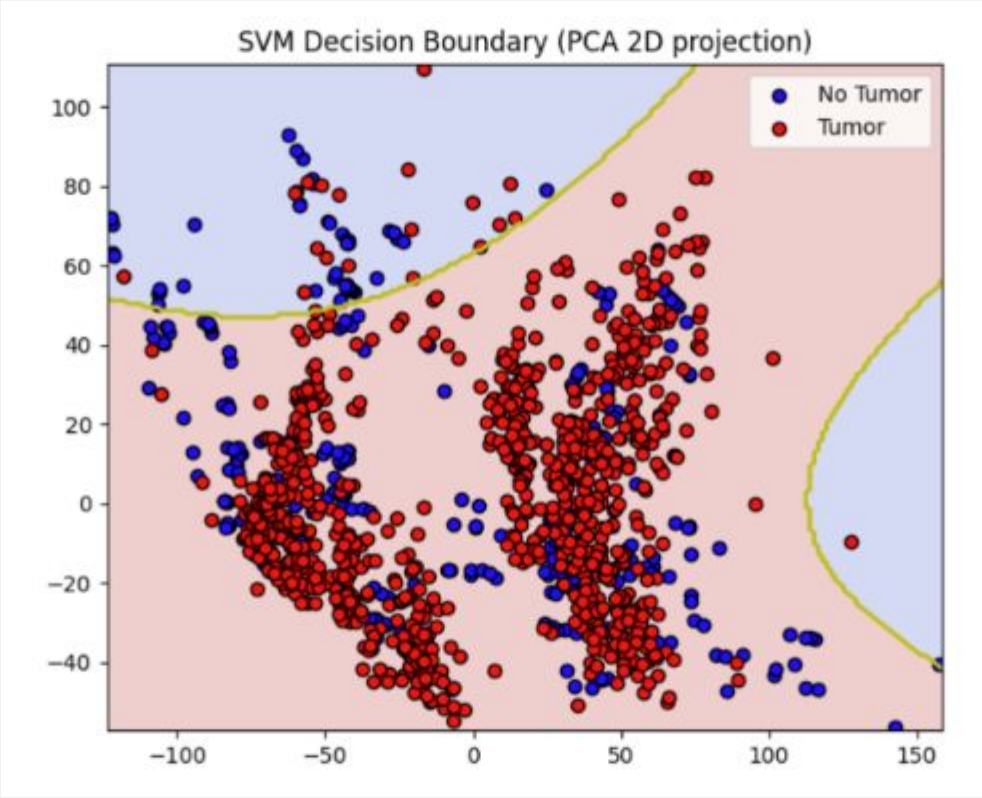




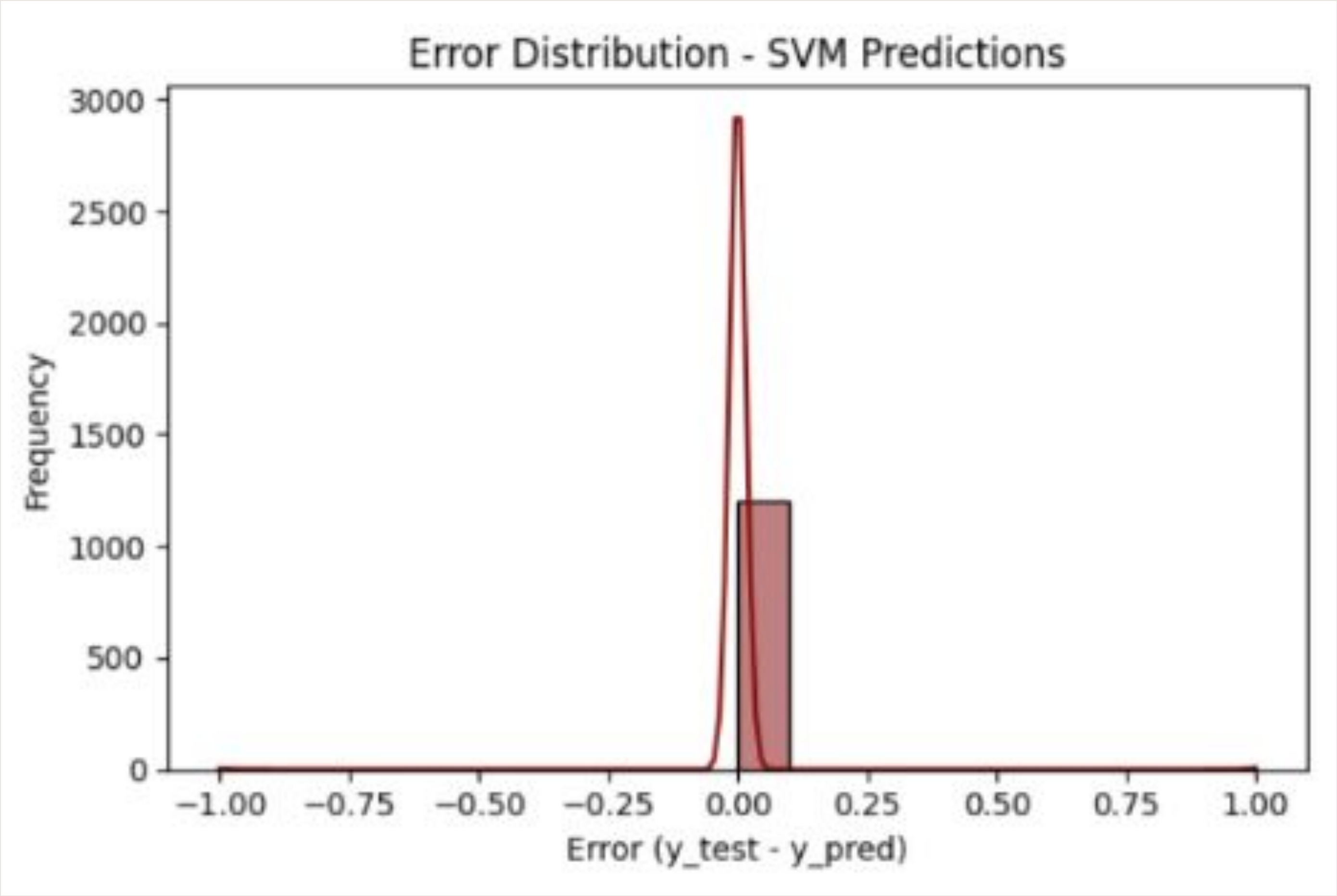




Confusion Matrix

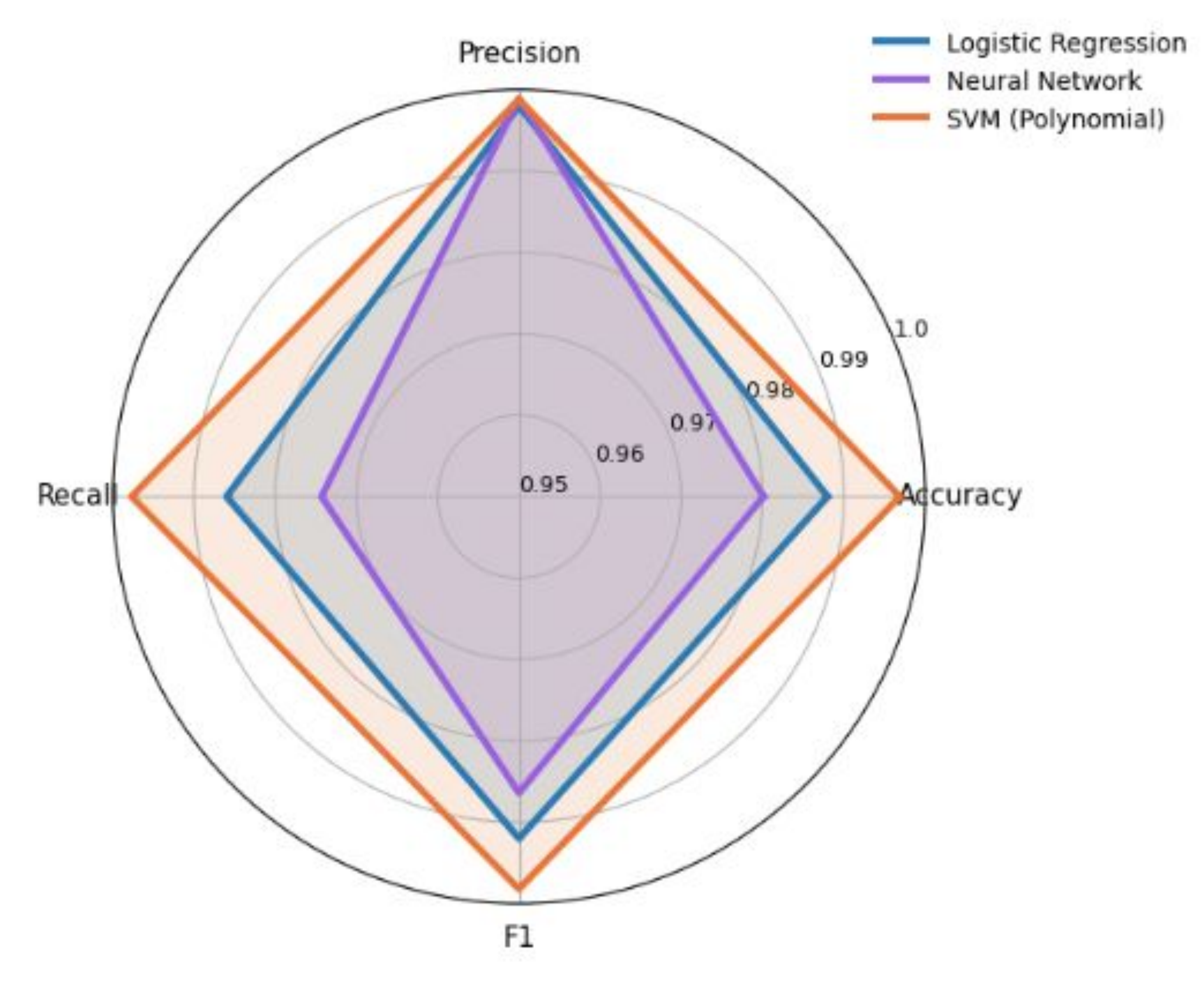


SVM Decision Boundary



Error distribution

Analysis of results



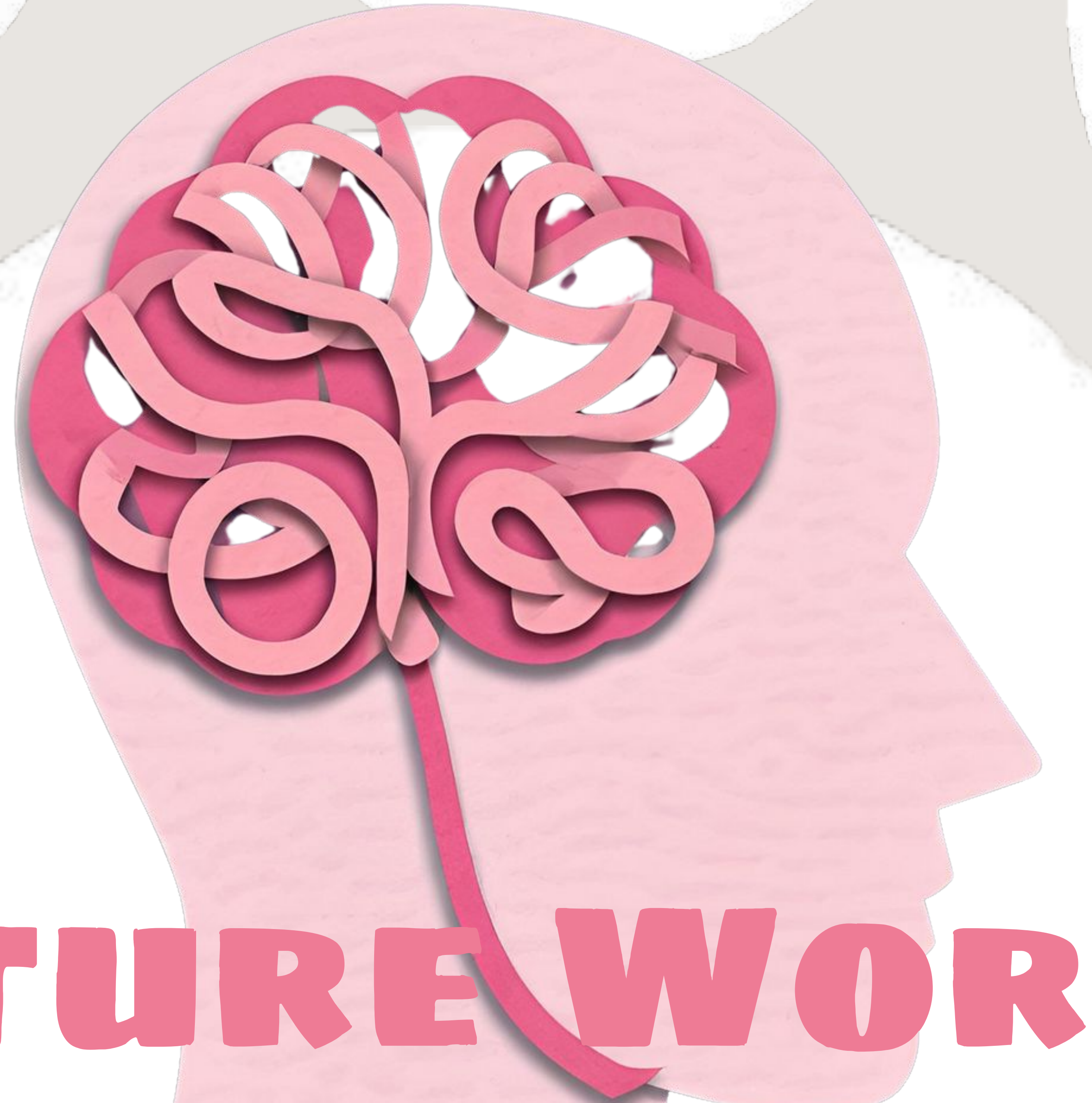
01 All models >98% accuracy

02 SVM > Logistic Regression > Neural Network

03 NN affected by overfitting (higher FN)

04 Pre-processing crucial for separability

Future Work



A

Extend to multi-class tumor identification

B

Use CNNs or transfer learning

C

Apply XAI (Grad-CAM, LIME)

D

Evaluate on multi-institution datasets

E

Improve NN regularization

WORK DIVISION

Carolina Silva	• Conclusion • Neural Network • State of the Art • Analysis of Results
Matilde Teixeira	• Introduction • Pre-processing • SVM • Logistic Regression

References

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THANKS!
QUESTIONS?