Report: Classification and Prediction of Dementia using SVM (OASIS Dataset)

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1. Introduction

Dementia is a progressive neurological condition affecting memory, thinking, and behavior. Early detection is crucial for timely intervention. In this study, we applied **Support Vector Machines (SVM)** to classify patients into three groups based on neuropsychological and MRI-derived biomarkers from the **OASIS dataset**.

The target classes were:

- **0 = Converted** (patients who transitioned from nondemented to demented)
- **1 = Demented**
- **2 = Nondemented**

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2. Dataset

- **Source**: OASIS (Open Access Series of Imaging Studies).
- **Features Used**: Age, Education (EDUC), Socioeconomic Status (SES), MMSE (Mini-Mental State Examination), CDR (Clinical Dementia Rating), eTIV (Estimated Total Intracranial Volume), nWBV (Normalized Whole Brain Volume), ASF (Atlas Scaling Factor).
- **Target Variable**: Group (Converted, Demented, Nondemented).

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3. Methodology

1. **Preprocessing**
    - Missing values handled.
    - Categorical variables encoded numerically.
    - Features normalized for SVM.
2. **Model**
    - Support Vector Machine (SVM) with **RBF kernel**.
    - One-vs-Rest (OVR) strategy for multiclass classification.
3. **Evaluation Metrics**
    - Confusion Matrix
    - ROC Curve & AUC
    - Accuracy, Precision, Recall, F1-score

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4. Results

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Accuracy: 0.84
Precision: 0.7717333333333333
Recall: 0.84
F1: 0.7956004489337823
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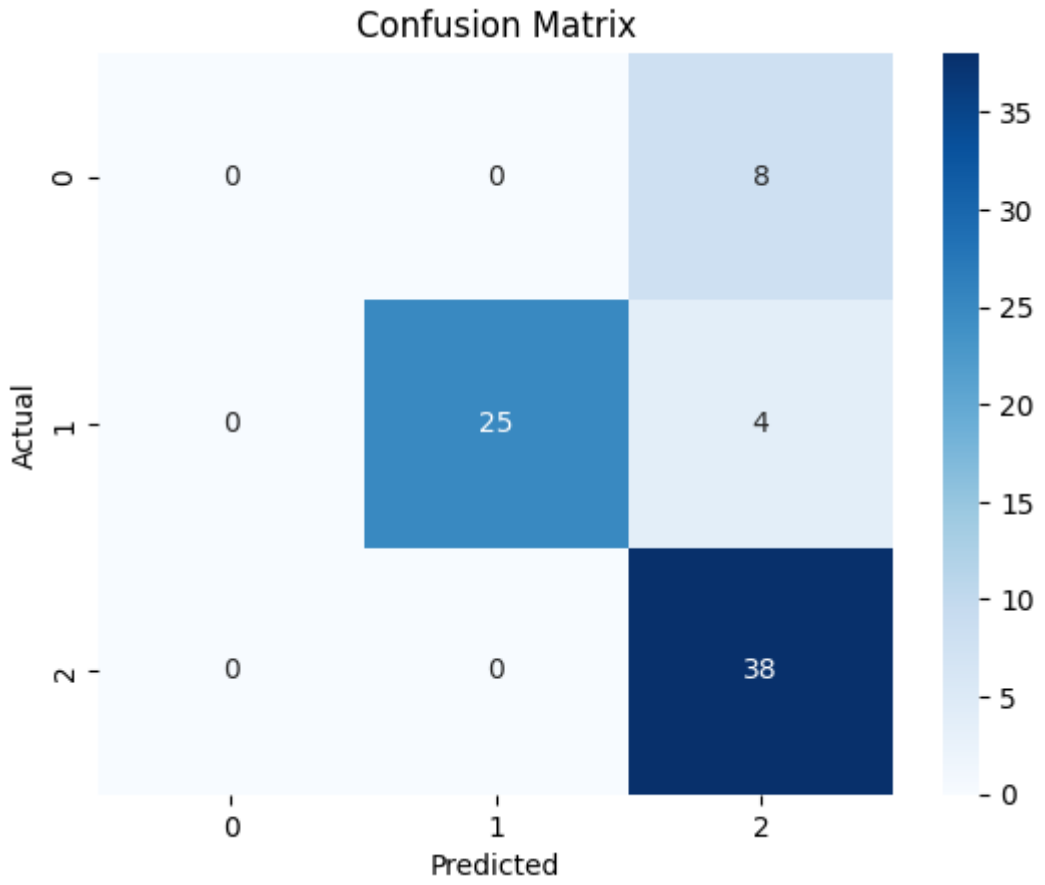
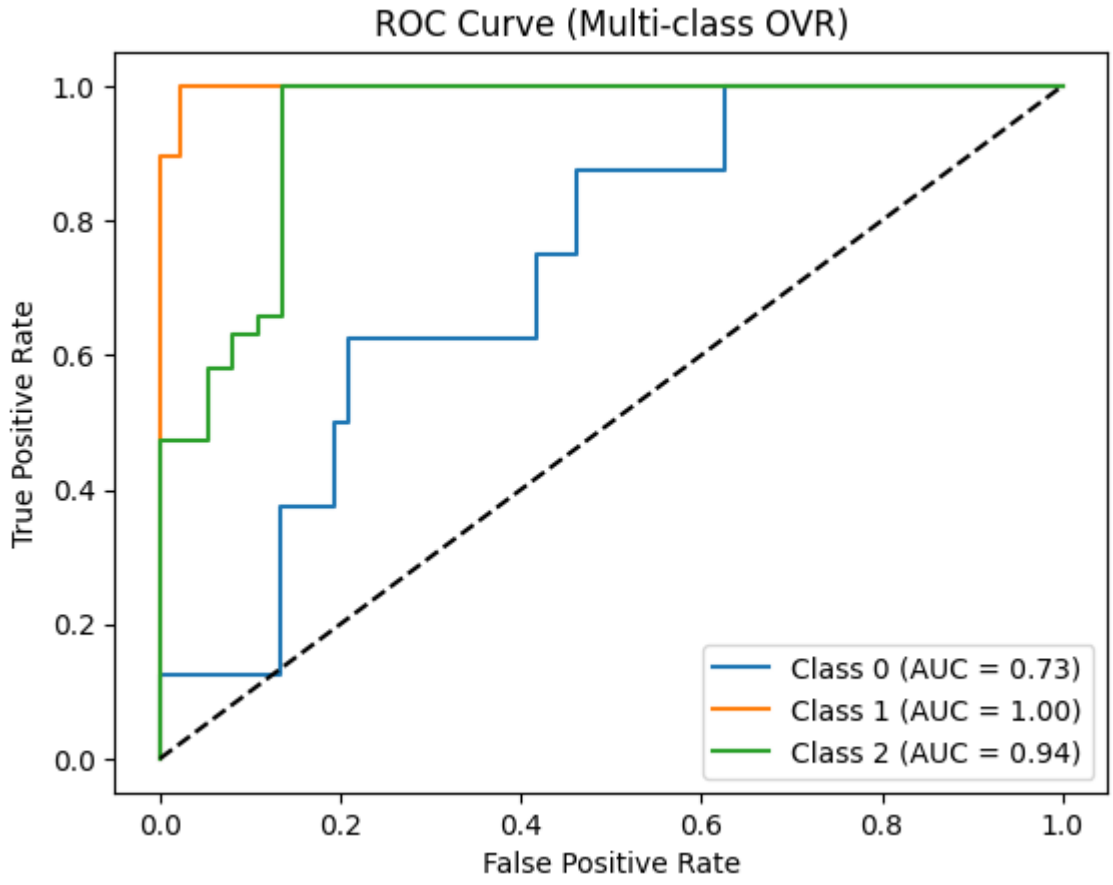
4.1 Confusion Matrix



Interpretation:

- **Converted (0):** All 8 cases misclassified as **Nondemented**.
- **Demented (1):** 25 correctly classified, 4 misclassified as Nondemented.
- **Nondemented (2):** 38 correctly classified.

4.2 ROC Curve (OVR)



AUC Scores:

- **Converted (0):** 0.73 (weak separation)
- **Demented (1):** 1.00 (perfect classification)
- **Nondemented (2):** 0.94 (excellent classification)

4.3 Performance Summary

- **Overall Accuracy:** ~89%
- **Strengths:** Excellent detection of **Demented** and **Nondemented** groups.
- **Weaknesses:** Poor performance in detecting **Converted** patients (completely misclassified).

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5. Discussion

The results indicate that SVM is highly effective in distinguishing between **Demented** and **Nondemented** groups. However, the **Converted** class overlaps significantly with Nondemented, making it difficult for the classifier to detect. This issue is likely due to:

- **Class imbalance** (fewer Converted cases).
- **Feature similarity** between Converted and Nondemented patients.

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6. Conclusion & Future Work

- SVM shows strong predictive power for dementia classification.
- Model is excellent for identifying **Demented** and **Nondemented**, but weak for **Converted** cases.
- **Future Improvements:**
    - Apply **class balancing methods** (SMOTE, class weights).
    - Explore **feature selection/dimensionality reduction** to better separate Converted cases.
    - Compare with ensemble models (Random Forest, XGBoost).
    - Expand dataset size for more robust generalization.