How You Split Matters: Data Leakage and Subject Characteristic Studies in Longitudinal Brain MRI Analysis

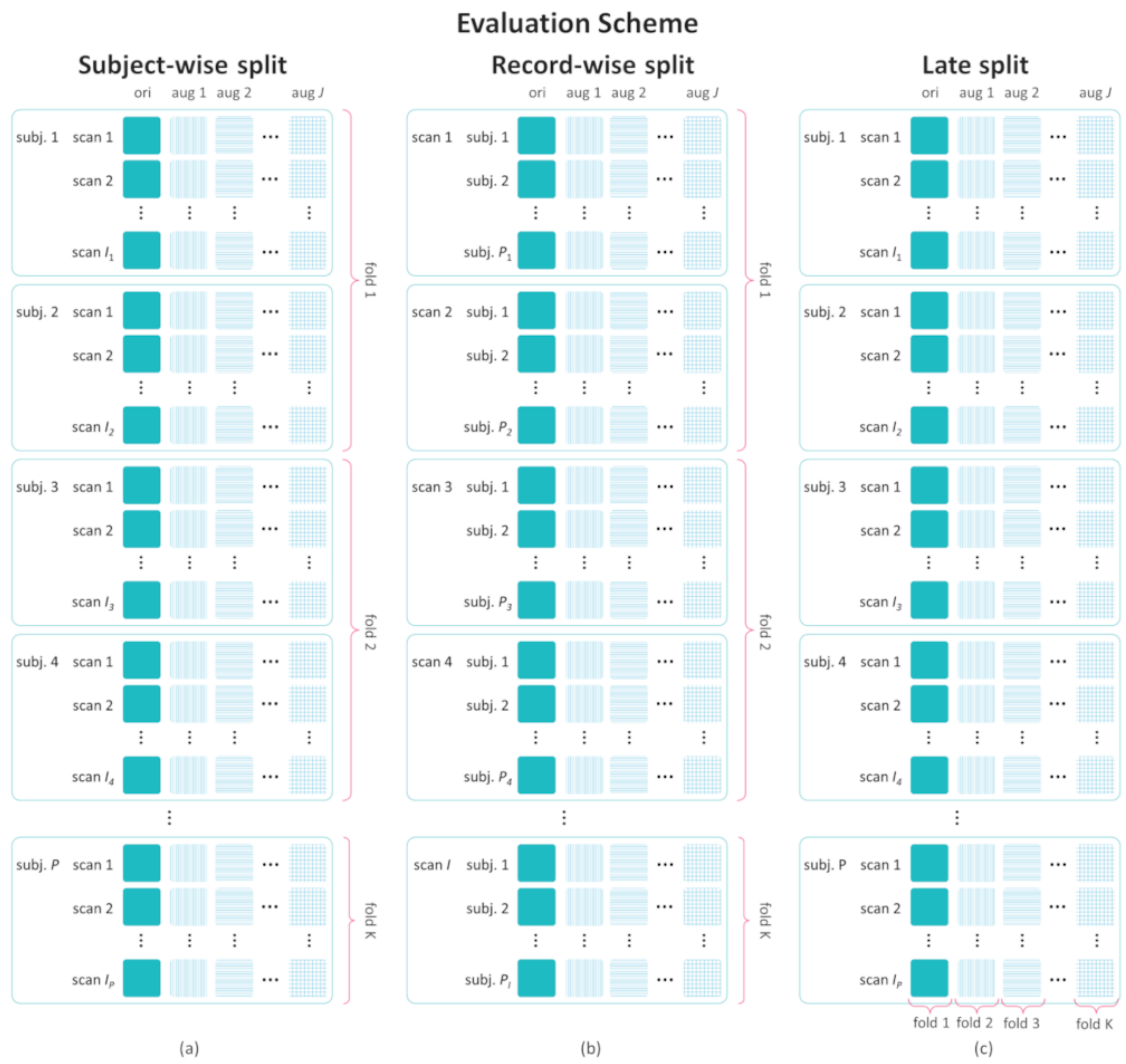
Dewinda J. Rumala

Introduction

- Longitudinal data offers critical insights into disease progression and treatment efficacy
- Improper handling of longitudinal data poses issues even in 3D-based medical image analysis
- The reliability of deep learning models can be jeopardized by biases, such as data leakage

Methods

- 3D CNN for Alzheimer's Disease (AD) diagnosis with longitudinal brain MRI data from ADNI



Discussion

- **How You Split Matters**
  The choice of data splitting strategy during CV significantly influences the performance of AI models
- **Data Leakage and Identity Confounding**
  Improper data splitting can lead to data leakage, affecting model generalization and causing identity confounding within the models
- **Shortcut Learning Revealed by GradCAM**
  GradCAM visualization highlights potential shortcut learning in models from record-wise and late splitting strategies possibly due to identity confounding
- **Validating Robustness with Subject-Wise Split**
  This study validates previous findings suggesting subject-wise split as a less data leakage-prone approach
- **Future Directions**
  Promoting Subject-Wise Split: future research should consider subject-wise split for more reliable model evaluation and development
  Investigating Data Variance and Sensitive Attributes: Further research should delve into the correlation between data splitting strategies and data variance

Data	Scheme	Acc	Prec	Rec	F1-score
Cross-Validation	Subject-wise	67.11±6.11	69.38±6.02	67.11±6.12	68.28±5.63
	Record-wise	97.33±1.86	97.54±1.66	97.33±1.86	97.34±1.85
	Late split	81.33±12.37	89.45±8.31	79.31±13.29	89.44±77.64
Hold-out	Subject-wise	42.15±5.45	38.71±7.54	42.12±5.50	38.57±4.99
	Record-wise	38.71±7.75	37.48±9.20	38.63±7.72	35.68±7.37
	Late split	40.43±8.95	37.62±13.31	40.43±8.95	39.92±4.80

Results

Data Splitting Strategy Impact

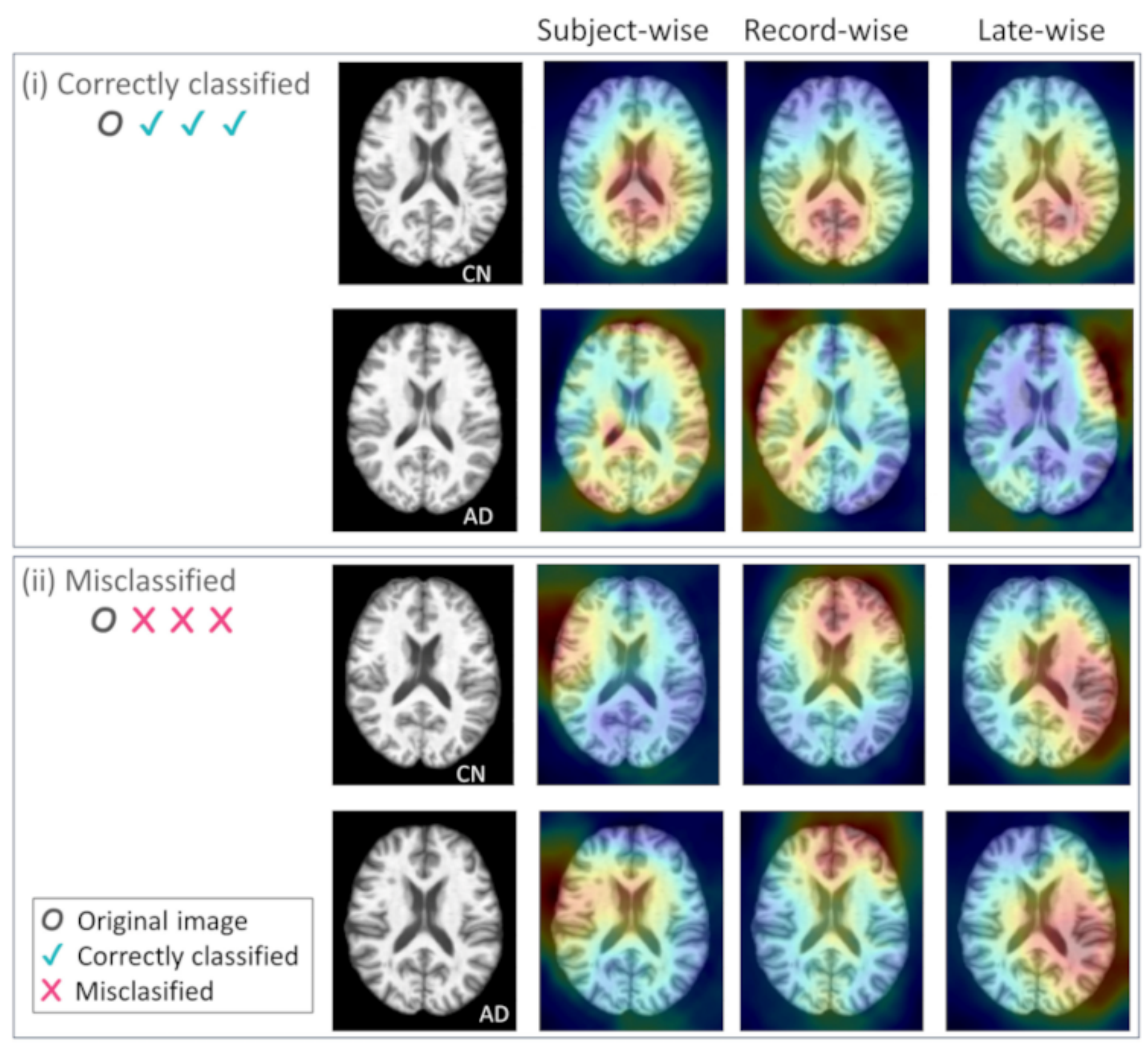
- Record-wise split excels during CV, closely followed by late split, but performs the worst on hold-out data
- Subject-wise split performs poorest during CV but generalizes best to hold-out data
- Data splitting strategy influences model performance (P=0.0389)

MRI Sequence Influence

- The choice of T1 or T2 MRI sequences has no significant impact on classification performance (P=0.7921)

Insights from GradCAM Visualization

- Shortcut learning was observed in record-wise and late splits



References

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Contact information:
dewinda.207022@mhs.its.ac.id
djrumala.github.io