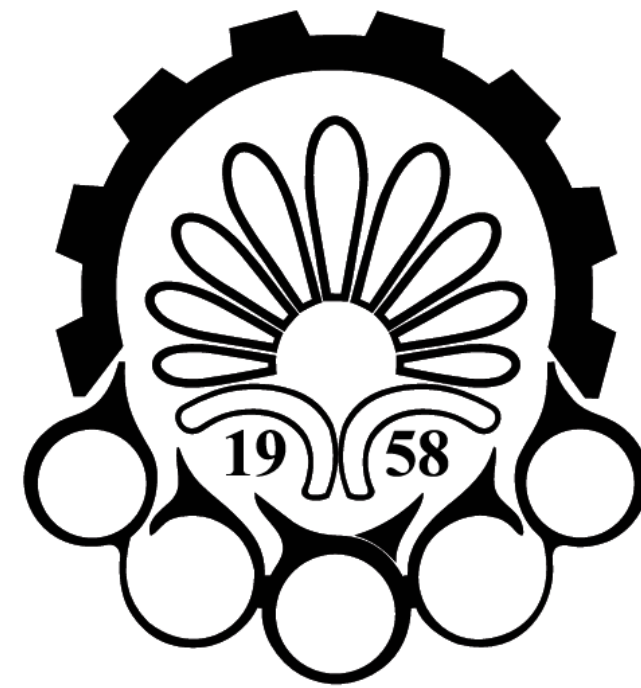


Frequency Domain Analysis Of Hippocampal MRI Using Distance Correlation For Early Alzheimer’s Disease Detection

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Key Take Way
Frequency domain analysis of hippocampal MRI significantly improves early Alzheimer’s (EMCI) detection, while distance correlation captures non-linear dependencies to achieve perfect group separation. These robust metrics establish a highly effective feature-extraction pipeline for downstream machine learning and non-invasive clinical diagnosis.

INTRODUCTION

Early detection of Alzheimer’s disease (AD) remains challenging, particularly when distinguishing early mild cognitive impairment (EMCI) from cognitively normal (CN) individuals. Because hippocampal alterations emerge early in the disease course, hippocampal MRI may provide sensitive neuroimaging biomarkers. We evaluated whether frequency-domain hippocampal features and robust dependence measures improve separation among CN, EMCI, AD .

METHODS

1.Data Extraction

ADNI

MRI data of CN, EMCI, and AD subjects were collected from the ADNI database

2.Preprocessing

3D Slicer

Images were denoised and intensity-normalized to reduce noise and subject variability

3.Registration

Images were registered to the MNI152 standard atlas for spatial alignment

4.Segmentation

Brain regions of interest were segmented for further analysis

5.Fourier Transform

python

Transformed images to the frequency domain using Fourier transform

6.Similarity Measurement

Four types of correlation were used to evaluate the similarity between the images and the atlas in both spatial and frequency domains.

7.Result Analysis

Results showed high effectiveness of the method in distinguishing EMCI from CN in the frequency domain

A

B

RESULT

Frequency-domain similarities between EMCI and AD groups reveal early textural alterations as potent AD biomarkers.

Figure 2. Spatial frequency power spectra across clinical groups

Frequency domain improves group separation across all metrics. Distance Correlation proves superior, achieving 95% confidence in the frequency domain with perfect diagnostic classification.

Figure 3. Graph comparing non-overlapping confidence levels for Pearson, Spearman, Kendall, and distance correlations.

CONCLUSIONS

- Superiority of Frequency Domain** : Frequency-domain features consistently outperform spatial analysis, offering higher stability (lower standard deviation) and enhanced sensitivity to subtle hippocampal neurodegeneration.
- Breakthrough Metric**: Distance Correlation is the first metric to achieve perfect diagnostic separation across all groups, establishing it as the most robust pipeline for early Alzheimer’s detection.
- Clinical Impact**: The high precision of frequency-domain features effectively resolves the classification ambiguity typically seen in the EMCI group, making it a reliable biomarker for early disease progression.

Performance	Confidence Level(%)	Domain	method
Several overlaps	60	Image	Pearson
Moderate separation	75	FFT	
Moderate separation	70	Image	Spearman
Good separation	90	FFT	
Moderate separation	75	Image	Kendal
Good separation	85	FFT	
Complete separation	75	Image	Distance
Complete separation	95	FFT	

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