Early Stage Analysis of Alzheimer's Disease Using Fractal Dimension Calculations

Karaarslan, Eylem (School: Kartal Prof. Dr Saban Teoman Durali Bilim Ve Sanat Merkezi)

Early-stage identification of Alzheimer's disease is regarded as a critical factor for effective disease and intervention management. Structural changes of the brain are difficult to quantify through visual inspection of MRI images. Fractal dimension is a mathematical measure used to quantify geometric complexity across multiple spatial scales. Early detection of Alzheimer’s disease has primarily been investigated using electrophysiological signals such as EEG, along with clinical evaluations. In this study, a novel intensity-aware reformulation of the classical box-counting method aimed to combine grayscale pixel values with fractal dimension calculation. The proposed method demonstrates stage-dependent variations in early stages, which provides a mathematical and systematic diagnostic process with a higher accuracy rate. The novel method is implemented as a MATLAB-based algorithm. A total of 100 MRI images, with 20 images representing each Alzheimer's stage, are processed using the algorithm. The resulting fractal dimension values are analyzed statistically to identify stage-dependent variations and to determine the inequations among stages. The derived inequations are integrated into the algorithmic decision framework. When an MRI image is provided as input, the algorithm is designed to estimate the most probable Alzheimer's stage for the given image. Overall, this research introduces a novel and quantitative fractal dimension calculation method grounded for medical usage. The findings indicate that the proposed approach is capable of capturing subtle changes associated with neurodegeneration, particularly at early stages.

Awards Won: