The diagnosis of Parkinson’s disease (PD) at early stages is crucial for management and treatment to be worthwhile. It is a difficult problem, since the early signs and symptoms are subtle for discrimination, and often fuzzy. Further, the golden standard for current clinical diagnosis of PD is anchored to classic symptoms, which appear in a patient when dopaminergic neuronal degeneration has reached 60%. Furthermore, various non-motor symptoms accompany these classic motor symptoms, with some of them appearing years before the cardinal signs do. Further complications arise due to overlapping symptoms from other disorders. The only sure-shot clinical diagnosis is possible during autopsy, which necessitates other reliable diagnosing mechanisms. In this thesis, we propose new features and methodologies to recognize early PD and to model their progression. The first two parts are based on shape-based features; the third involves detection of ‘probable PD’ cases using patient questionnaires, while the fourth is a statistical modeling of striatal degeneration.

**Shape Characterization Using SPECT Based Radial and Gradient Features.** We identify easy-to-compute features which characterize striatal shape. We combine these with striatal binding ratios, both sets of features identified from SPECT scans. We propose a scheme which employs feature selection to reduce redundancy and pick the most relevant features to be used for performing Early PD-vs-Normal and Early PD-vs-SWEDD classification, using machine learning tools. The radial and gradient features proposed are simple and computationally light, and they show high accuracy for both Early PD-vs-Normal and Early PD-vs-SWEDD.

**Shape Based Features Derived from Parametric Eigenspace.** This framework presents a stable and accurate representation of striatal shape and size change, using a parametric eigenspace. These features are then integrated with striatal binding ratios to perform Early PD-vs-Normal and Early PD-vs-SWEDD classification. The features used in this scheme are obtained from active contours and are affine invariant and further, are mapped to an eigenspace to obtain a completely decorrelated feature set. The performance measures of the classifiers are appreciably high and should aid clinicians in early detection of the disease.

**The Prodromal Phase as a Possible Indicator for Detection of Early PD.** A model capable of identifying ‘probable PD’ cases is suggested. PD has its clinical diagnosis dependent on the presence of clinical features such as bradykinesia, tremor, rigidity, or postural instability. There is evidence of neuropathological, clinical and imaging features, in evincing the onset of PD pathology, preceding its manifestation. This PD latent phase is of particular importance for neuroprotective or disease altering
therapies. This chapter proposes a computer aided detection framework for classifying prodromal and healthy normals. The features include MDS-UPDRS part 1 and 2 evaluations, combined with Epworth Sleepiness Scale (ESS) values and Rapid Eye Movement (REM) sleep Behaviour Disorder (RBD) screening questionnaire values. Support Vector Machine (SVM), Linear Discriminant Analysis (LDA), RUSBoost and Logistic Regression are employed for the classification stage. Encouraging results with these features can reliably assist medical community and provide better management of the disease.

**Striatal Shape Change Modeling over Temporal Data of PD Patients.** This scheme proposes a temporal model of the striatal shape change in time, over three stages of PD. These prognostic models aid in designing clinical trials and in research for disease management. This study involves longitudinal SPECT data of subjects acquired from the PPMI. The dataset consists of SPECT scans taken at 3-time intervals: screening-stage 1, 12 months after screening-stage 2 and at 24 months after screening-stage 3. The shape changes of striata are analyzed in shape space and modeled with a closed form equation for both striata. Further, the discernment between different stages has been carried out using nearest neighbor classifiers. The accuracy obtained is appreciable considering there is a large overlap between stage 2 and stage 3 (as the rate of change reduces with time).