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**Cerebellar Structure Segmentation and Shape Analysis
with Application to Cerebellar Ataxia**

Dissertation Defense by
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Abstract

The cerebellum plays an important role in motor control and cognitive functions. Cerebellar dysfunction can lead to a wide range of movement disorders. Despite the significant impact on the lives of patients, the current standard of diagnosis, prognosis, and treatment for cerebellar disease is limited. Magnetic resonance imaging (MRI) based morphometric analysis of the cerebellum, which studies the brain structural pattern associated with disease and functional decline, is of great interest and importance. It sets the stage for developing disease-modifying therapies, monitoring individual patient progress, and designing efficient therapeutic trials. Compared to the cerebrum, morphometric analysis in the cerebellum has been limited. Automated and accurate volumetric analysis techniques are lacking. Methods using MR based morphometric biomarkers to predict disease type and functional decline have been lacking or inconclusive. The work presented in this thesis is motivated by the need for better cerebellar structure segmentation and effective structure-function correlation and prediction methods in cerebellar disease.

The thesis makes four major contributions: 1) we proposed an automated method for segmenting cerebellar lobules from MR images. The proposed method achieved better performance than two state-of-the-art segmentation methods when validated on a cohort of 15 subjects including both healthy controls and patients with various degrees of cerebellar atrophy; 2) we presented two highly-informative shape representations to characterize cerebellar structures: a landmark shape representation of the collection of cerebellar lobules and a level set based whole cerebellar shape representation; 3) we developed an analysis pipeline to classify healthy controls and different ataxia types and to visualize disease specific cerebellar atrophy patterns based on the proposed shape representations and high-dimensional pattern classification methods. The classification performance is evaluated on a cohort consisting of healthy controls and different cerebellar ataxia types. The visualized cerebellar atrophy patterns are consistent with the regional volume decreases observed in previous studies in cerebellar ataxia. Compared to existing analysis method, the proposed method provides intuitive and detailed visualization of the differences of overall size and shape of the cerebellum, as well as that of individual lobules; 4) we also developed and tested a similar analysis pipeline for functional score prediction and function specific cerebellar atrophy pattern visualization.

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