4D Software Tools for Longitudinal Prediction of Brain Disease

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Principal Investigators

SHEN, DINGGANG

Institution

UNIV OF NORTH CAROLINA CHAPEL HILL

Contact information of lead PI
Country

USA

Title of project or programme

4D Software Tools for Longitudinal Prediction of Brain Disease

Source of funding information

NIH (NIA)

Total sum awarded (Euro)

€ 1,680,780.73

Start date of award

01/04/2008

Total duration of award in years

2

The project/programme is most relevant to:

Alzheimer's disease & other dementias

Keywords

4D Imaging, Software Tools, Brain Diseases, Atlases, imaging biomarker

Research Abstract

DESCRIPTION (provided by applicant): Neuroimaging allows safe, non-invasive measurement of brain structures and functions and their changes over time. This has led to many longitudinal studies to discover imaging biomarkers for better prediction of brain disorders. However, the

associated longitudinal changes are often tiny within a short follow-up time, and are thus difficult to detect by conventional methods since the measurement errors could be larger than the actual changes. Also, with the significant increase of data with longitudinal follow-ups, it becomes challenging to capture a small set of effective imaging biomarkers from large data for accurate disease prediction. This issue becomes even more critical when there is missing data in the longitudinal study, which is unavoidable in clinical application. The goal of this renewal project is to create a set of innovative 4D software tools that are dedicated to more effective early diagnosis and prediction of brain disorders with longitudinal data. These tools wil allow elucidating subtle abnormal changes that would be otherwise left undetected with existing tools. Specifically, in Aim 1, we will create a novel multi-atlas guided 4D brain labelling method for consistent and accurate labeling of Regions of Interest (ROIs) across longitudinal images (4D image) of the same subject. All longitudinal images of each subject will be first aligned by a novel groupwise 4D registration algorithm that can more accurately estimate longitudinal deformations. Then, these aligned longitudinal images can be further registered with multiple atlases guided by a graph that locally connects all (subject and atlas) images, thus obtaining more accurate/consistent registration and ROI labeling for the longitudinal images of same subject. In Aim 2, we will further create a multimodal, sparse longitudinal prediction model to effectively integrate serial imaging and non-imaging biomarkers for early diagnosis and prediction of brain status. Also, to further extract effective biomarkers, a new machine learning technique, called deep learning, will be adapted to learn high-level features for helping prediction with a novel temporally-constrained group sparse learning method, which is able to predict clinical scores consistently for future time-points. Finally, in Aim 3, we will create nove methods to deal with missing data in longitudinal study, which is unavoidable in clinical application. In particular, we will first develop several data completion methods (including matrix completion) to complete the missing data. Then, instead of designing a single predictor that may be limited, we will design multiple diverse predictors (by multi-task learning) for ensemble prediction, thus significantly increasing the overall prediction performance. Also, considering that the individual’s future images are not available at early time-points, to improve the clinical utility of the proposed methods, we will apply our models to various cases with different numbers of longitudinal images and then further train them jointly to achieve the overall best performance. Note that the performance of all proposed methods will be evaluated in this project for Alzheimer’s Disease (AD) study, although they are also applicable to studies of other brain disorders.

Lay Summary

PUBLIC HEALTH RELEVANCE: This project aims to create a set of innovative 4D software tools that are dedicated to more effective early diagnosis and prediction of brain disorders with longitudinal data. To achieve this goal, we will create 1) a novel multi-atlases guided 4D brain labelling framework for consistent and accurate labeling of Regions of Interest (ROIs) across the longitudinal images (4D image) of the same subject by harnessing the manifold of anatomical variation of 4D image and the atlases, 2) a multimodal, sparse longitudinal prediction model that will automatically learn the relevant information from imaging and non-imaging data of past time-points to predict future status of brain, and 3) novel methods for missing data completion and then multiple diverse predictors for ensemble prediction. We will also make these methods practical for clinical diagnostics setting. Finally, we will package all our methods into a softwar tool and release it publicly, as we have done before. The methods that we will develop can find their applications not only in Alzheimer’s Disease (AD) that will be used as example in this

project, but also in other fields such as longitudinal monitoring of other neurological diseases (i.e., schizophrenia) and measuring the effects of different pharmacological interventions on the brain.

Further information available at:

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Investments > €500k

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United States of America

Diseases:
Alzheimer's disease & other dementias

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2016

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N/A

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