Introduction
Ventricular changes are associated with a variety of human diseases such as HIV/AIDS, hydrocephalus, vascular dementia, diabetes mellitus, drug addiction, and Alzheimer’s disease (AD). Currently available automated ventricular segmentation programs have been of limited use for surface-based ventricular morphometry. In this study, we present a novel automated atlas-based ventricular segmentation algorithm that reduces both the computational time and expertise required for manual segmentation. The combined holomorphic 1-form based surface analysis and this newly introduced procedure constitutes a complete automated ventricular morphometry system for structural MRI analysis. In the current research, we set out to apply our software to Alzheimer’s disease imaging research.

Methods
1. The T1-weighted MR images of all the subjects were first linearly registered to MNI space using FSL/FLIRT.
2. Voxel-based morphometry processing (VBM) in SPM8 toolbox was used to automatically segment each aligned T1 image to three tissue classes (GM, WM and CSF).
3. After warping the CSF probabilistic mask to the binary mask, we applied the geodesic shooting (GS) to merge all CSF masks to create a group averaged atlas in which the nonlinear deformation for each CSF mask was estimated.
4. The ALVIN (Automatic Lateral Ventricle delineation) ventricle binary mask were applied to exclude CSF that is outside the lateral ventricles.
5. Warping back the group average ventricular atlas by referring the nonlinear deformation estimated in the GS registration.

6. Using a topology-preserving level set method to build a surface mesh from the binary ventricular mask.
7. The conformal grids of each ventricular surface were generated and further segment the ventricle into three parts based on its zero point on the surface.
8. After surface registration on each part, we merged them together for the extraction of surface features such as multivariate tensor-based morphometry (mTBM) and radial distance at each surface point.

Experiments
149 normal subjects from Arizona APOE cohort were included in this study including 70 e4 non-carriers (e3/e3), 46 APOE e4 heterozygotes (e3/e4) and 33 APOE e4 homozygotes (e4/e4). The results of atlas-based segmentation of lateral ventricle showed consistency and stability among all the subjects that anatomical characteristics were clearly depicted on three ventricular horns.

Discussion
In this study, by combining a new atlas-based segmentation algorithm with our prior surface-based holomorphic 1-forms work, we develop an automatic surface-based ventricular morphometry pipeline. When applying to a large normal database, it worked efficiently and precisely on construction of the lateral ventricular surface. Our work may provide a convenient tool to study the genetic influence of APOE e4 in a preclinical population.

References