Deep Learning for Classifying Heavy Drinkers from Normal Controls

Team Member: Chuanqi Chen
Sponsor: Qingyu Zhao
Mentor: Ahmadreza Momeni

Problems

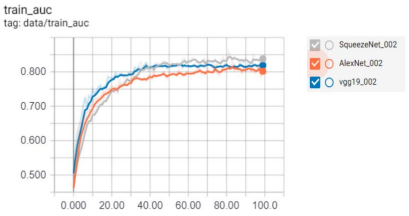
- The human brain always changes through the life span, but the critical development is after birth throughout adolescence and into young adulthood. There is speculation that adolescent brain is especially vulnerable to environmental insult such as heavy alcohol drinking.
- One of our goals in this project is then to test whether neural-network-based methods can reasonably classify heavy drinkers versus normal adolescents based on their brain structural data. From the classification, we also want to identify patterns of the brain that show difference across groups, and we want to see if these patterns agree with existing evidences in the literature.

Dataset

- National Consortium on Alcohol and NeuroDevelopment in Adolescence (NCANDA) magnetic resonance imaging (MRI) data, acquired in 674 adolescents meeting no/low alcohol or drug use criteria and 134 adolescents exceeding criteria
- MRI Data for each subject: 224x224x150, i.e. 150 slices of 224x224 image data
- Preprocessing of MRI data was performed via the Biomedical Informatics Technology for Imaging Studies procedure, which included denoising, bias field correction, and skull stripping by voting. The preprocessed images were then non-rigidly [affinely] registered to the sri24 atlas (Rohlfing et al. 2010).
- The registered images were then downsampled to 2mm spatial resolution

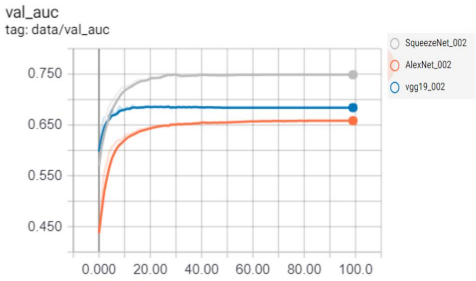
Models

- Pretrained Model
  - SqueezeNet
  - AlexNet
  - VGG19
- Dropout
- AdaptiveAvgPool2d
- Linear Classifier



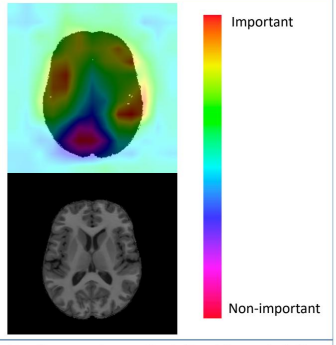
Results

- No prior art of applying deep learning algorithms, so our target is to achieve prediction accuracy rejecting null-hypothesis (significantly better than chance by Fisher exact test)
- Train/Validation/Test:
  - 70%: 15% : 15%
- Validation Results
- Test Set Results
  - SqueezeNet: 74.87%
  - AlexNet: 65.85%
  - Vgg19: 68.4%



Discussion

- Pre-trained Model SqueezeNet performs the best
- Pre-trained model Vgg19 is the second best due to limited dataset of 808 MRI images. It might be a good candidate model as we gather more images in the future.
- Heatmap indicates importance of different brain regions in classifying the heavy drinkers vs normal controls. This result is convergent with existing literatures in the brain regions that are more vulnerable to heavy drinking during adolescence. E.g., frontal and temporal lobes are more impacted than occipital lobe.



Future and Reference

- Biologically we may often see bilateral (symmetric) effects; that is, if one region on the left got impacted, then the symmetric region on the right should probably be impacted too. The above heatmap is somewhat symmetric but not exactly, so further investigation and interpretation are needed.

- Reference
- Adolf Pfefferbaum, Torsten Rohlfing, Kilian M. Pohl, Barton Lane, Weiwei Chu, etc.: Adolescent Development of Cortical and White Matter Structure in the NCANDA Sample: Role of Sex, Ethnicity, Puberty, and Alcohol Drinking. Cerebral Cortex, October 2016;26: 4101–4121
- Sang Hyun Park, Yong Zhang, Dongjin Kwon, Qingyu Zhao, etc.: Alcohol use effects on adolescent brain development revealed by simultaneously removing confounding factors, identifying morphometric patterns, and classifying individuals. https://www.nature.com/srep/