Alzheimer's Analysis with Convolutional Neural Network

Marcia Hon

Dr. Naimul Khan

Literature Review and Exploratory Data Analysis

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Literature Review (15 References)

Articles

Many previous works have used deep learning on images to perform Alzheimer's detection. [1] Uses 3D CNN to perform Alzheimer's classification. This is beyond the objective of this MRP. In this MRP only CNN will be used and not 3D CNN. [2] is educational in regards to understanding Alzheimer's in a statistical sense rather than neural imaging with deep neural networks. [4] Studies models of how the brain's visual cortex works in order to replicate the abilities of the brain in machines. [7] Gives a good background on what is Alzheimer's. It also explores and describes the different types of machine learning that may be used for classification. The surprising conclusion is that decision trees are better models than neural networks. [8] Uses deep convolution in both supervised and unsupervised settings with data from ADNI without manual labelling of ROI (regions of interest). They achieved accuracies of 97.18% (AD) and 93.21% (MCI). [10] Introduces CNN concepts such as stochastic gradient descent, error back propagation, convolution layer, and pooling layer. [12] Is a medical article that details scientifically what is Alzheimer's. It is important to know that Alzheimer's is a growing disease which by 2030 would affect 65 million Americans. [15] This article tries to understand why convolutional networks are winning year-after-year the ImageNet competition. [16] Uses two CNN models: Conv-Pool-FC and all convolutional network. In addition, saliency maps and data augmentation were used without significant improvement to classification. [20] Used Alzheimer's classification using CNN. They adopted LeNet and GoogleNet which successfully predicted Alzheimer's. [21] Uses state-of-the-art deep learning-based pipelines to distinguish Alzheimer's in MRI and fMRI using GPU-based high performance computer platforms. [22] Details what Alzheimer's is on a cellular/biological level. This is important in order to understand what the Alzheimer's MRI images are like. [23] Alzheimer's classification using AlexNet (with TensorFlow) and ADNI is used. Many important components of the MRP will use this article. [24] Explains the mathematics of CNNs, specifically: Convolution, Pooling, and Transposed Arithmetic. [25] Explains the importance and the revolutionary nature of Deep Learning by describing breakthroughs in processing images, video, speech, and audio.

Competitions (5 References)

Yearly, IMAGENET Large Scale Visual Recognition Challenge (ILSVRC), does a competition to test what Neural Network is best able to recognize images. ImageNet provides over ten millions URLs of images in order to train a Neural Network. Year after year, Convolutional Neural Networks are the infrastructures that have won this competition.

I am going to build my project based on these infrastructures that have won this competition. The difference, is that I will remove the last full-connected layers and then retrain my Convolutional Neural Network with Alzheimer's MRI information. The theoretical understanding is that humans first learn to recognize every day things and only after are we able to recognize neural images.

[6], [11], [13], [14], [26] are from the teams that won the competition. In these articles, they describe how they built and trained their networks along with how successful they were. These are to be carefully studied and adopted into the MRP.

Textbooks (6 References)

To get a better theoretical and mathematical understanding of Convolutional Neural Networks, several textbooks were consulted. [2] Gives a thorough mathematical and theoretical understanding of Machine Learning. [5] Is a classic textbook on Machine Learning that II am actively reading to gain better understanding. [9] Describes the history and resulting application of Neural Networks and also provides a mathematical foundation. [17] Details "TensorFlow" which is a Machine Learning Python library created by Google. It is used in abundance and therefore it is a very important tool to learn and use. I plan to use this tool in my project. Both [18] and [19] give solid foundations in Linear Algebra and Calculus necessary to understand Neural Networks.

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Exploratory Data Analysis

Data is obtained from http://www.oasis-brains.org . The Open Access Series of Imaging Studies (OASIS) is a project to make neural MRI data freely available [c]. Accordingly, they hope to accelerate discoveries in neuroscience. OASIS is a product of Washington University Alzheimer's Disease Research Center, Dr. Randy Buckner at the Howard Hughes Medical Institute (HHMI) at Harvard University, the Neuroinformatics Research Group (NRG) at Washington University School of Medicine, and the Biomedical Informatics Research Network (BIRN). This server consists of two projects:

1. OASIS: Cross-sectional MRI Data in Young, Middle Aged, Nondemented and Demented Older Adults
2. OASIS: Longitudinal MRI Data in Nondemented and Demented Older Adults

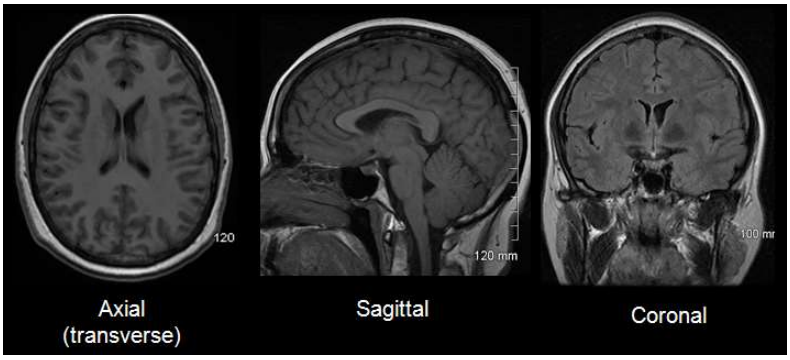
This project uses data from choice (1). The reasoning is that it has almost 3 times more data than (2), 416 compared with 150. The population for this data are subjects aged 18 to 96 who are both men and women and are all right-handed. Additionally, 100 of subjects aged over 60, have been clinically diagnosed with very mild to moderate Alzheimer's disease. The total data size is 50 GB uncompressed. The following is descriptive statistics of the data divided by Age Groups and Dementia [c]. Clearly, we see that Alzheimer's is absent for those bellows 60s as is expected.

		Non-Demented				Demented				
Age Group	N	N	Mean	Male	Female	N	Mean	Male	Female	CDR 0.5/1/2
<20	19	19	18.53	10	9	0		0	0	0/0/0
20s	119	119	22.82	51	68	0		0	0	0/0/0
30s	16	16	33.38	11	5	0		0	0	0/0/0
40s	31	31	45.58	10	21	0		0	0	0/0/0
50s	33	33	54.36	11	22	0		0	0	0/0/0
60s	40	25	64.88	7	18	15	66.13	6	9	12/3/0
70s	83	35	73.37	10	25	48	74.42	20	28	32/15/1
80s	62	30	84.07	8	22	32	82.88	13	19	22/9/1
>=90	13	8	91.00	1	7	5	92.00	2	3	4/1/0
Total	416	316		119	197	100		41	59	70.28.2

To simply imaging data for this project, only the middle images for Axial (Transverse), Sagittal, and Coronal axis were selected. The location is at: OAS1_####_MR1\PROCESSED\MPRAGE\T88_111. And these GIF images have the following naming convention:

1. OAS1_####_MR1_mpr_n4_anon_111_t88_gfc_tra_90 (Transverse)
2. OAS1_####_MR1_mpr_n4_anon_111_t88_gfc_sag_95 (Sagittal)
3. OAS1_####_MR1_mpr_n4_anon_111_t88_gfc_cor_110 (Coronal)

Each patient, has all three images. The following is an image that visually presents the meaning of the different axis.



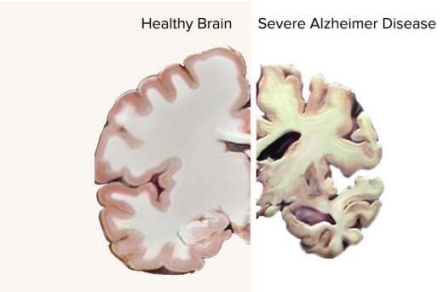
For this project, all images are used (all three axis) for a total of 705 images. Even images belonging to the same patient are considered individually as the purpose is to increase the training and test sets. There is no negative consequence as the images can be considered on their own.

The objective of this project is for Alzheimer's classification given an MRI image using Convolutional Neural Network. Consequently, it is supervised machine learning. According to the demographics data provided by OASIS, "CDR" which stands for "Clinical Dementia Rating", is the variable used to designate an image as either having Alzheimer's or not. CDR has the following ratings:

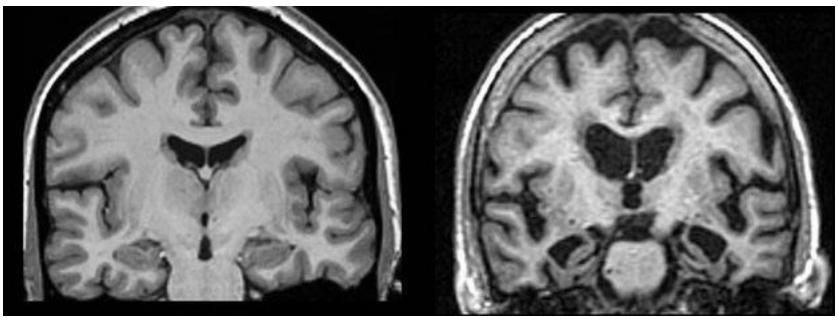
1. 0 = nondemented
2. 0.5 = very mild dementia
3. 1 = mild dementia
4. 2 = moderate dementia

For subjects have CDR > 0, they are to be diagnosed with probable Alzheimer's Disease. For subjects without a CDR value, they were removed from the data set.

Alzheimer's can be correctly diagnosed via neuroimaging as it is characterized as atrophy of certain parts of the brain. The following is an image comparing healthy brain with Alzheimer's:



In the next image, the left is of a healthy brain and the right is one with Alzheimer's.



Clearly, there is a significant loss of mass in the Alzheimer's MRI thus indicative of brain atrophy. The objective for this project is for the Convolutional Neural Network to be able to capture these differences and therefore accurately classify these MRI as to whether there is or is not Alzheimer's.

Additionally, since this is a project whose objective is vital for medicine, it is safer that when in doubt, the images be forwarded to the radiologist and neurologist. Accuracy is important, but most important is an accurate diagnosis as it could mean life or death for the patient. Images that are not clear-cut either Alzheimer's or not, must be forwarded for further analysis by human experts.

References for Exploratory Data Analysis

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