

### *49275 Neural Networks and Fuzzy Logic*

L10. DEMENTED AND NONDEMENTED BRAIN MRI IMAGES CLASSIFICATION Seminar 1 12910939 Yuk Leong 13886357 Robert Makepeace 13797093 Sannjit Saha



- Aim / Background
- Data Source
- Literature Review
- Software
- Method
- Functional Block Diagram
- Feasibility
- Conclusion



(National Institute on Aging, 2021)

### Motivations

- Most common form of dementia
- No immunity or cure for the disease
- According to WHO, more than 55 million people live with dementia globally.
- "In 2019, the estimated total global societal cost of dementia was US\$ 1.3 trillion, and these costs are expected to surpass US\$ 2.8 trillion by 2030 as both the number of people living with dementia and care costs increase" (World Health Organisation, 2021)

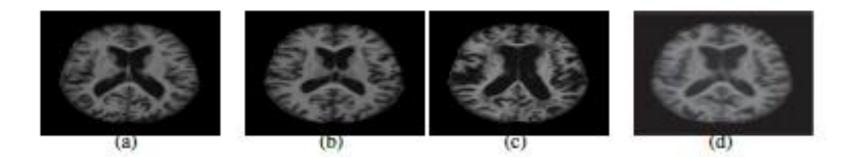


Figure 1: Example of different brain MRI images presenting different AD stage. (a) Nondemented; (b) very mild dementia; (c) mild dementia; (d) moderate dementia.

Awate et al., 2018 figure 1.1

Aim / Objectives

- Aim: Classification and prediction of demented and nondemented brain MRI using neural networks
- Ideal outcome: High accuracy (>90%) performing model, low variance and not overfitting.
- Objectives:

Pre-processing data to select most relevant features.

Create neural network capable of predicting patients likely to develop Alzheimer's disease.

Verify constantly model is not overfitting

### SCIENTIFIC **REPORTS**

#### OPEN Predicting Alzheimer's disease progression using multi-modal deep learning approach

ceived: 10 September 2018 cepted: 12 December 2018 Garam Lee<sup>1,2</sup>, Kwangsik Nho<sup>3,4</sup>, Byungkon Kang<sup>1</sup>, Kyung-Ah Sohn<sup>1</sup>, Dokyoon Kim<sup>2,5</sup> & for Alzheimer's Disease Neuroimaging Initiative® An Ensemble of Deep Convolutional Neural Networks for Alzheimer's Disease Detection and Classification

Jyoti Islam Yanqing Zhang Department of Computer Science Georgia State University jislam20student.gsu.edu yzhang0gsu.edu

#### Detection of Alzheimer's Disease from MRI using Convolutional Neural Network with Tensorflow

G. J. Awate <sup>1</sup> Dept of Information Technology, Sinhgad Academy of Engineering, Kondhwa (Bk), Pune, India, gurung Jformal/agmaall.com Dr. G. Pradeepini <sup>3</sup> Professor, Dept. of Computer Science & Engineering K. L. University, Guntur, A.P., India prodeebing coer/klumiversity in

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S. L. Bangare<sup>2</sup> PhD Detestratic Scholar, Dept CSE, K. L. University, Gruntz, A.P., India, Assistrat Professor, Dept of 10, T., Sindagad Academy of Engineering, Kondlwo (Rk), Pune, India, anul bangare/granal.com Dr. S. T. Patil<sup>4</sup> Professor Dept of Computer Engineering, VIT, Pune, stynUT/20 multi-com FEATURED ARTICLE

#### THE JOURNAL OF THE ALZHEIMER'S ASSOCIATION

#### Predicting sporadic Alzheimer's disease progression via inherited Alzheimer's disease-informed machine-learning

$$\label{eq:linear_states} \begin{split} & \mathsf{Nicolai Franzmeier^{1.6}} \quad | \quad \mathsf{Nikolaos Koutsouleris^2} \quad | \quad \mathsf{Tammie Benzinger^{3.4}} \quad | \quad \mathsf{Alison Goate^{5.6}} \quad | \quad \mathsf{Celeste} \, \mathsf{M}, \mathsf{Karch^{7.7,8}} \quad | \quad \mathsf{Anne} \, \mathsf{M}, \mathsf{Fagan^{5.7,9}} \quad | \quad \mathsf{Eric} \, \mathsf{MCDade^{6.9}} \mid \\ & \mathsf{Marco Duering^3} \quad | \quad \mathsf{Martin Dickgans^{1.0,01,11}} \quad | \quad \mathsf{Johannes Levin^{10,11,12}} \mid \\ & \mathsf{Brian} \, \mathsf{A}, \mathsf{Gordon^{13,13,4}} \quad | \quad \mathsf{Yen Ying Lim^{15}} \quad | \quad \mathsf{Colin L}, \mathsf{Masters^{15}} \quad | \quad \mathsf{Martin Rossor^{16}} \mid \\ & \mathsf{Nick} \, \mathsf{C}, \mathsf{Fox^{16}} \mid \quad \mathsf{Antoinette} \, \mathsf{O'Connor^{16}} \mid \quad \mathsf{Jasmeer Chhatwal^{17}} \quad | \quad \mathsf{Stephen Salloway^{18}} \mid \\ & \mathsf{Adrian Danek^{12}} \quad | \quad \mathsf{Jason Hassenstab^{4,514}} \quad | \quad \mathsf{Peter} \, \mathsf{R}, \mathsf{Schoffield^{15,20}} \quad | \quad \mathsf{John C}, \mathsf{Moris^{4,6,9}} \\ & \mathsf{Randall} \, \mathsf{J}, \mathsf{Bateman^{4,9}} \quad | \quad \mathsf{the Alzheimer^{4} \, dise neuroimaging initiative (\mathsf{ADNI})^{21}} \quad | \quad \mathsf{the} \\ & \mathsf{Dominantly \ Inherited \, \mathsf{Alzheimer} \, \mathsf{Network} \, (\mathsf{DIANI}^{2} \mid \quad | \\ & \mathsf{Michael Evers^{1.9}} \bullet \end{split}$$

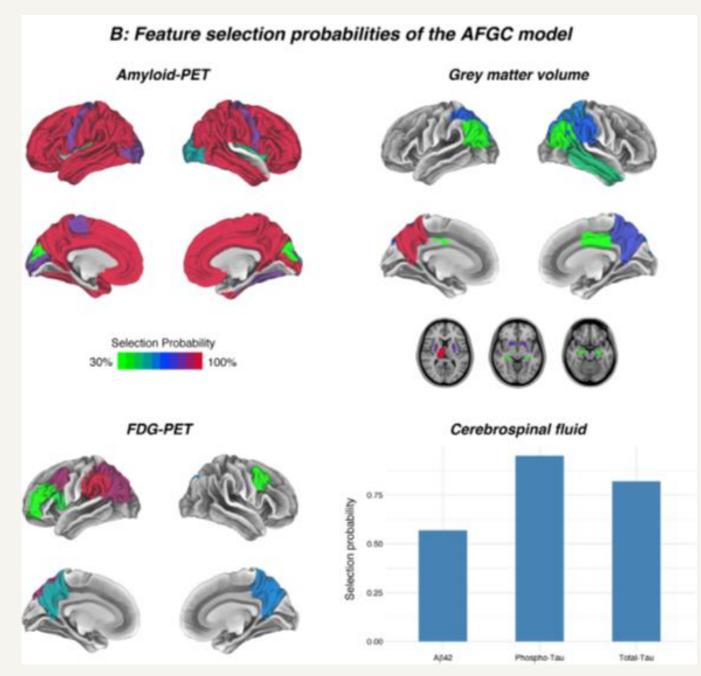
*Literature Review / Market Review* 

- Alzheimer's disease is classified into 3 stages
  - Pre-clinical Normal cognitive function
  - Prodromal Mild cognitive impairment (MCI)
  - Dementia Functional impairment

(Scharre D. W., 2019)

### Literature Review /Market Review

Author(s)	Data source	Model	Modality(s)	Accuracy (r^2)
Detection of Alzheimer's disease from MRI using convolutional neural network with Tensorflow	OASIS	Convolutional neural network (CNN)	MRI images	99%
An Ensemble of Deep Convolutional Neural Networks for Alzheimer's Disease Detection and Classification	OASIS	Ensemble of 3 Dense net (a type of CNN)	MRI images	93.18%
Predicting Alzheimer's disease progression using multi- modal deep learning approach	ADNI	Multimodal recurrent neural network	Demographic information Longitudinal CSD biomarkers Longitudinal cognitive performance	81%
Predicting sporadic Alzheimer's disease progression via inherited Alzheimer's disease- informed machine- learning	DIAN & ADNI	Multi-modal support vector regression to predict future symptom manifestation between 1 – 4 years.	MRI images Cerebral spinal fluid (CSF) Amyloid-PET Fluorodeoxyglucose (FDG-PET) Grey matter volume (GM)	N/a (R <sup>2</sup> = 0.53)



(Franzmeier et al., 2020) Figure 2 B.

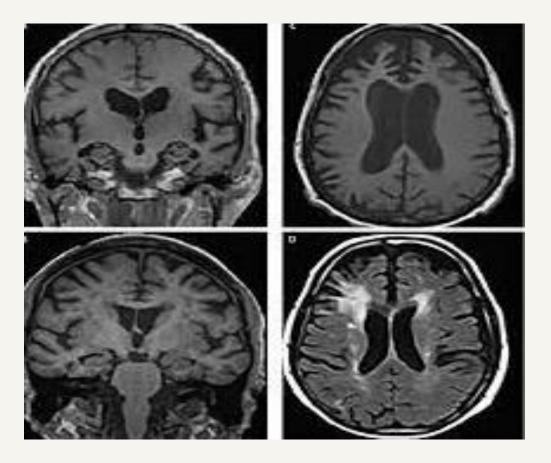
## Method



- We use various methods to find out about the demented and non-demented MRI Brain classification.
- Some of them are the Medulla Oblongata and other various parts of the human brain.
- In case of any injury to the skull or the brain, we need to do a few MRI scans in order to get the photographs of the brain in case there is any abnormality.
- The various methods are by using an MRI scanner which helps to record images of the human brain in case there is any abnormality.
- Demented and Non-Demented Brain MRI classification depends on various biological platforms and other various Central Nervous System and Neural Studies.
- These can be classified on the basis of Neural Network and Fuzzy Logic Theory.

Functional Block Diagram





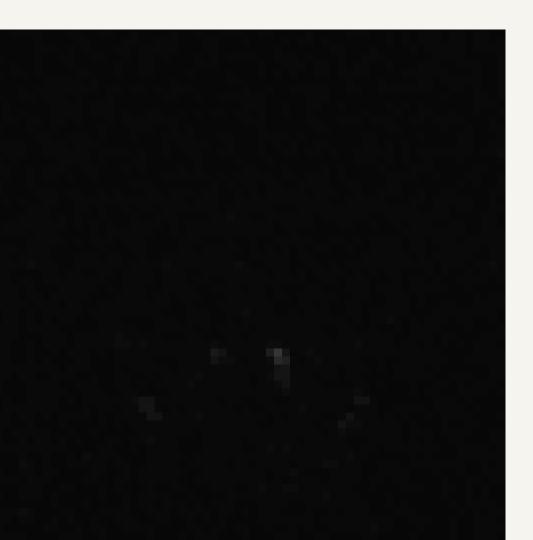
Various Demented and Non- Demented Brain MRI classification images.

# Feasibility



- Nowadays Brain MRI scanning has become very convenient with added technology.
- New Radio Waves and Magnetic scanners at a reasonable price are available in the market.
- These help to record and scan Magnetic Resonance Imaging of various parts of the Demented and Non-Demented Human Brain.
- This is the feasibility with added technology how we can record and scan various MRI images of the human brain with scanners and computer systems that show the images processed.
- These kind of Scanners are available in Hospitals and Diagnostic Centers.

### Data Source



#### • www.oasis-brains.org.

- Open access series of imaging studies (OASIS)
- OASIS-2: Longitudinal MRI Data in Nondemented and Demented Older Adults
- 150 subjects with 373 MRI sessions

64 demented 51 mild to moderate dementia 14 developed later Rest undemented

#### Source:

Open Access Series of Imaging Studies (OASIS): Longitudinal MRI Data in Nondemented and Demented Older Adults

Marcus, DS, Fotenos, AF, Csernansky, JG, Morris, JC, Buckner, RL, 2010. Journal of Cognitive Neuroscience, 22, 2677-2684. doi: 10.1162/jocn.2009.21407

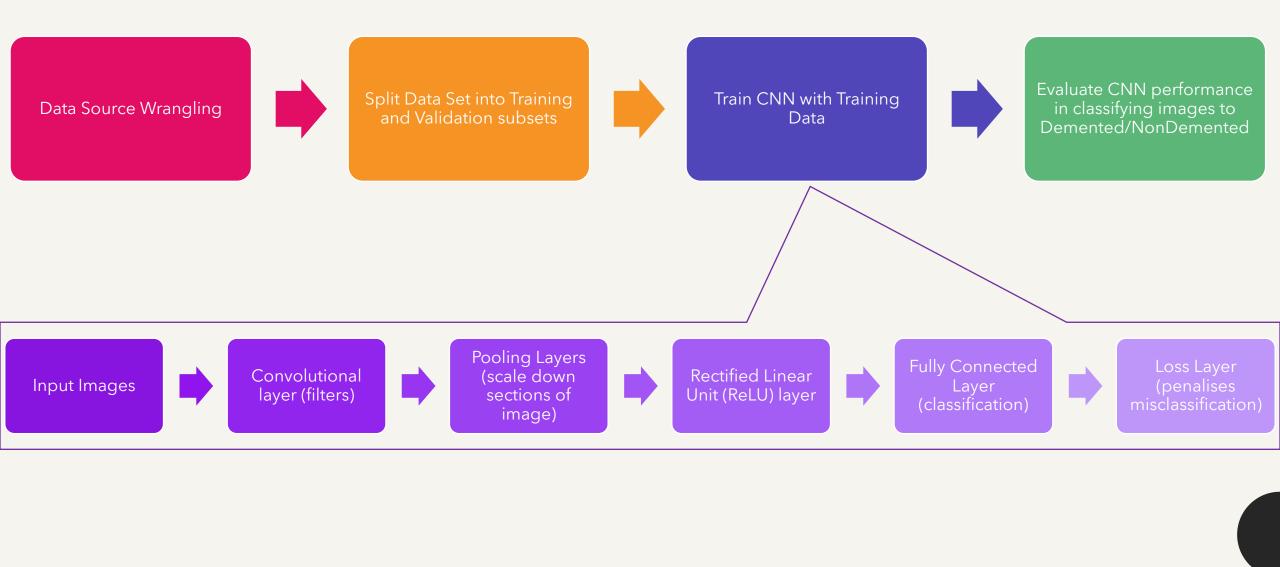
# Software

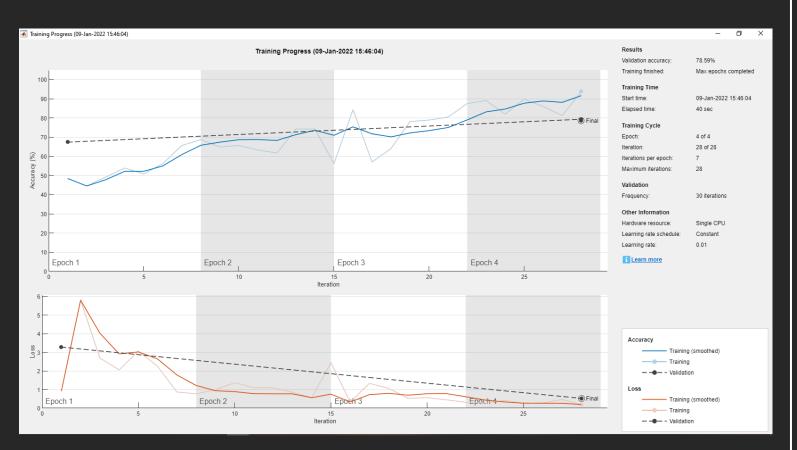
- Matlab
- Deep Learning Toolbox
- Built In CNN functions, graphs and visualisations

s <b>is for trainNetwork usage</b> net <b>s date:</b> 09-Jan-2022 15:46:52			<b>15</b> layers	0 🛕 0 🥊 warnings error
	ANALYSIS RESULT			
imageinput	Name	Туре	Activations	Learnables
<b></b>	1 imageinput 64×84×1 images with 'zerocenter' normalization	Image Input	64×64×1	-
e conv_1	2 COTV_1 8 3 x43 x1 convolutions with stride [1 1] and padding 'same'	Convolution	64×64×8	Weights 3×3×1×8 Bias 1×1×8
batchnorm_1	3 batchnorm_1 Batch normalization with 8 channels	Batch Normalization	64×64×8	Offset 1×1×8 Scale 1×1×8
relu_1	4 relu_1 ReLU	ReLU	64×64×8	-
	5 maxpool_1 2+2 max pooling with stride [2 2] and padding [0 0 0 0]	Max Pooling	32×32×8	-
maxpool_1	8 conv_2 16 3×3×3 convolutions with stride [1 1] and padding 'same'	Convolution	32×32×16	Weights 3×3×8×16 Bias 1×1×16
• conv_2	7 batchnorm_2 Batch normalization with 16 channels	Batch Normalization	32×32×16	Offset 1×1×16 Scale 1×1×16
batchnorm_2	relu_2  ReLU	ReLU	32×32×16	-
T	maxpool_2 2×2 max pooling with stride [2 2] and padding [0 0 0 0]	Max Pooling	16×16×16	-
relu_2	10 conv_3 32 3x3x18 convolutions with stride [1 1] and padding 'same'	Convolution	16×16×32	Weights 3×3×16×32 Bias 1×1×32
• maxpool_2	11 batchnorm_3 Batch normalization with 32 channels	Batch Normalization	16×16×32	Offset 1×1×32 Scale 1×1×32
conv_3	12 relu_3 ReLU	ReLU	16×16×32	-
batchnorm_3	13 fc 2 fully connected layer	Fully Connected	1×1×2	Weights 2×8192 Bias 2×1
batchnorm_3	14 softmax softmax	Softmax	1×1×2	-
relu_3	15 classoutput crossentropyex with classes "Demented" and "Nondemented"	Classification Output	1×1×2	-
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sofimax				

1	Edito	or - C:\Users\robma\Documents\MATLAB\groupL10_cnn.m	
[	gro	upL10_openimage.m 🗶 groupL10_imds.m 🗶 groupL10_cnn.m 🗶	1
1		%example CNN code from: https://au.mathworks.com/help/deeplearning/ug/create-sin	mp
2		&Load the workspace variables	
4		<pre>load('groupL10 fulldataset.mat')</pre>	
5		load('groupL10 trainingdata.mat')	
6		<pre>load('groupL10_validationdata.mat')</pre>	
7			
8		%Generate figure of random MRI images	
9		figure;	
10		<pre>perm = randperm(config.numberOfImages,64);</pre>	
11		for i = 1:64	
12		<pre>subplot(8,8,i); imshow(imds.Files{perm(i)});</pre>	
13		end	
15		citu	
16		%Configure CNN layers	
17		layers = [	
18		<pre>imageInputLayer([config.imageresolution config.imageresolution 1])</pre>	
19			
20		convolution2dLayer(3,8,'Padding','same')	
21		batchNormalizationLayer	
22		reluLayer	
23		maxPooling2dLayer(2,'Stride',2)	
25		hoxrootingzocoyer(z, stride,z)	
26		convolution2dLayer(3,16, 'Padding', 'same')	
27		batchNormalizationLayer	
28		reluLayer	
29			
30		maxPooling2dLayer(2,'Stride',2)	
31		convolution2d succ(2, 22, (Dadding), (concl)	
32		convolution2dLayer(3,32, 'Padding','same') batchNormalizationLayer	
33 34		reluLayer	
35		r cabbayer	
36		fullyConnectedLayer(config.numberofclasses)	
37		softmaxLayer	
38		classificationLayer];	
39			
40		%Configure CNN options	
41		options = trainingOptions('sgdm',	
42		'InitialLearnRate',0.01, 'MaxEpochs',4,	
44		'Shuffle', 'every-epoch',	
45		'ValidationData', imdsValidation,	
46		'ValidationFrequency', 30,	
47		'Verbose',false,	
48		'Plots', 'training-progress');	
49			
50		% Run CNN Training	
51 52		<pre>net = trainNetwork(imdsTrain,layers,options);</pre>	
53		%Classify the validation images	
54		<pre>YPred = classify(net,imdsValidation);</pre>	
55			
56		%Validation Dataset labels	
57		<pre>YValidation = imdsValidation.Labels;</pre>	
58			
59		%Caluclate CCN classification accuracy	
60		accuracy sum(YPred == YValidation)/numel(YValidation)	
61 62		%Analyze Network	
63		analyzeNetwork(net)	

### Functional Block Diagram





# What we have achieved so far?

#### • Data Wrangling

Matlab Scripts to convert MRI files to 64 x 64 pixel images

Import images into Matlab image datastore structure

Labelling images with classification (Demented / Nondemented)

Splitting data into training (70%) and validation (30%) subsets

 Ran through Matlab example Convolutional Neural Network script

Baseline accuracy: 79%

Show feasibility of method

Room for improvement with CNN structure and training

# Individual Project Contributions:

### Yuk Leong

- Literature Review
- Motivations / Objectives

### Robert Makepeace

- Data wrangling of data source
- Functional Block
  Diagram
- Setup of example CNN Matlab script

### Sannjit Saha

### Method

• Feasibility

# Conclusion

- Automated classification of Alzehmier's from MRI images is a powerful tool to assist medical professionals
- Our projects aims to develop a Convolutional Neural Network to accurately and automatically classify patients as demented / nondemented
- So far we have completed our literature review, data wrangling and have preliminary results with our Convolutional Neural Network.



- [1] Awate, G., Bangare, S., Pradeepini, G., & Patil, S. (2018). Detection of alzheimers disease from mri using convolutional neural network with tensorflow. arXiv preprint arXiv:1806.10170.
- [2] World Health Organisation. *Dementia*. (2021). Retrieved 11 January 2022, from <u>https://www.who.int/news-room/fact-sheets/detail/dementia</u>.
- [3] Franzmeier, N., Koutsouleris, N., Benzinger, T., Goate, A., Karch, C., Fagan, A., Mcdade, E., Duering, M., Dichgans, M., Levin, J., Gordon, B. A., Lim, Y. Y., Masters, C. L., Rossor, M., Fox, N. C., O'connor, A., Chhatwal, J., Salloway, S., Danek, A., Hassenstab, J., Schofield, P. R., Morris, J. C., Bateman, R. J. And Ewers, M. (2020). Predicting sporadic Alzheimer's disease progression via inherited Alzheimer's disease-informed machine-learning. *Alzheimer's & Dementia*, 16(3), 501-511. <u>https://doi.org/10.1002/alz.12032</u>
- [4] Islam, J., & Zhang, Y. (2017). An ensemble of deep convolutional neural networks for Alzheimer's disease detection and classification. arXiv preprint arXiv:1712.01675.
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- [6] Scharre, D. (2019). Preclinical, Prodromal, and Dementia Stages of Alzheimer's Disease Practical Neurology. Practical Neurology. Retrieved 8 January 2022, from <u>https://practicalneurology.com/articles/2019-june/preclinical-prodromal-and-dementia-stages-ofalzheimers-disease</u>.
- [7] National Institute on Aging. (2021). *Alzheimer's Disease Fact Sheet*. Retrieved 8 January 2022, from https://www.nia.nih.gov/health/alzheimers-disease-fact-sheet.