AD MRI Images Classification

Regis University - MSDS696_C70 - Data Science Practicum II

Application of Deep Learning on MRI processed brain images to predict the level of dementia from Alzheimer's Disease patients.

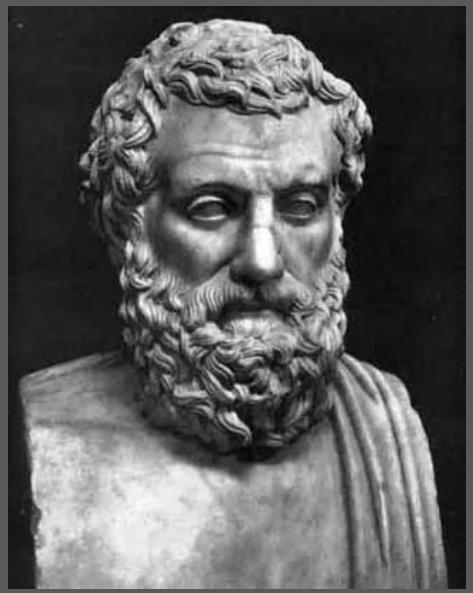
Dilyor Mikhidinov

Image from James Webb Telescope

Content

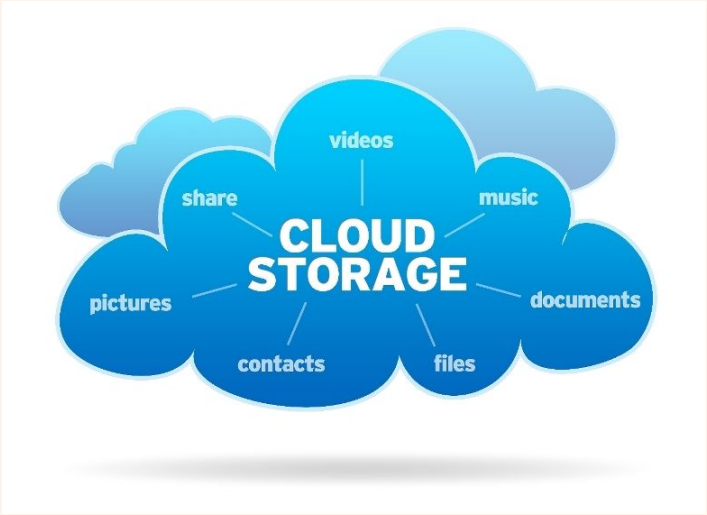
- Problem or Situation
- Research Question
- The Dataset
- Methodology
- Issues and Personal Learnings
- Some recommendations from experts
- References

Aeschylus - (525 BCE -456 BCE)

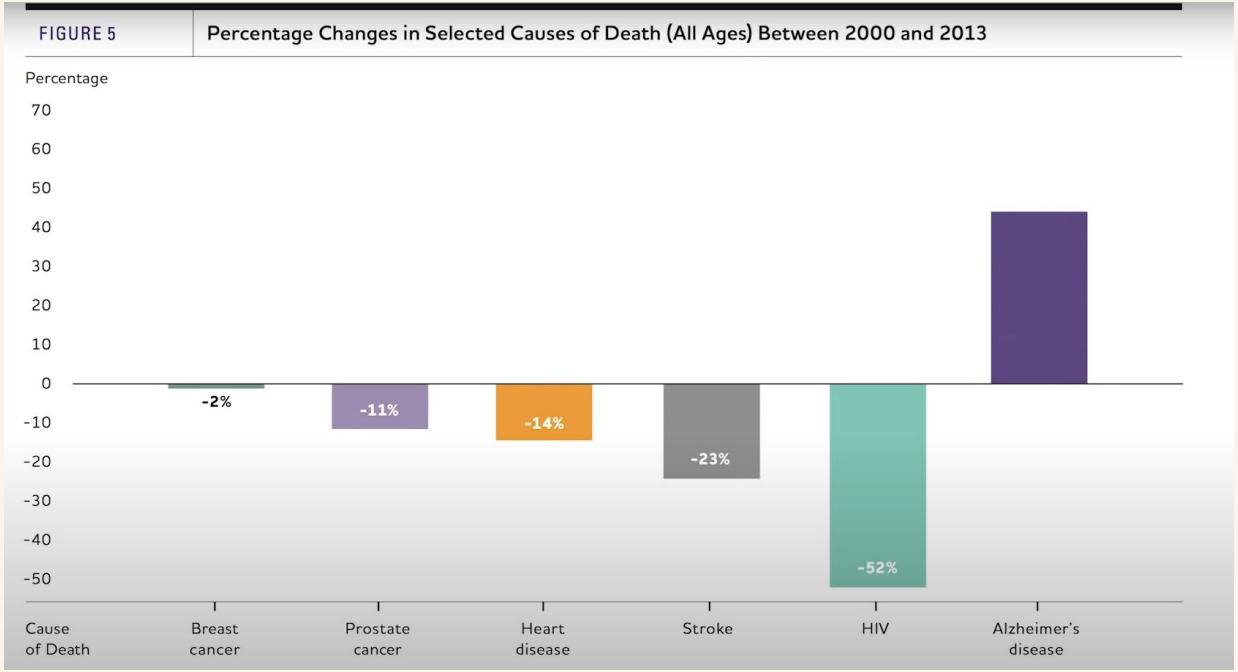


Memory is the mother of all wisdom

Memory solutions



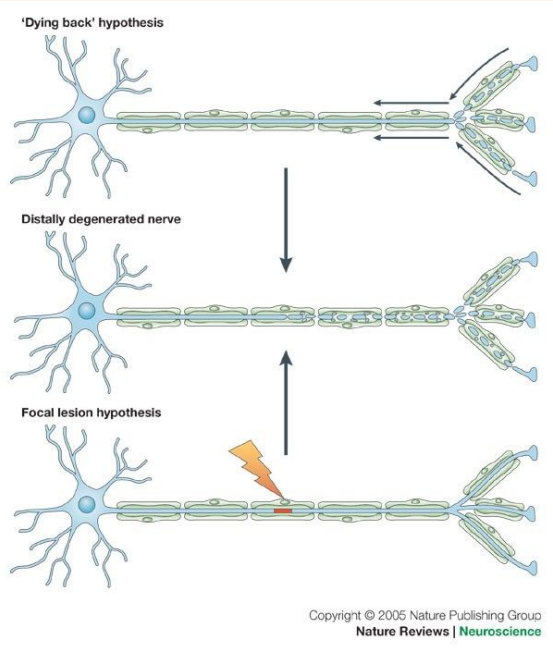
Causes of Death

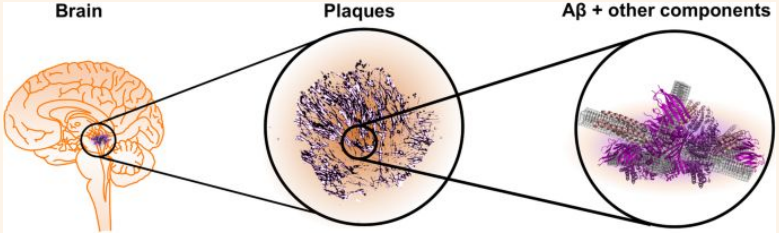


National Center for Health Statistics

"Stopping it, preventing it, postponing its development in our brains long enough that we at least die of something else with our memories is something we can achieve"
Michael Stevens

Axon entanglement in AD

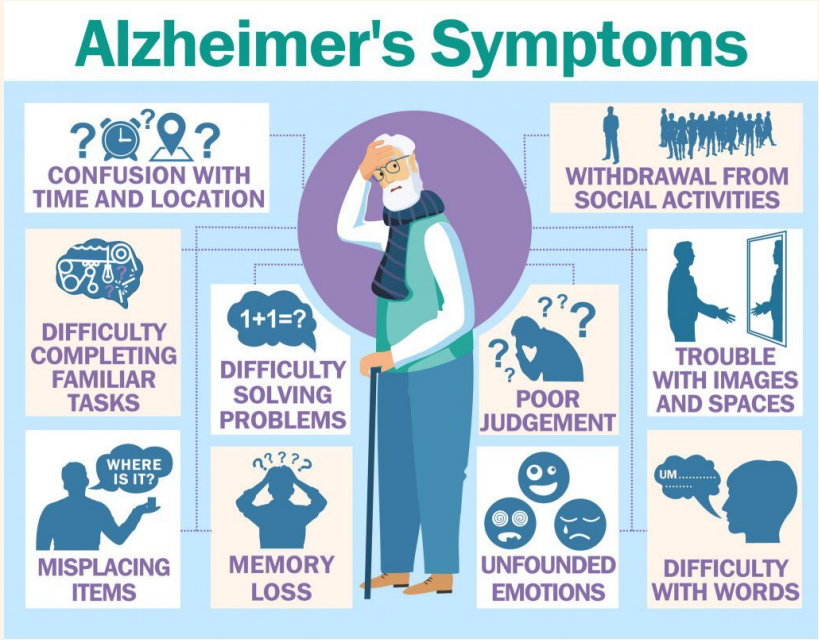




- Plaques
- Tangles - Protein related anomaly
- Alzheimer's Disease (AD) is:
- - an Incurable Disease as gradual deterioration of cognitive functions.
- - is 5th leading cause of mortality in the United States
- - is leading cause of death among people aged 65 and higher (Sheikhtaheri & Sabermahani, 2022).

Problem or Situation

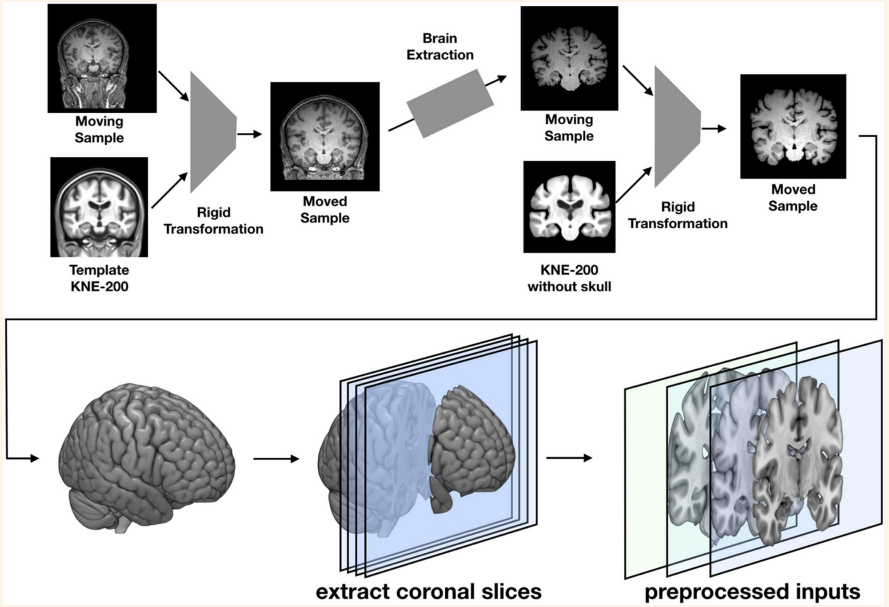
- The topic of this Data Science project will be more appropriate if classified as “general problem” case. Data from different sources and different patients will be analyzed for general identification of dementia level. Such problem solving is one of the crucial steps in improving the current models and contributing for improvement of Health Internet of Things.



Research Question

Which deep learning algorithms can efficiently predict the level of dementia from AD patients?

- Applying different deep learning algorithms and compare them in terms of efficiency
- Analyzing available literature to learn about past research done on this topic
- Analyzing alternative IT solutions that can be applied to contribute the improvement of research in AD.
- I am hoping with this research to find out which DS solutions are more efficient to help patients with AD.

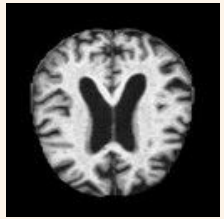


The Dataset

[Alzheimer MRI Preprocessed Dataset] from Oasis - open access series of imaging studies. Also available partially in [kaggle].

Resolution: 128x128 resolution.
Dataset is classified into four groups:

- Group - 1: Mild Demented (896 images)
- Group - 2: Moderate Demented (64 images)
- Group - 3: Non Demented (3200 images)
- Group - 4: Very Mild Demented (2240 images)

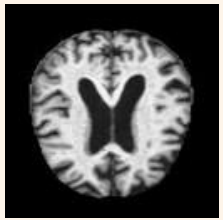


example image from the dataset (mildly demented brain image)

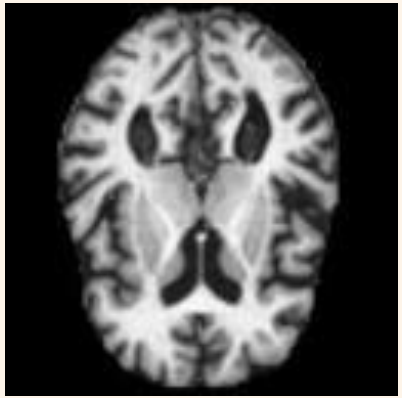
Methodology - Data Preparation

Data Augmentation

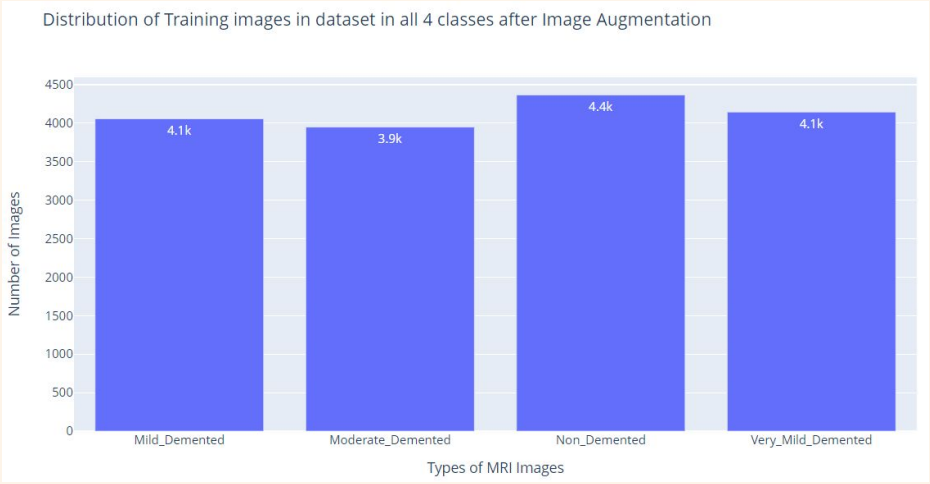
Shear Range and Zoom Range are scaled to 0.2



Original Image



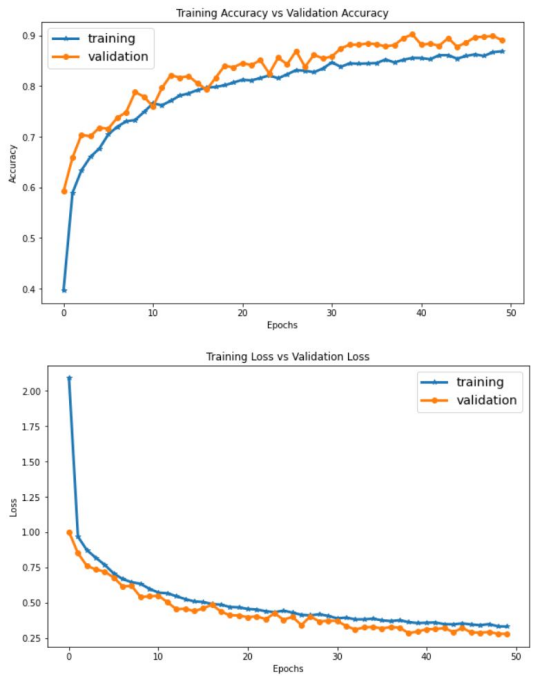
Augmented Image



Keras Conv2D Model 1

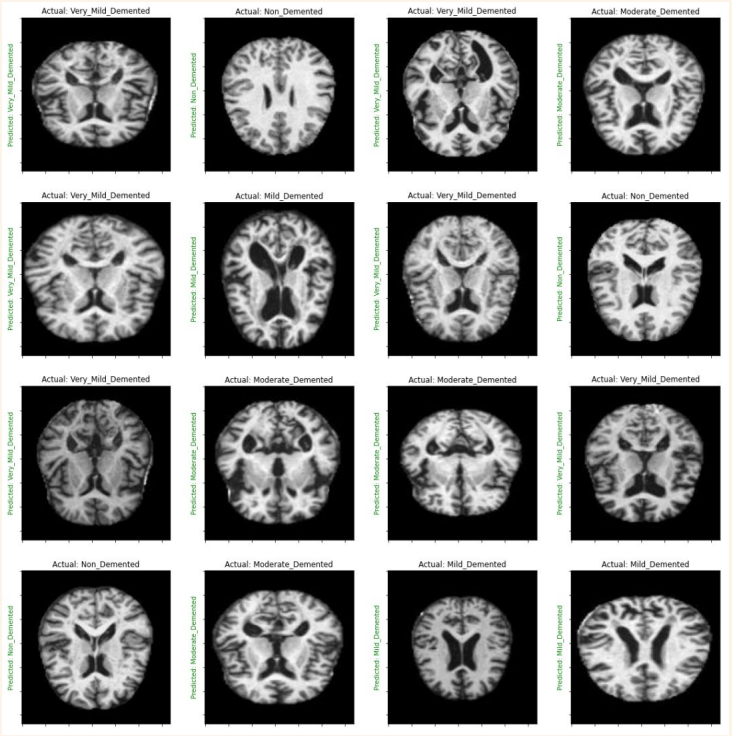
```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 126, 126, 64)      1792

 max_pooling2d (MaxPooling2D  (None, 63, 63, 64)       0
 )

 dropout (Dropout)           (None, 63, 63, 64)        0

 conv2d_1 (Conv2D)           (None, 61, 61, 32)        18464

 max_pooling2d_1 (MaxPooling  (None, 30, 30, 32)       0
 2D)

 dropout_1 (Dropout)         (None, 30, 30, 32)        0

 separable_conv2d (Separable  (None, 28, 28, 16)       816
 Conv2D)

 max_pooling2d_2 (MaxPooling  (None, 14, 14, 16)       0
 2D)

 dropout_2 (Dropout)         (None, 14, 14, 16)        0

 flatten (Flatten)           (None, 3136)              0

 dense (Dense)               (None, 16)                50192

 dense_1 (Dense)             (None, 4)                 68

=================================================================
Total params: 71,332
Trainable params: 71,332
Non-trainable params: 0
```

Model Performance



Accuracy on testing data

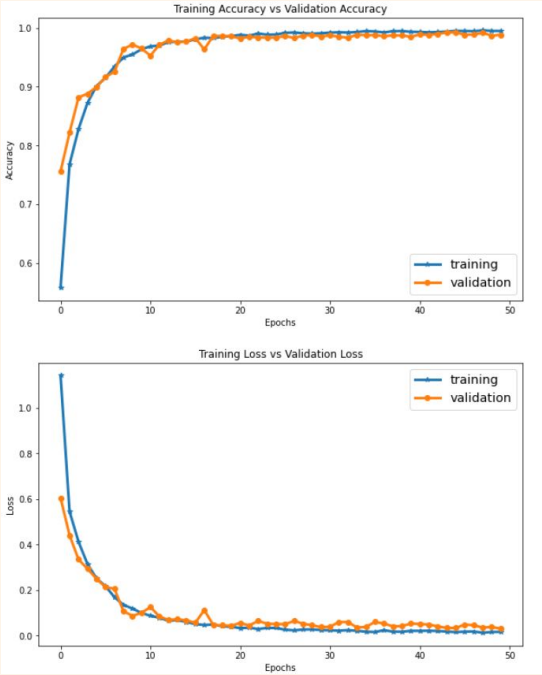
```
1 loss, accuracy = model_1.evaluate(test_data)
33/33 [==============================] - 2s 56ms/step - loss: 0.2864 - accuracy: 0.8884
```



Keras Conv2D Model 2

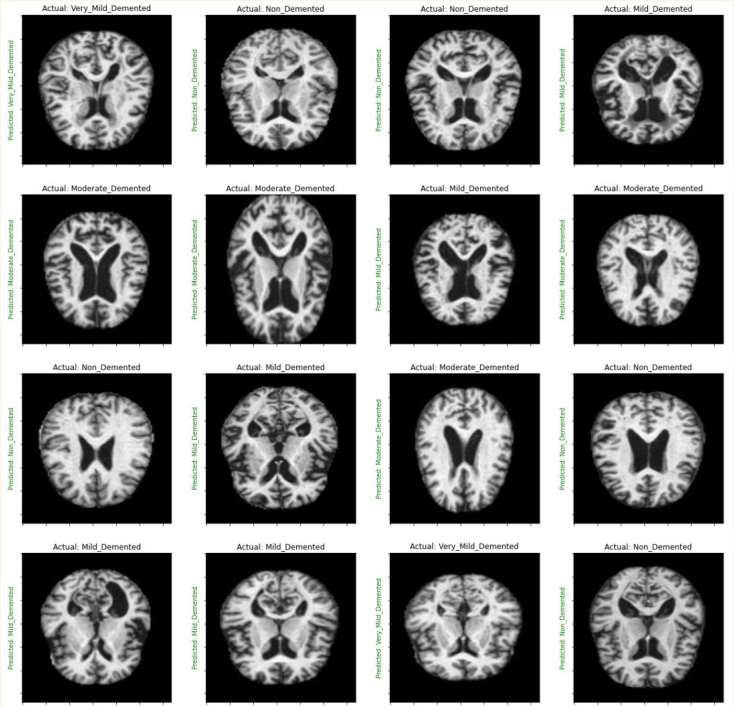
```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 rescaling (Rescaling)       (None, 128, 128, 3)       0

 conv2d_2 (Conv2D)           (None, 128, 128, 16)      448

 max_pooling2d_3 (MaxPooling  (None, 64, 64, 16)       0
 2D)

 conv2d_3 (Conv2D)           (None, 64, 64, 32)        4640

 max_pooling2d_4 (MaxPooling  (None, 32, 32, 32)       0
 2D)

 dropout_3 (Dropout)         (None, 32, 32, 32)        0

 conv2d_4 (Conv2D)           (None, 32, 32, 64)        18496

 max_pooling2d_5 (MaxPooling  (None, 16, 16, 64)       0
 2D)

 dropout_4 (Dropout)         (None, 16, 16, 64)        0

 flatten_1 (Flatten)         (None, 16384)             0

 dense_2 (Dense)             (None, 128)               2097280

 dense_3 (Dense)             (None, 4)                 516

=================================================================
Total params: 2,121,380
Trainable params: 2,121,380
Non-trainable params: 0
```

Model Performance




```
1 loss, accuracy = model_2.evaluate(test_data)
33/33 [==============================] - 1s 30ms/step - loss: 0.0313 - accuracy: 0.9918
```

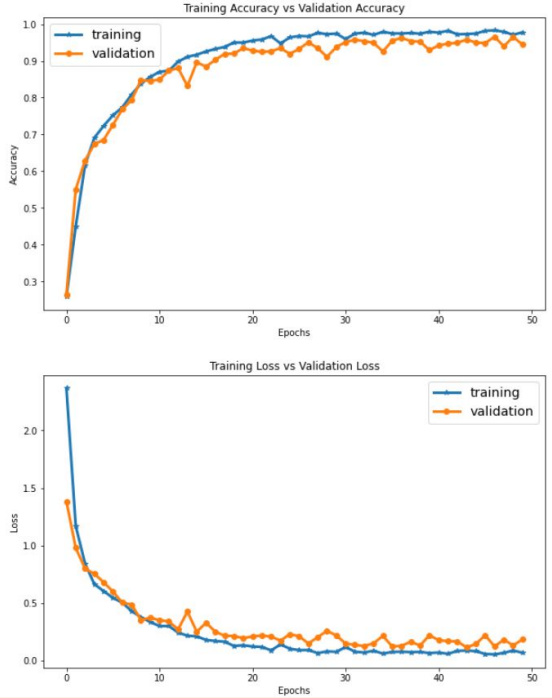
Accuracy on testing data



VGG19 Pretrained Model

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 vgg19 (Functional)          (None, 4, 4, 512)         20024384

 flatten_2 (Flatten)         (None, 8192)              0

 dense_4 (Dense)             (None, 64)                524352

 dense_5 (Dense)             (None, 16)                1040

 dense_6 (Dense)             (None, 4)                 68

=================================================================
Total params: 20,549,844
Trainable params: 20,549,844
Non-trainable params: 0
```

Model Performance



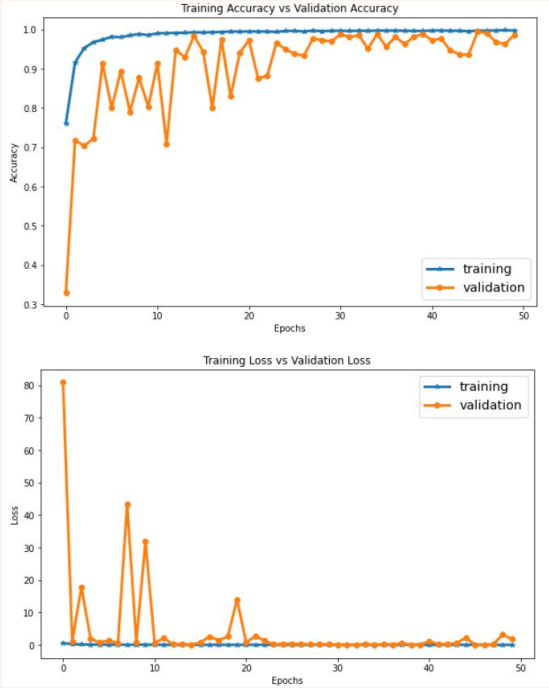
Accuracy on testing data

```
loss, accuracy = vgg_model.evaluate(test_data)
33/33 [==============================] - 4s 122ms/step - loss: 0.1648 - accuracy: 0.9483
```

Inception V3 Pretrained Model

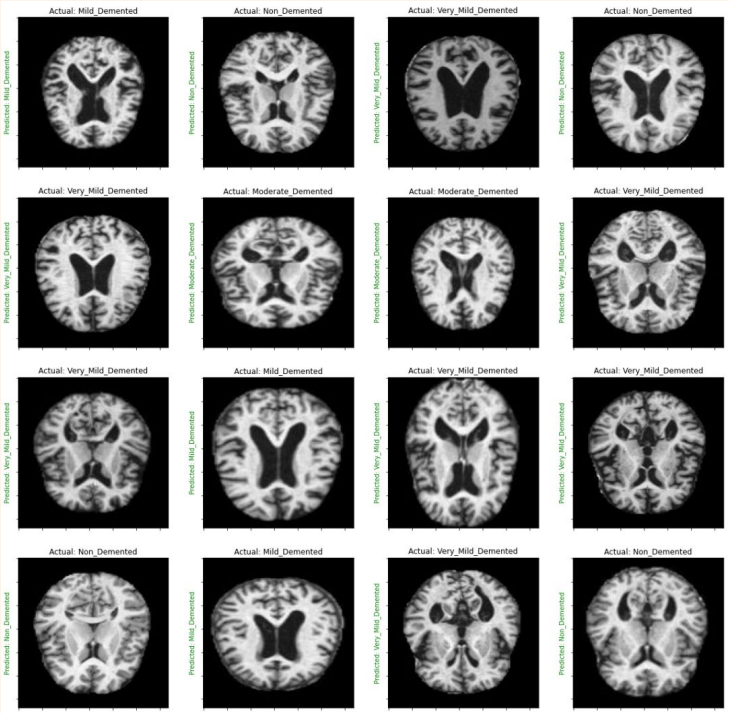
```
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 inception_v3 (Functional)   (None, 2, 2, 2048)        21802784

 flatten_3 (Flatten)         (None, 8192)              0

 dense_7 (Dense)             (None, 64)                524352

 dense_9 (Dense)             (None, 4)                 260

=================================================================
Total params: 22,327,396
Trainable params: 22,292,964
Non-trainable params: 34,432
```

Model Performance




```
loss, accuracy = inc_model.evaluate(test_data)
33/33 [==============================] - 3s 71ms/step - loss: 1.8475 - accuracy: 0.9865
```

Accuracy on testing data



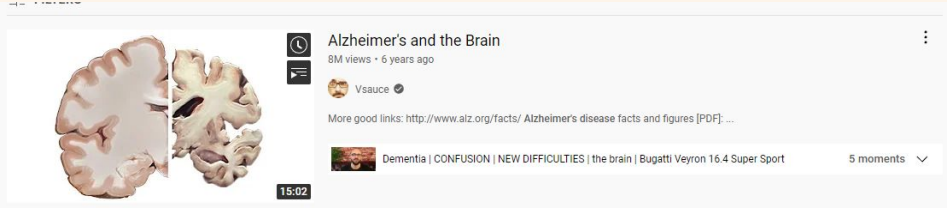
Issues and Personal Learnings

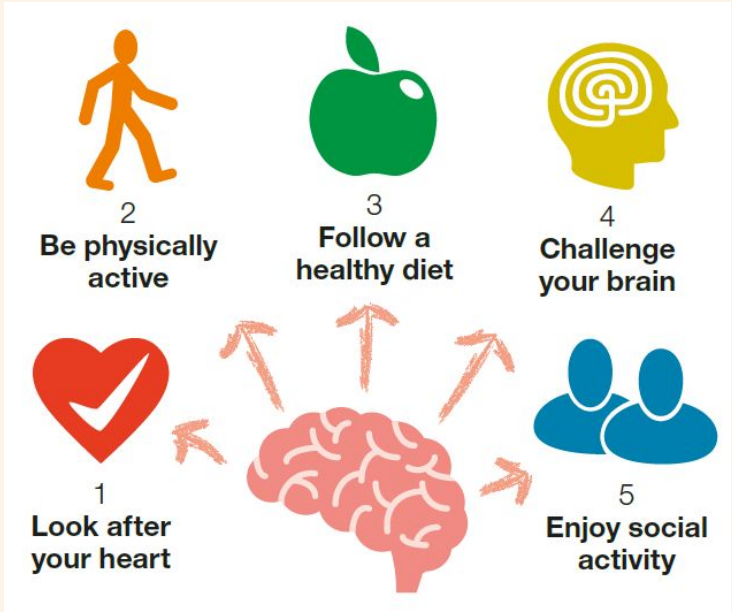
Over 30 peer reviewed research papers have been analyzed

- Big data and AI solutions to help AD patients, Analysis of top software from Google and Apple mobile app stores related to AD, Ethics and privacy issues in studies related to AD patients, Analysis of government projects for helping patients with AD
- Hyperparameters
- Model underfitting issue
- Incredible experience to put all DS program knowledge together

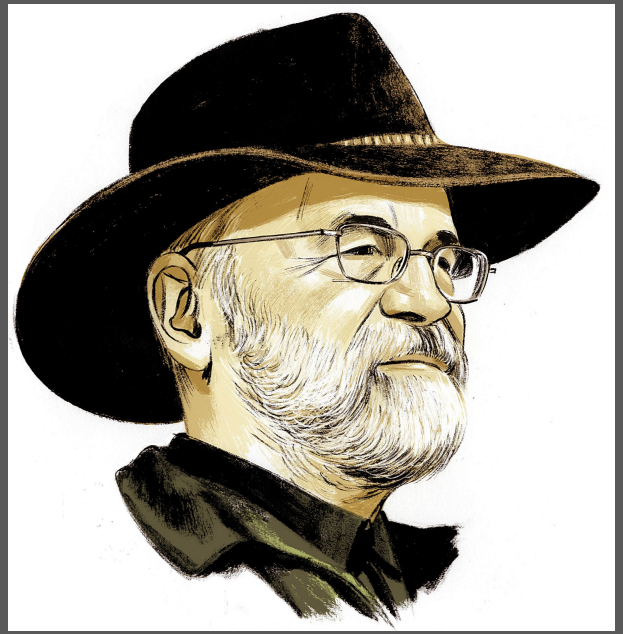
Some recommendation from experts

- Not smoking and keeping alcohol to a minimum
- Healthy diet (more fruits and vegetables)
- At least 150 minutes of exercising weekly
- Social activities
- Cognitive exercises (playing chess, sudoku, learning new language, memory games etc. (nhs.uk, 2022)
- “Alzheimer’s and the Brain” video from Vsauce, 2016)



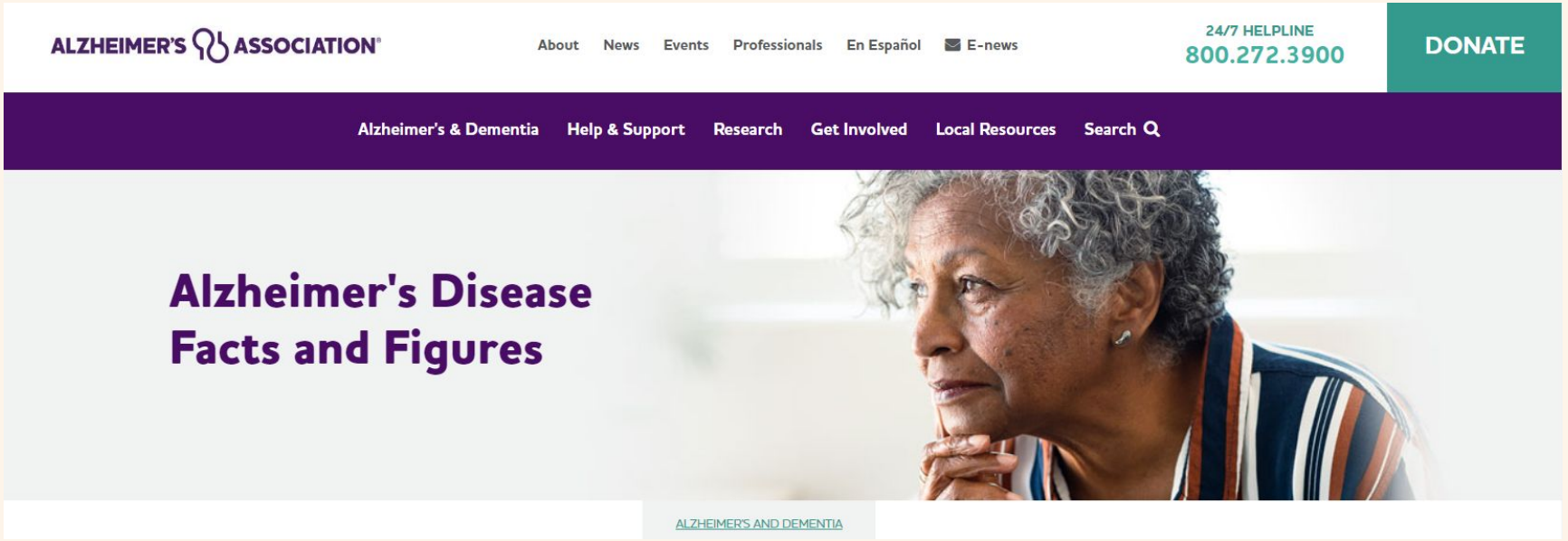


Terry Pratchett - British Author



“Right now the sword that will defeat Alzheimer’s is probably made of gold”

Donate at www.alz.org to help to fund community researches



Reference

- Alvarez, F., Popa, M., Solachidis, V., Hernandez-Penaloza, G., Belmonte-Hernandez, A., & Asteriadis, S. et al. (2018). Behavior Analysis through Multimodal Sensing for Care of Parkinson's and Alzheimer's Patients. *IEEE Multimedia*, *25*(1), 14-25. https://doi.org/10.1109/mmul.2018.011921232

- Alzheimer's Association. (2017). 2017 Alzheimer's disease facts and figures. Alzheimer's & Dementia, 13, 325–373. doi:10.1016/j.jalz.2017.02.001

- Lee, C., & Chuang, H. (2021). Design of a seniors and Alzheimer's disease caring service platform. *BMC Medical Informatics and Decision Making*, *21*(S10). https://doi.org/10.1186/s12911-021-01626-3

- Machado, S., Tavares, J., Martins, M., Barbosa, J., González, G., & Leithardt, V. (2021). Ambient Intelligence Based on IoT for Assisting People with Alzheimer's Disease Through Context Histories. *Electronics*, *10*(11), 1260. https://doi.org/10.3390/electronics10111260

- OASIS Brains - Open Access Series of Imaging Studies. (n.d.). OASIS Brains - Open Access Series of Imaging Studies. http://www.oasis-brains.org/

- Zhou, Y., Lu, Y., & Pei, Z. (2021). Intelligent diagnosis of Alzheimer's disease based on internet of things monitoring system and deep learning classification method. *Microprocessors and Microsystems*, 83, 104007. https://doi.org/10.1016/j.micpro.2021.104007