Increasing Robustness of Deep Network Model of Neurological Disease

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Currently more than

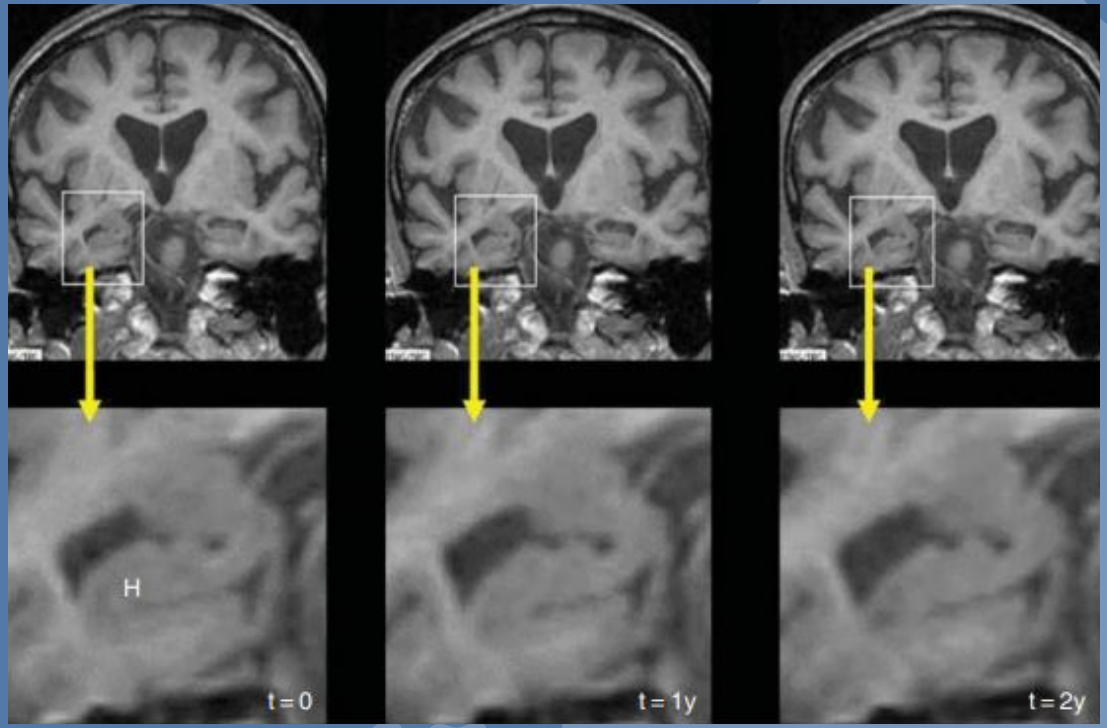
55,000,000

people live with dementia worldwide, and there are nearly 10 million new cases every year. Alzheimer's disease may contribute to 60-70% of cases.


NORMAL BRAIN
ADVANCED ALZHEIMER'S
MEDICALNEWSTODAY

HOW IS IT DIAGNOSED?

Atrophy in AD Progressive cerebral atrophy is a characteristic feature of neurodegeneration that can be visualized in life with MRI



WHY DEEP NEURAL NETWORK?

- Deep neural networks are able to create deeper representations, at every layer, the networks learns a new, more abstract representation of the input.
- While there are studies that a shallow network can fit any function, it will need to be really wide. That causes the number of parameters to increase a lot.
- A technique to perform machine learning inspired by our own brain's own network of neurons.

OBJECTIVE

The project aims at using a pre-trained Convolutional Neural Network (*EfficientNet B7*) to see if it can perform human expert-level diagnoses on *Alzheimer's disease* dataset and check if **regularization** and **data augmentation** methods could improve its performance.

The neural network was trained on the ImageNet Dataset and fine-tuned to a dataset of MRI images of Alzheimer's disease classified in different stages.

- Non-Demented
- Very Mild Demented
- Mild Demented
- Moderated Demented

Further, we proposed to work on **Variational Encoder** trained on the same data to generate new images from misclassified examples.

TIMELINE

01 Found a phenomenon and a question to ask about it

02 Gathered the fMRI datasets

03 Did transfer Learning with EfficientNet B7 pre-trained model

04 Regularization and Data Augmentation to improve the performance on misclassified data

METHODOLOGY PIPELINE

01

Select Neural Network computer vision model

02

Select database of neurological disease (Alzheimer's Disease)

03

Refine weights of neural network model to the new database with a training set of images

04

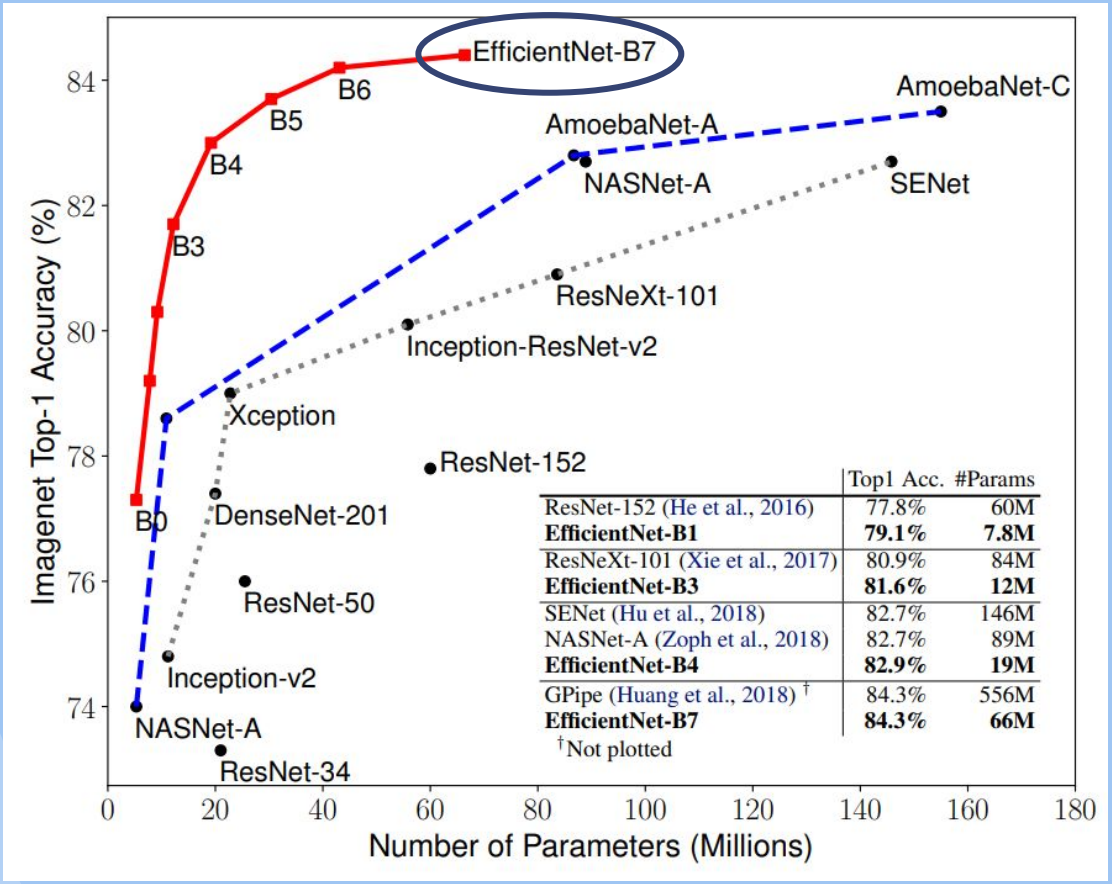
Output results of model on test set

05

Investigate the misclassified images in the test set

06

Things to ponder on later



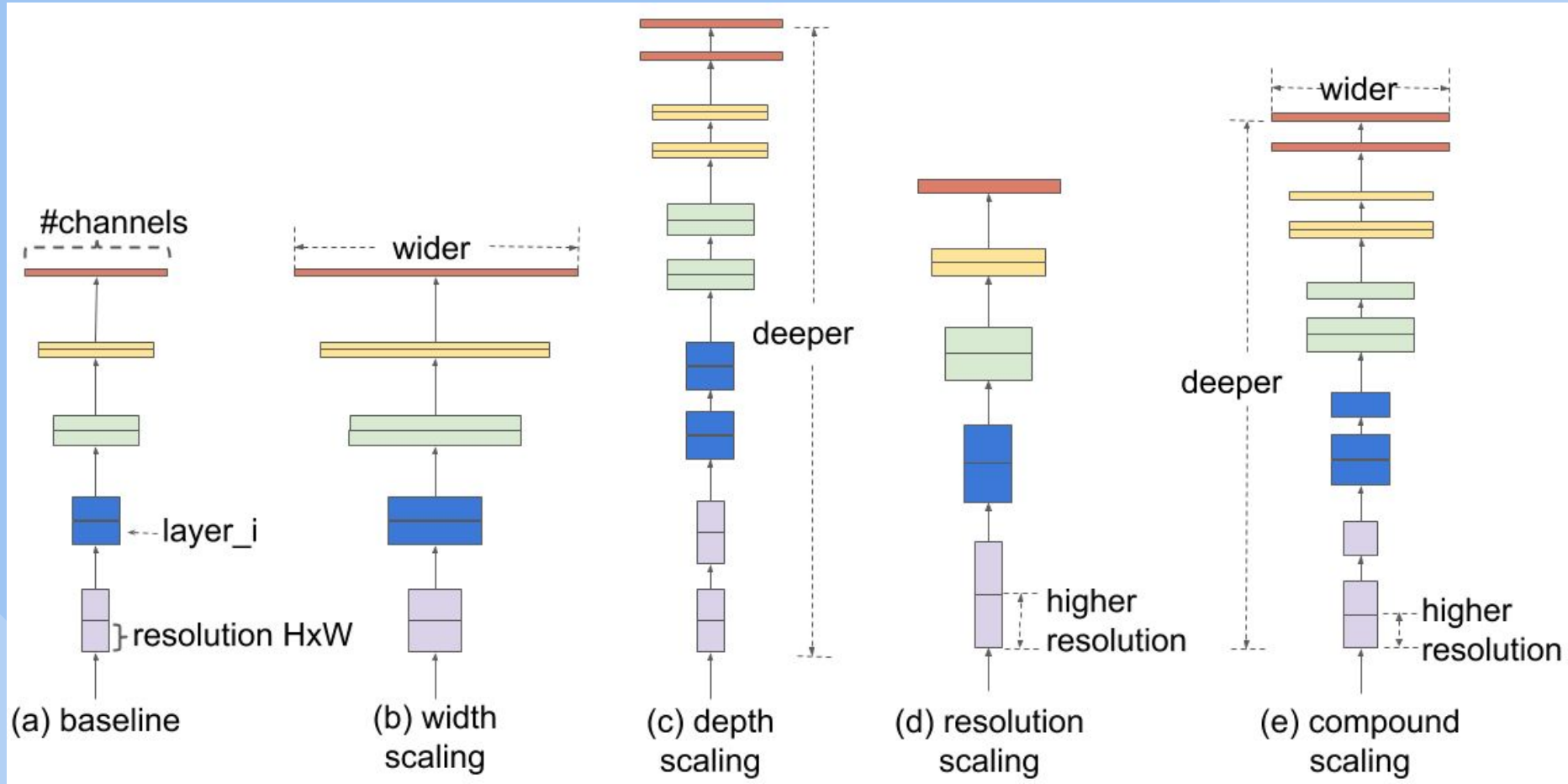
	Top1 Acc.	#Params
ResNet-152 (He et al., 2016)	77.8%	60M
EfficientNet-B1	**79.1%**	**7.8M**
ResNeXt-101 (Xie et al., 2017)	80.9%	84M
EfficientNet-B3	**81.6%**	**12M**
SENet (Hu et al., 2018)	82.7%	146M
NASNet-A (Zoph et al., 2018)	82.7%	89M
EfficientNet-B4	**82.9%**	**19M**
GPipe (Huang et al., 2018) †	84.3%	556M
EfficientNet-B7	**84.3%**	**66M**

†Not plotted

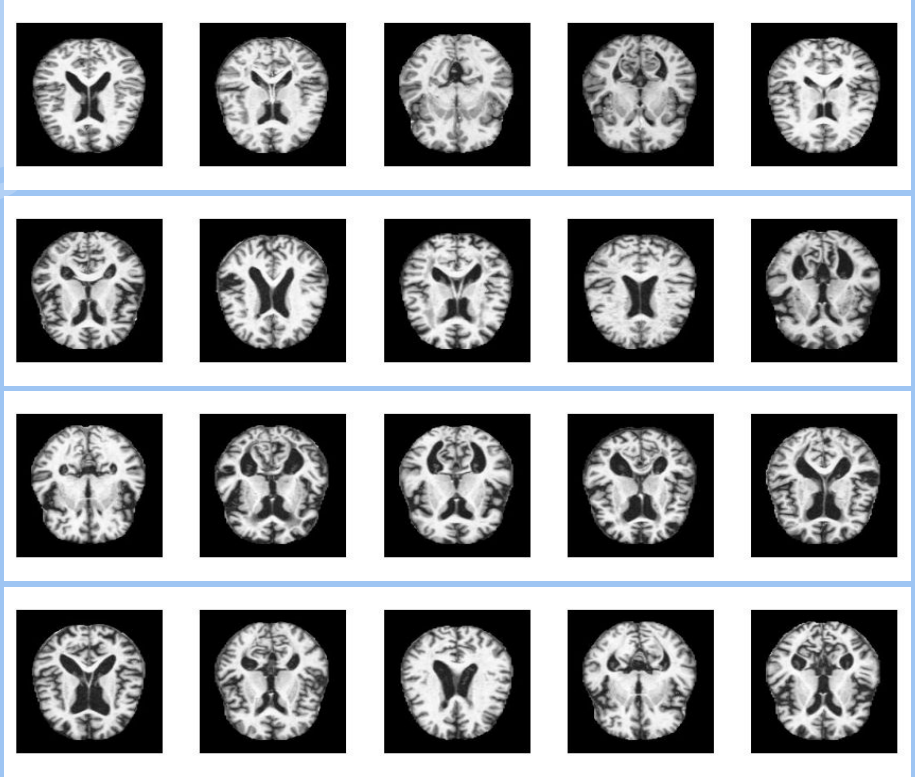
Methodology: Model Selection

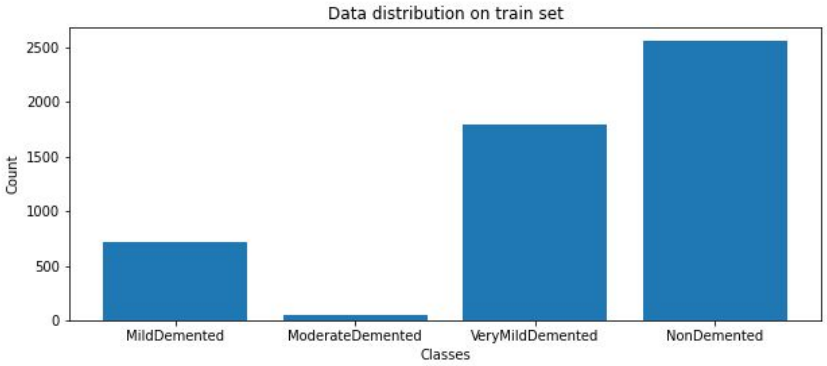
Idea: take a pre-trained model and fine-tune on our data

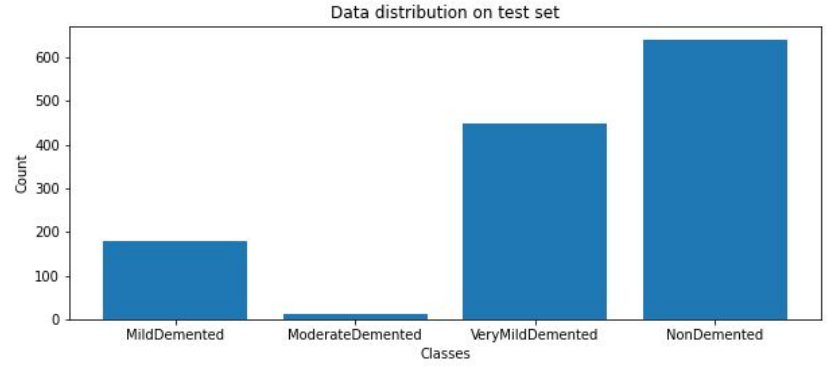
EfficientNet-B7 has few parameters, while achieving high accuracy in image classification (Imagenet)


#channels
layer_i
resolution HxW
(a) baseline
wider
(b) width scaling
deeper
(c) depth scaling
higher resolution
(d) resolution scaling
wider
deeper
higher resolution
(e) compound scaling

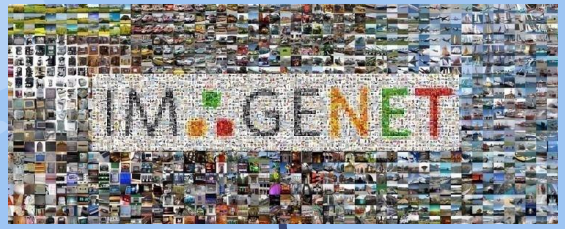
Methodology: Our Dataset



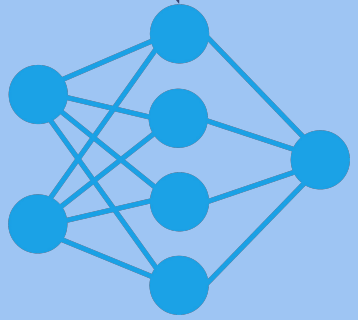




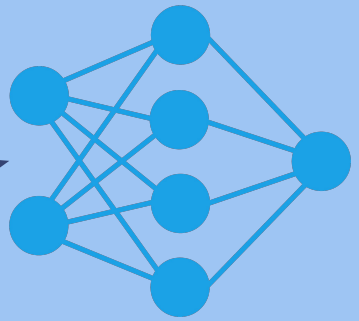
Methodology: Fine-Tuning EfficientNet B7

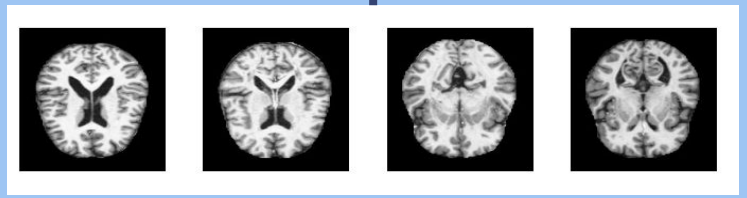


Training

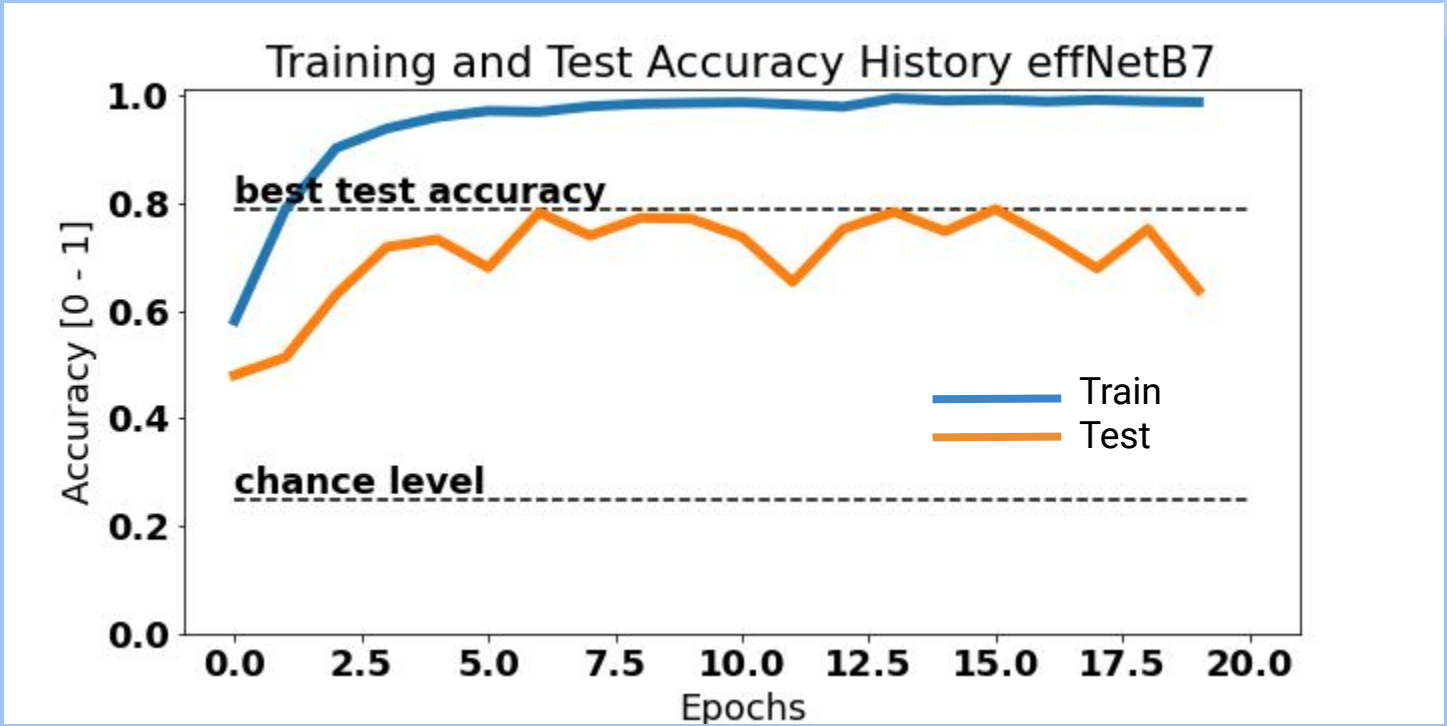


Fine-Tuning

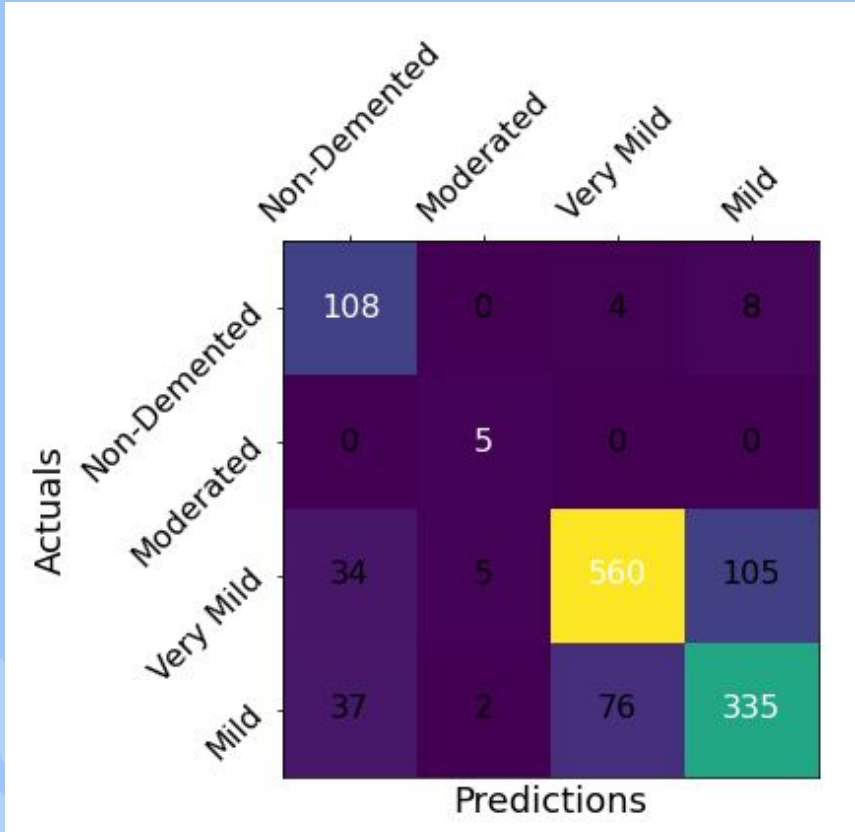


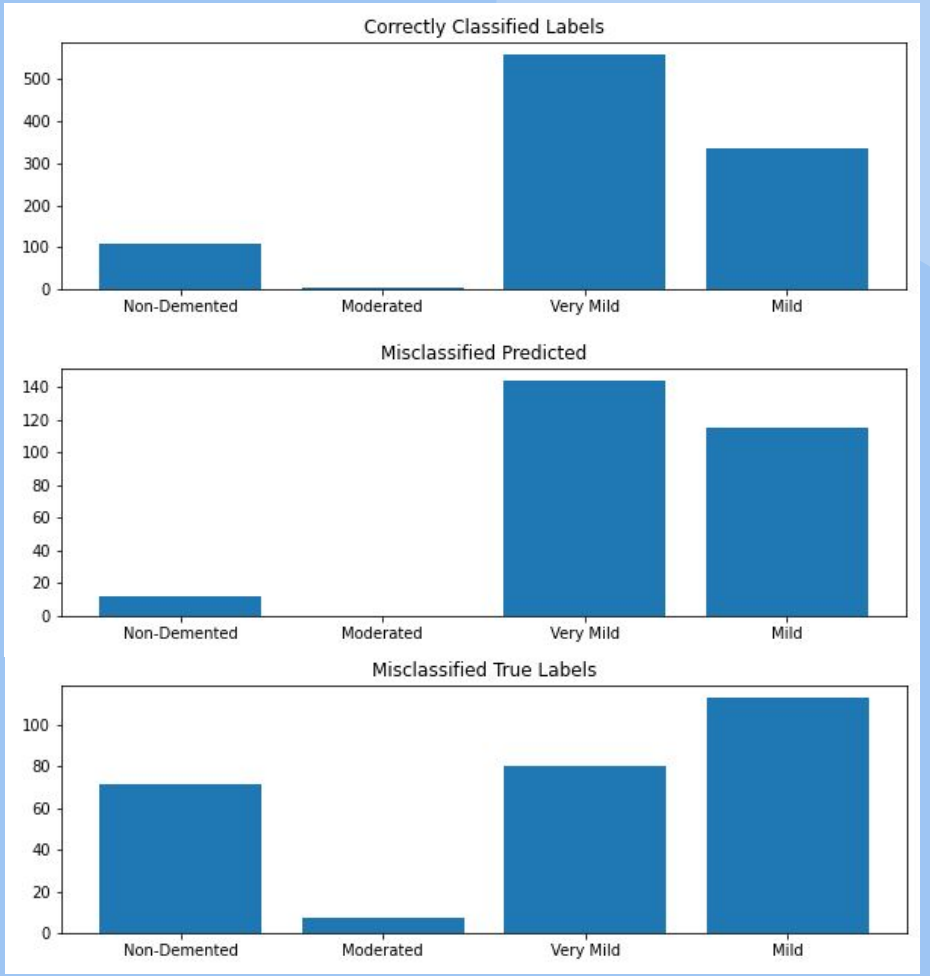


RESULTS: EfficientNet-B7 Validation



RESULTS: Misclassified examples





Pre-processing: Fitting the Biological data to Deep Neural Network

Image segmentation: delineation of the region of interest (ROI) in two-dimensional (2D) or of the volume of interest (VOI) in three-dimensional (3D) approaches.

Image Processing: divided into: Interpolation to isotropic voxel spacing, Range re-segmentation and intensity outlier filtering (normalization), and discretization of image intensities inside the ROI/VOI.

Feature Extraction: where feature descriptors are used to quantify characteristics of the grey levels within the ROI/VOI. However, adherence to the (IBSI) guidelines is recommended

Deep Learning suggested solution: Data Augmentation

Image manipulations

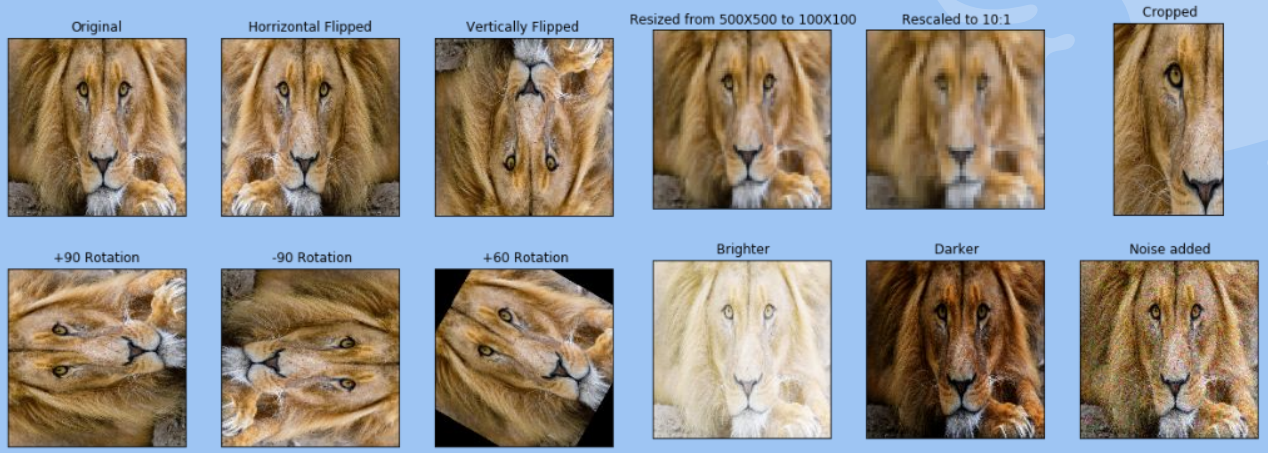
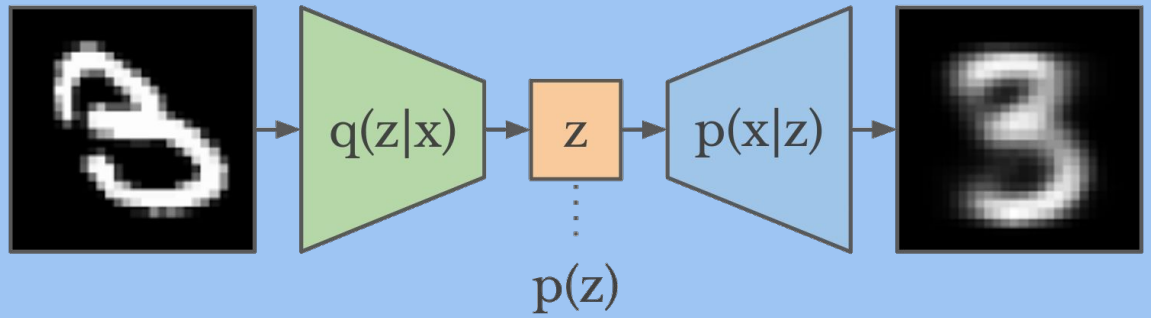


Image Generation (VAE)

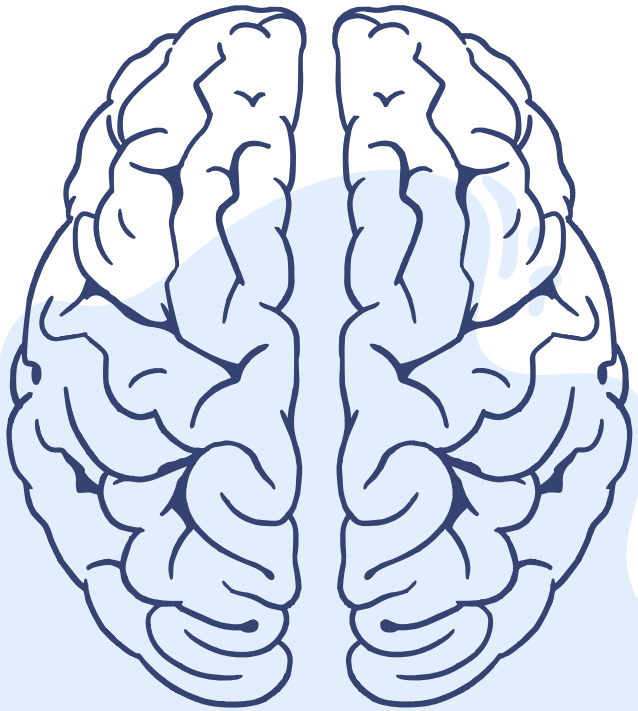


Use of Multimodal Data: building more reliable model

ID	M/F	Hand	Age	Educ	SES
OAS1_0001_MR1	F	R	74	2	3
OAS1_0002_MR1	F	R	55	4	1
OAS1_0003_MR1	F	R	73	4	3
OAS1_0004_MR1	M	R	28		
OAS1_0005_MR1	M	R	18		
OAS1_0006_MR1	F	R	24		
OAS1_0007_MR1	M	R	21		
OAS1_0009_MR1	F	R	20		
OAS1_0010_MR1	M	R	74	5	2
OAS1_0011_MR1	F	R	52	3	2
OAS1_0012_MR1	M	R	30		
OAS1_0013_MR1	F	R	81	5	2

Conclusion:

- The number of people who suffer from Alzheimer, Dementia and neurological diseases are increasing and early diagnosis allows us to access to broader types of treatment
- Segmenting the hippocampus region might help in improving the accuracy of the model
- We used a pre-trained light and high performance Convolutional Neural Network, fine-tuned in our dataset of Alzheimer's disease resonance images.
- Some images were misclassified, and we propose methods like a better pre-processing, image augmentation and use of multimodal data.



THANK YOU

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RESOURCES

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