Early diagnosis of Alzheimer with DeepLearning

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The Problem

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- **Alzheimer's disease (AD)** is a neurological pathology that affects more than **47 million people** worldwide, being the first cause of neurodegenerative dementia.
- Its prevalence is estimated to be around 5% after 65 years old and a staggering 30% for the more than 85 years old in developed countries.
- From now to **2050** it is estimated that **640 Million people** in the world will be diagnosed with AD.
- The most **common symptoms are problems in remembering, reasoning, orienting**.
- **It has become** a major **social and economic** issue and its effects are devastating not only for the diseased but **also for their families**.
- For effective treatments to be administered that are capable **to slow down the progression** of the disease, **an early** and definite **diagnosis** is necessary.

The Old Solution

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Diagnosis of AD is still primarily **based** on:

- Mental status testing
- Neuropsychological tests
- Interviews with friends and family
- Measurement of **cerebrospinal fluid** (CSF), **invasive**
- **Rachisynthesis**, which is **painful and dangerous** for a patient

Early diagnosis requires an investigation of the pre-dementia, called **Mild Cognitive Impairment (MCI)**, that is a condition in which an individual's thinking ability shows some mild changes. This stage involves the challenging question of **predicting** whether MCI will **(MCIc) or will not (MCInc) convert** to AD.

Our New Solution

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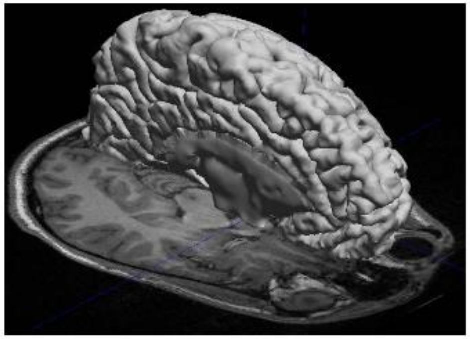

3D MRI picture

→ Ensemble of Machine Learning Algorithms →

"The patient has the **75%** of probability to contract **Alzheimer**'s disease in the **next 2 years**."

Our solution is **based** on the **classification of** Magnetic **Resonance** scans (MRI) **with DeepLearning Algorithms.** Not Invasive, not dangerous

Particularly our approach consist in solving **three binary classification problems**:

- CN vs AD
- CN vs MCIc
- MCInc vs MCIc

Why DeepLearning?

Nowadays, deep learning is becoming a leading machine-learning tool in the general imaging and computer vision domains. In particular, **convolutional neural networks (CNNs)** have presented **outstanding** effectiveness on **medical image computing problems**. Some examples:

- Prof. Greenspan, Tel Aviv University, Israel: employed CNN to improve three existing CAD systems for the recognition of colonic polyps on CT colonography, sclerotic spine metastases on body CT and enlarged lymph nodes on body CT.
- Prof. Qi Dou, **Imperial College London:** used 3D CNN and weighted **MRI scans to detect cerebral microbleeds.** They address developed predictions with their 3D CNN compared to various classical and 2D CNN approaches.
- Prof. Rajpoot, University of Warwick, UK: employed CNNs to detect nuclei in histopathological images.
- Prof. Anthimopoulos, University of Bern, Switzerland: employed CNNs to detect patterns of interstitial lung diseases from 2D patches of chest CT scans.

Their results show that CNNs can outperform existing methods that use hand-crafted features.

Image Extraction

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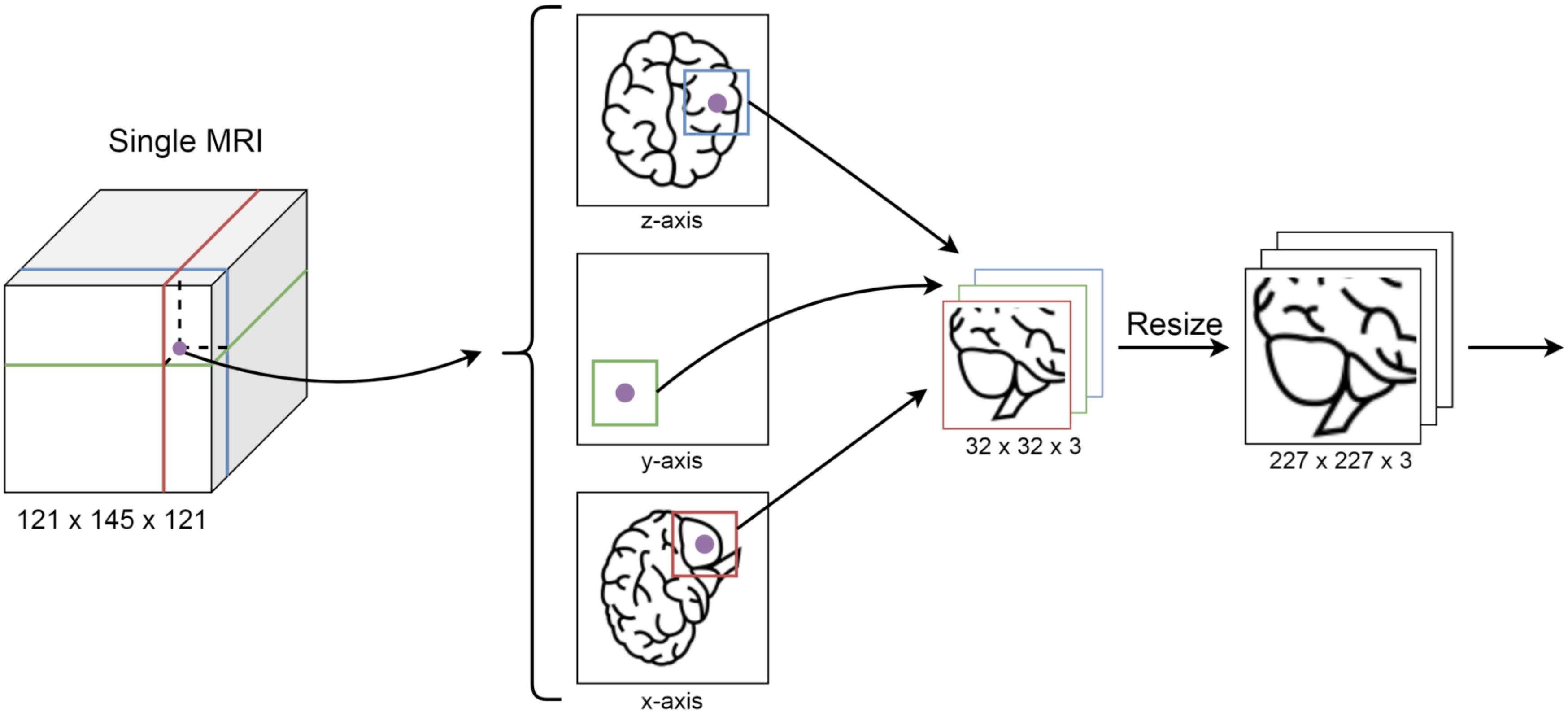
MRI are 3D so **to make them 2D** we used the following **image extraction operation:** for a given voxel point, three patches of MRI 32x32 are extracted from the three planes, concatenated into a three-channel picture and resized in order to match the input size of the neural network.



Example

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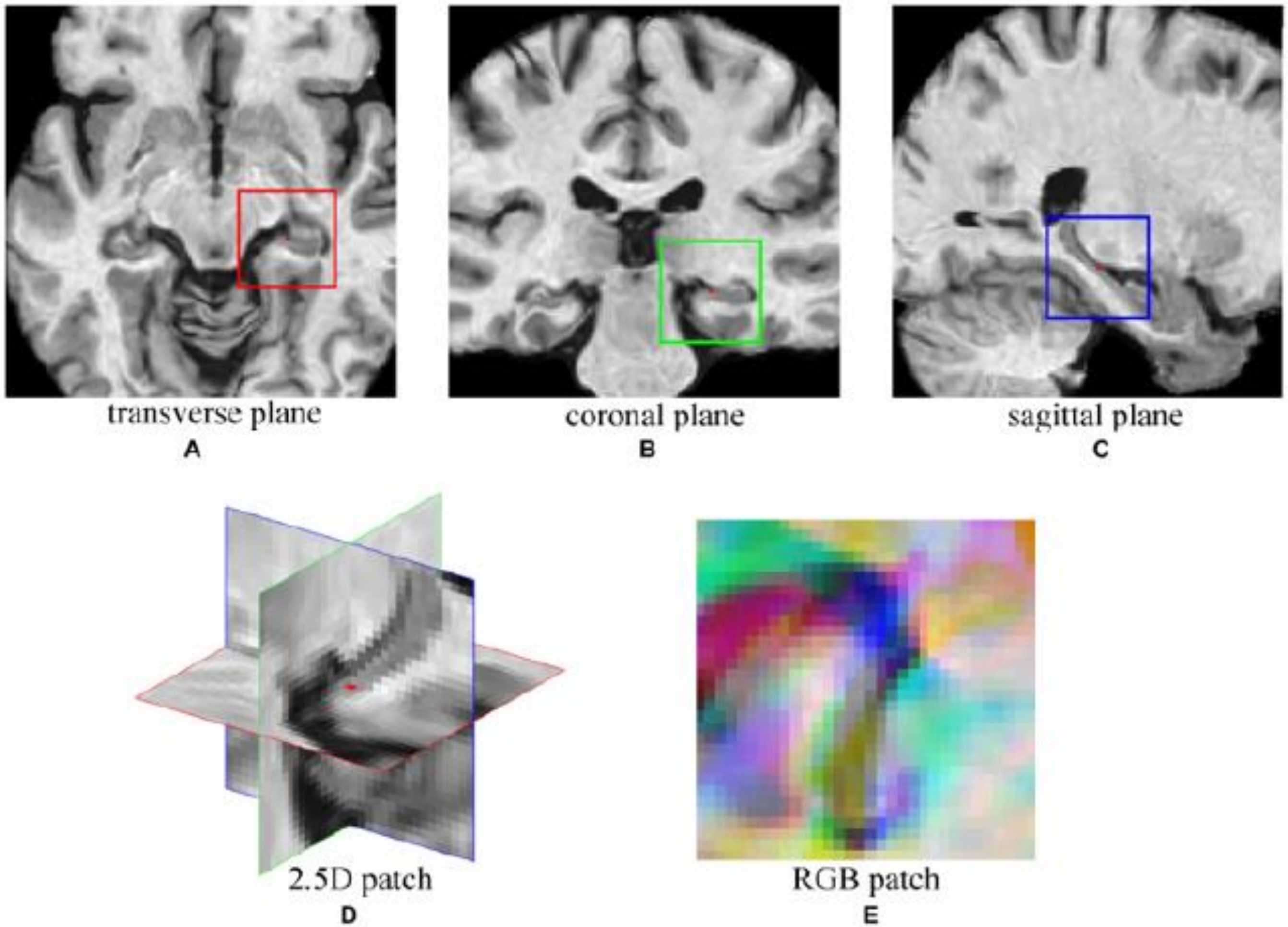

Figure 3.1: Example of image extraction operation.

Production Architecture

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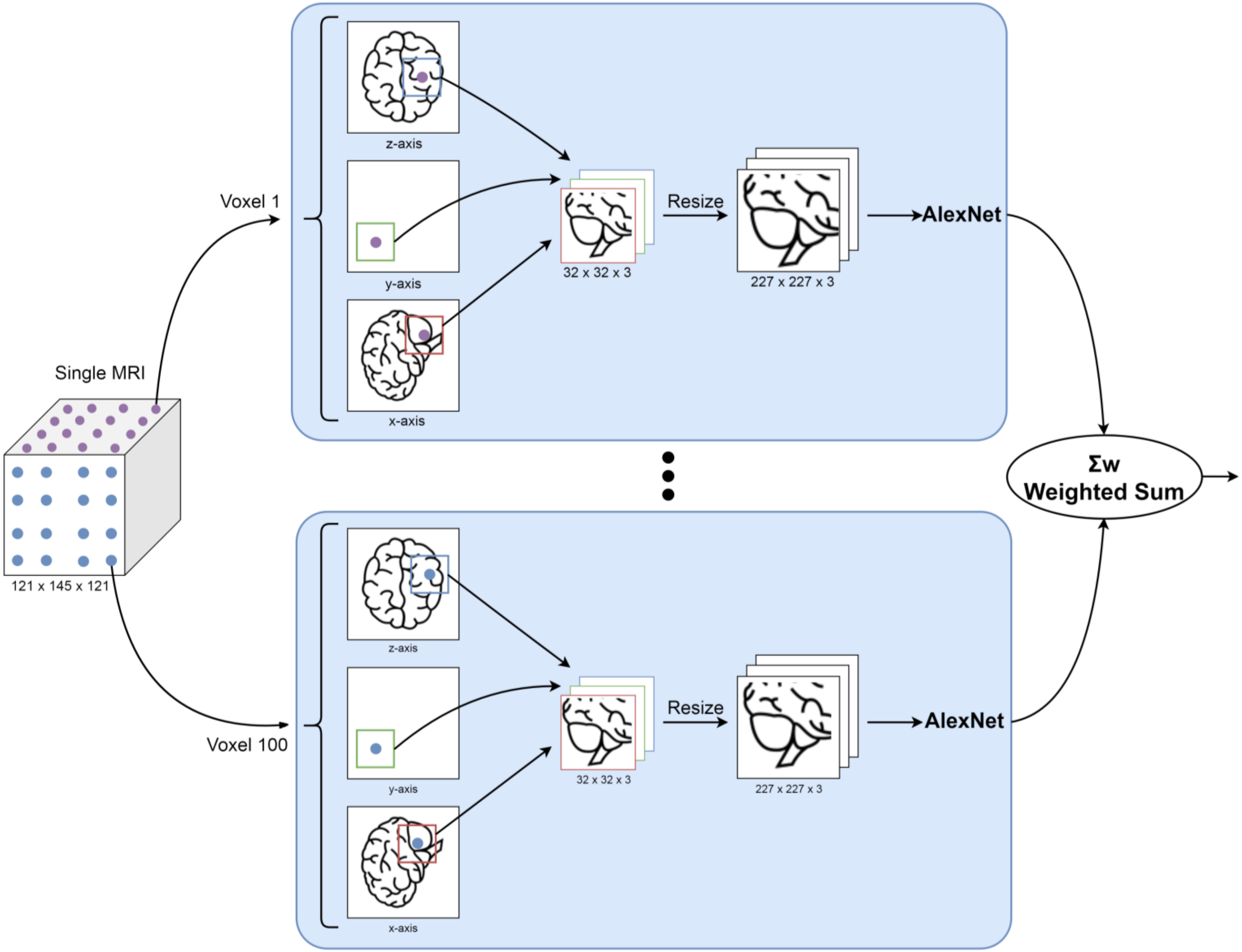

Training Architecture

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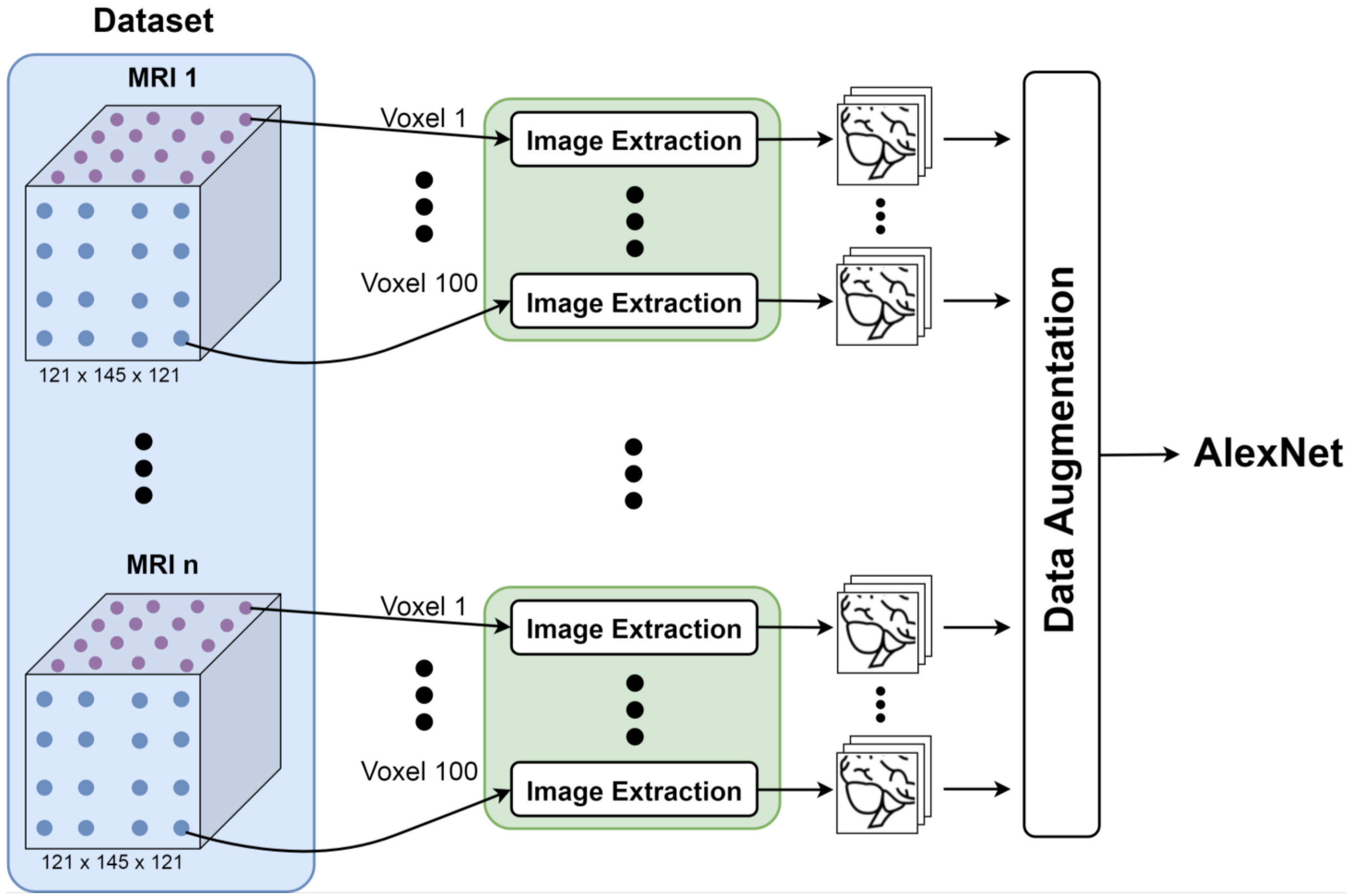
- Extract 100 pictures from each MRI
- Perform some data augmentation
- Fed them into AlexNet



Architecture

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A key challenge in applying CNNs is that sufficient training data are not always available in medical images. To avoid Over/Under-fitting:

- **Data Augmentation:** In case of medical images this often comes down to **mirror flipping**, small-magnitude translations, weak Gaussian blurring, **brightness augmentation** and **shadow augmentation**.
- **TransferLearning from AlexNet: training** CNN **from scratch** is usually challenging owing to the limited amount of labeled medical data. A promising alternative is to fine-tune the weights of a network that was trained using a large set of labeled natural images.
    - Prof. Tajbakhsh, Illinois Institute of Technology: considered several medical imaging applications and investigated how the performance of **CNNs** trained **from scratch compared** with the **pre-trained** CNNs. Their experiments demonstrated that pretrained **CNNs performed better** than CNN trained from scratch.

Performances

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Due to the **lack of** memory (RAM) and **computational power** given to us, as we were undergraduate students: Instead of converting each MRI in 100 pictures, we have extracted only 8 pictures for each MRI, Trained on 3 folds instead of 20, haven't performed any data augmentation. However, **our supervisor will execute more exhaustive tests**.

CN vs AD:

Fold	TP	TN	FP	FN	precision	recall	f1	specificity	accuracy
1	26	56	32	6	0.4483	0.7595	0.6471	0.8125	0.6833
2	60	29	19	12	0.7595	0.833	0.7947	0.3958	0.7417
3	11	74	6	29	0.6471	0.2750	0.3860	0.0750	0.7083

Average Accuracy: 0.7111

CN vs MCIc:

Fold	TP	TN	FP	FN	precision	recall	f1	specificity	accuracy
1	10	47	17	14	0.3704	0.4167	0.3922	0.2656	0.6477
2	16	52	12	16	0.5714	0.5000	0.5333	0.1875	0.7083
3	6	56	8	26	0.4286	0.1875	0.2609	0.1250	0.6458

Average Accuracy: 0.6673

MCInc vs MCIc:

Fold	TP	TN	FP	FN	precision	recall	f1	specificity	accuracy
1	4	49	7	20	0.3636	0.1667	0.2286	0.1250	0.6625
2	1	46	2	31	0.3333	0.0313	0.0571	0.0417	0.5875
3	4	52	4	20	0.5000	0.1667	0.2500	0.0714	0.7000

Average Accuracy: 0.6500

Conclusions

Conclusions:

- The tests showed that our model was **very good at classify CN vs AD**, that is an extraordinary results, because today to recognize if a person has Alzheimer different invasive medical tests must be done. With our model we need just a Magnetic Resonance.
- Unfortunately CN vs MCIc and MCInc vs MCIc problems doesn't reach good results, we think most of the problem is due to the lack of computational power.

Future Work:

- Try different hyper-parameters during training
- Change the **structure** of the **network** using:
  - pretrained **VGG-19** or **Inception v4**
  - **3D-Convolution**

Thank You

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Thanks for your attention!

Any questions?