Study of pulse-coupled neural networks for glioma segmentation.

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CONTEXT

Towards lighter diagnosis solutions

- High interest for **computer aided diagnosis**
- **Deep Learning** as a solution for medical image analysis
  - Training models is **time** consuming
  - Need for expensive dedicated **hardware**
  - High energy cost
- Rise of **biologically plausible** solutions
- Image processing using **Pulse-coupled neural networks**

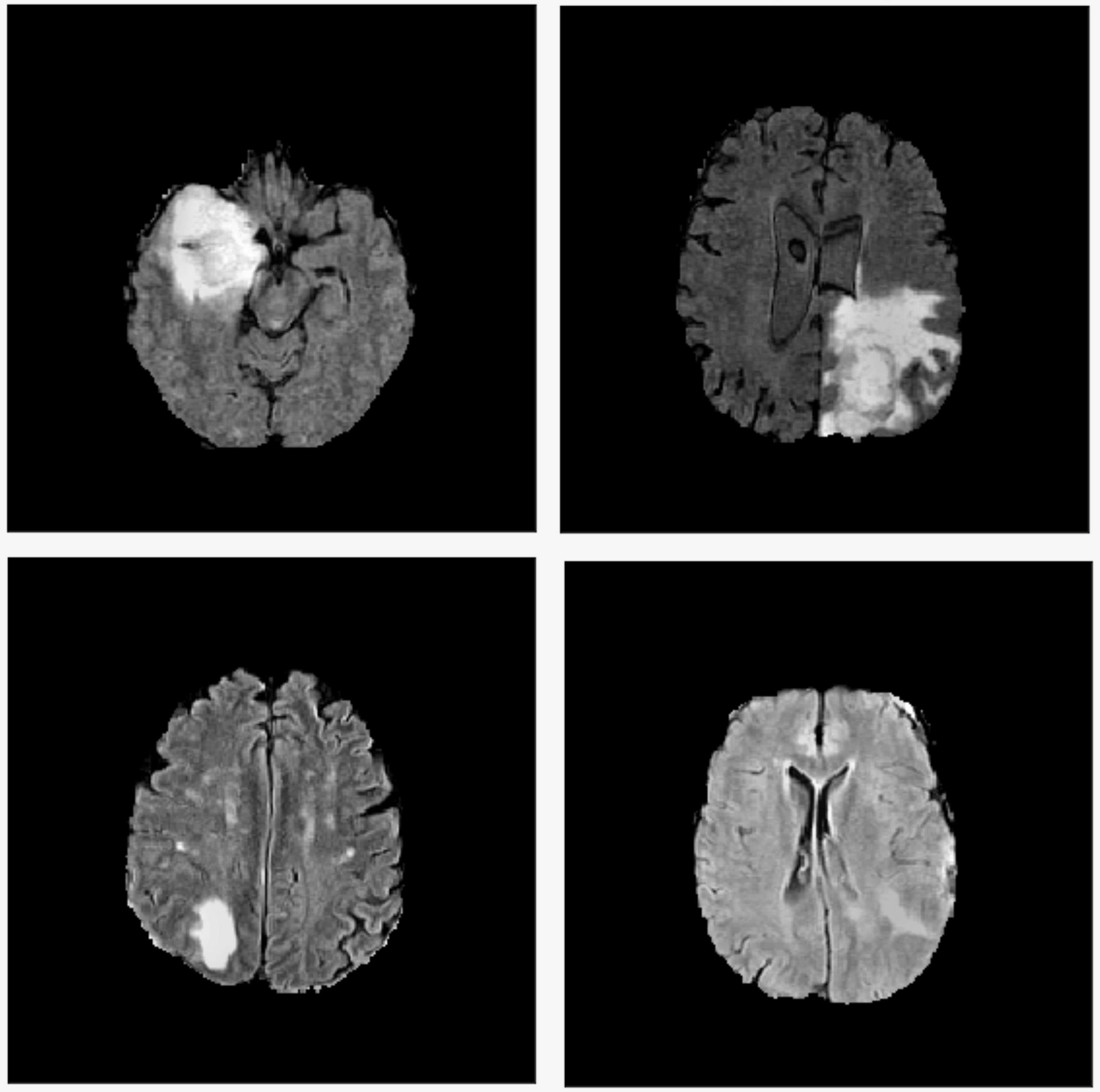

Fig 1. Example of MRI

02 METHODS

BRaTS 2020 Dataset

Dataset info :

- Pre-operative MRI scans
- **Manually** segmented by 1-4 raters
- Four MRI sequences : **Flair, T2, T1, T1C**
- Contains **3** unhealthy cell labels
- Focused on **segmentation** and **overall survival**

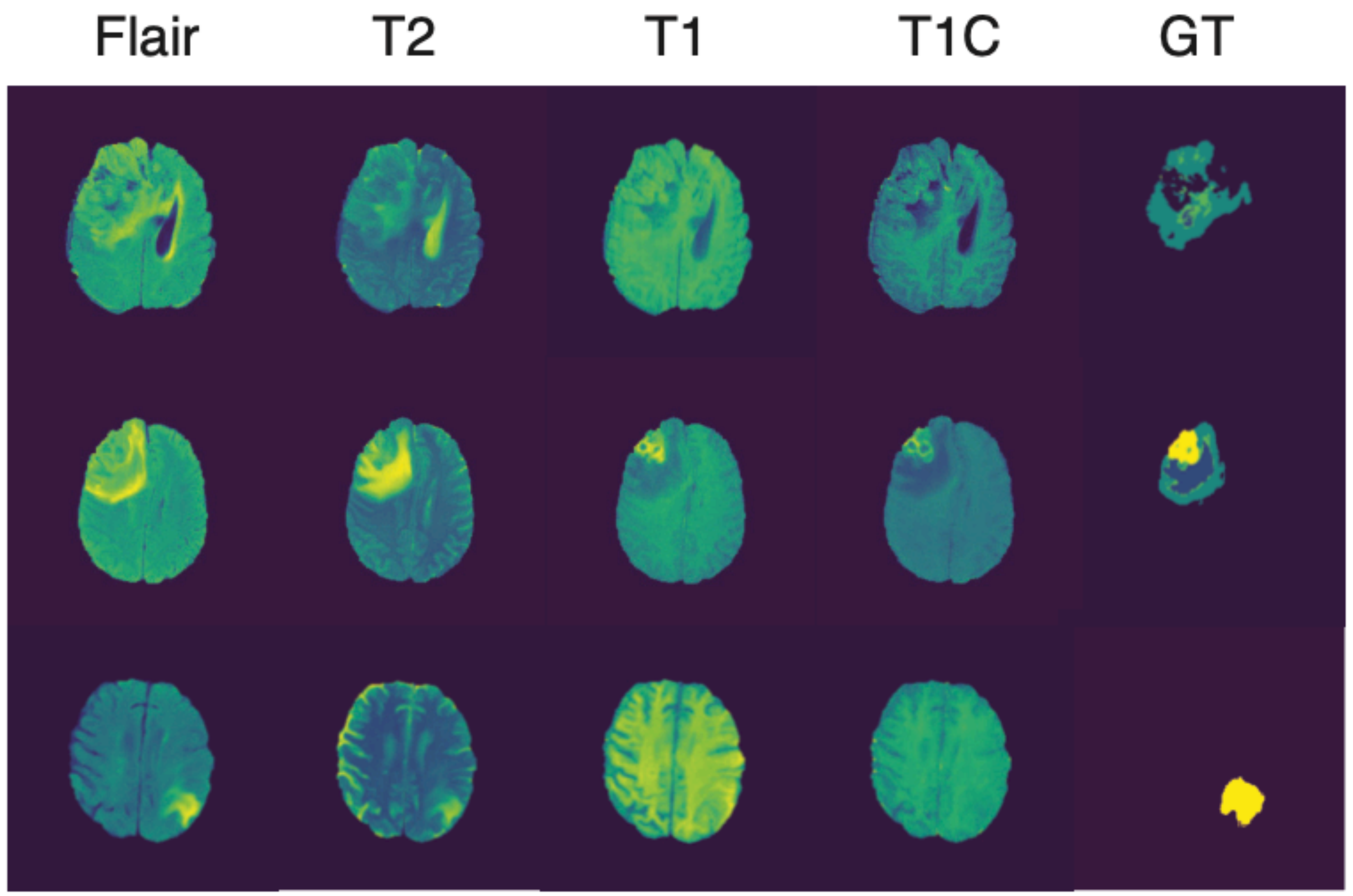

Fig 2. MRI cases taken from the BRaTS Dataset

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METHODS

BRaTS 2020 Dataset

Pixel intensity normalization and histogram matching applied

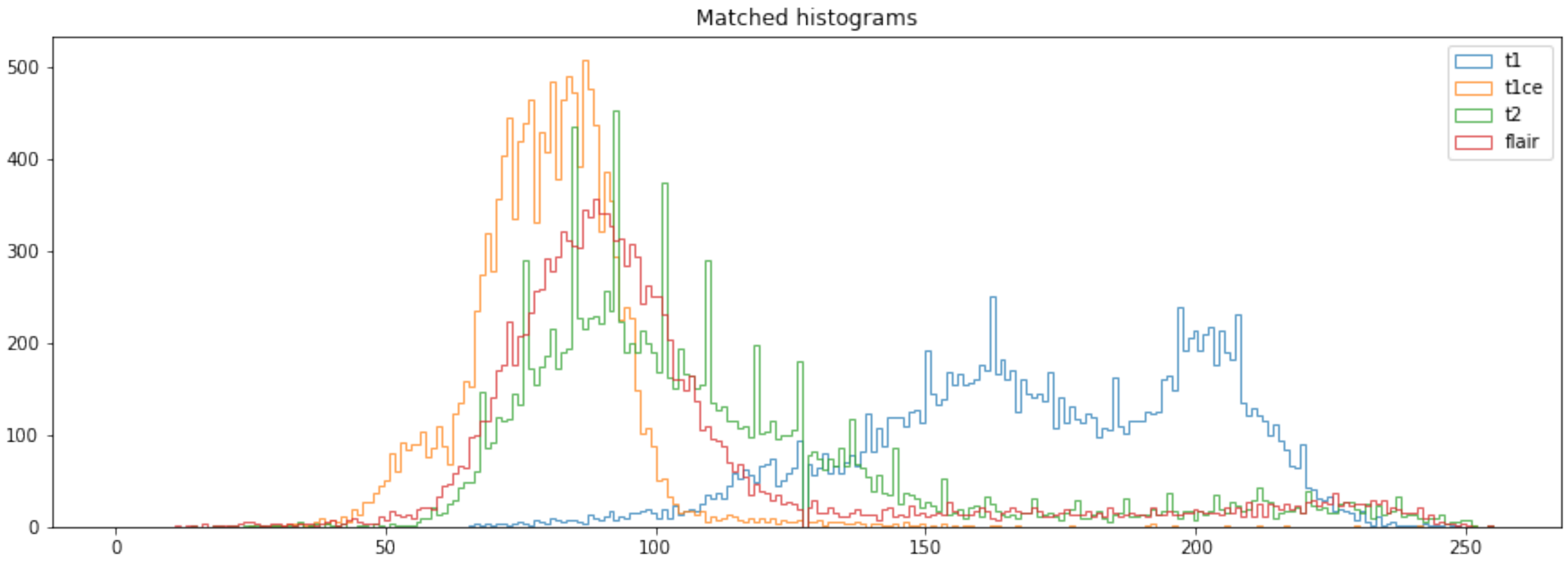

Fig 3. MRI sequence histogram matching

02 METHODS

BRaTS 2020 Dataset

Fusion strategy using Discrete Wavelet Transform

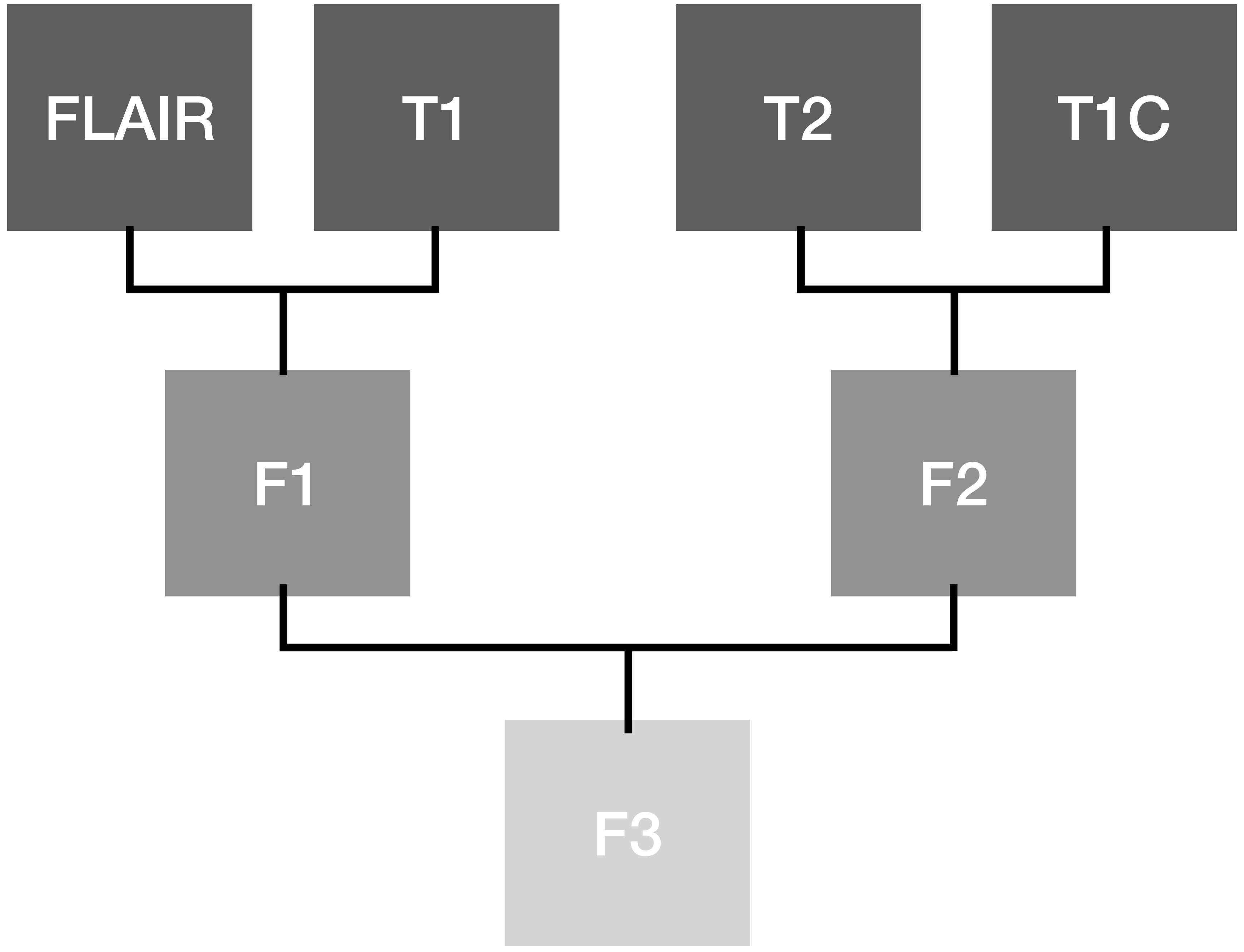

Fig 4. DWT computation tree

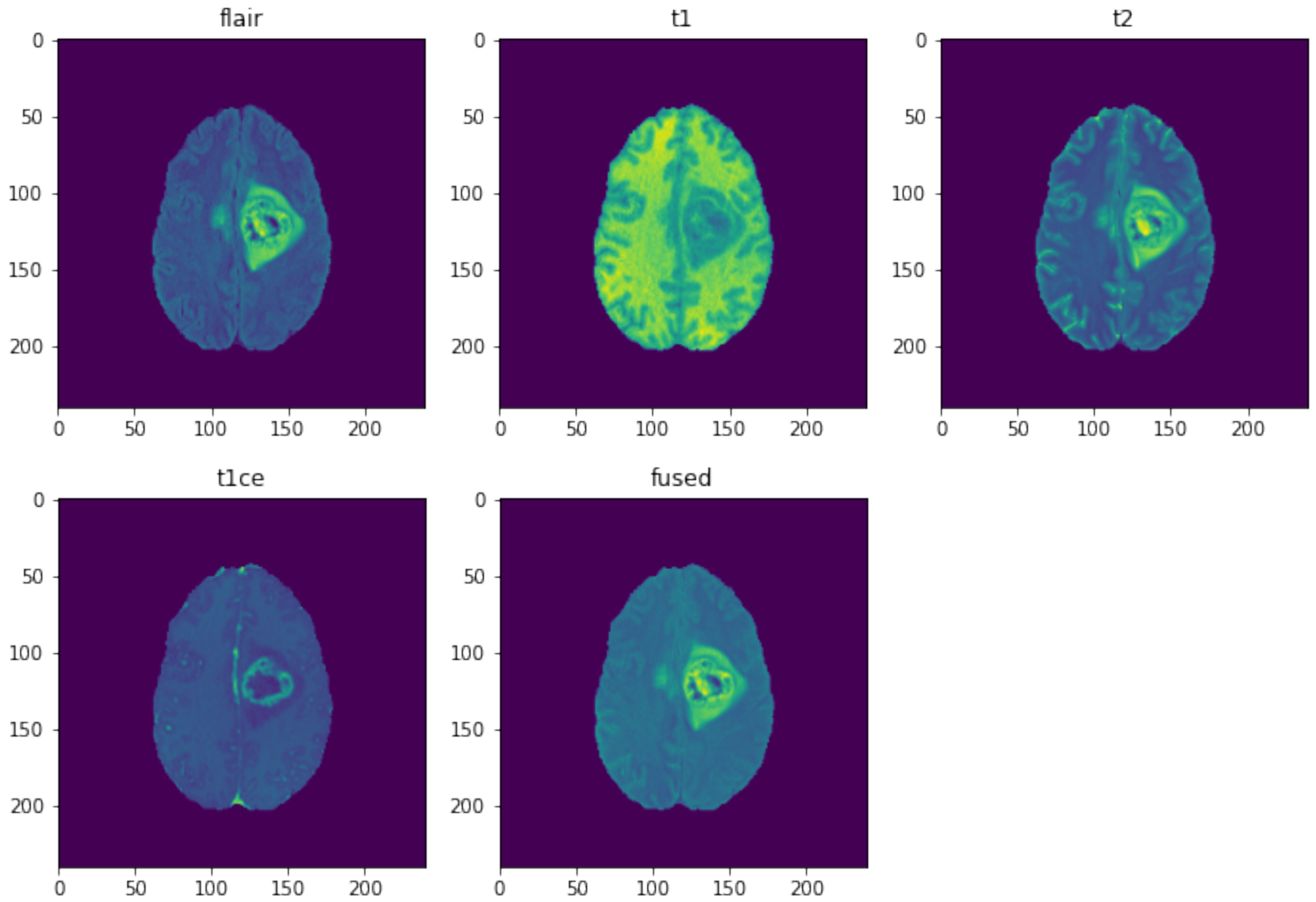

Fig 5. Sequences and fused image

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METHODS

PCNN Models

Standard PCNN :

- Laterally-connected neurons
- 2D input image
- **Feeding :** Computes voltage with input stimulus
- **Linking :** Updates neuron's internal activity
- **Pulse :** Fire if membrane potential exceeds threshold

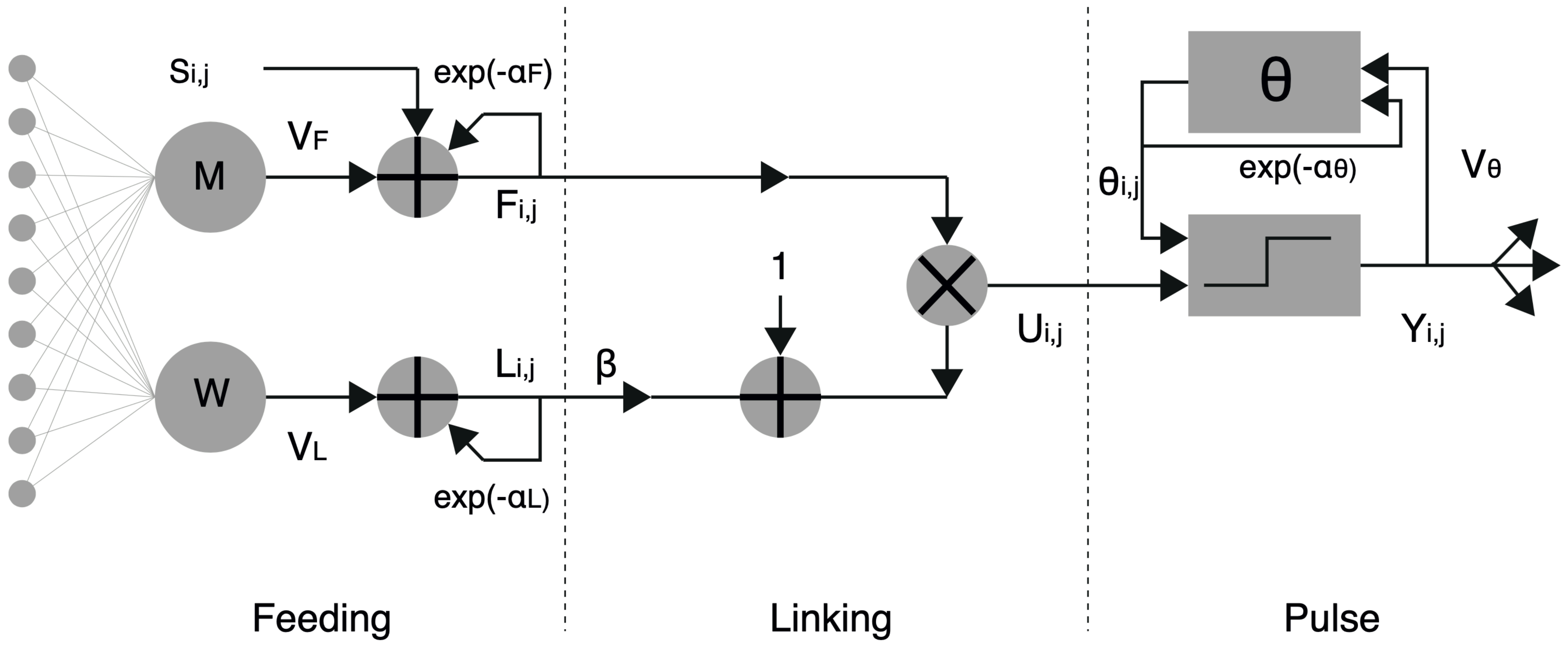

Fig 6. Standard PCNN

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METHODS

PCNN Models

Unit-linking

- Simplified version of PCNN
- Reduced computational cost
- Reduced parameters

Changes

- **Feeding :** Now equal to the intensity of a pixel
- **Linking :** Allows a neuron to fire when one or more neighbors fired

Fast-linking

- Uses Spiking cortical neurons
- Fast linking synapses
- Neurons fire faster

Changes

- **Feeding :** As for Unit-linking
- **Pulse :** Combines stimulus and synaptic modulation to charge the membrane

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METHODS

PCNN Models

Parameters settings :

- Differential Evolution for optimization
- Dice Score as loss function $\frac{2|Y \cap \hat{Y}|}{|Y| + |\hat{Y}|}$
- Iteration number constrained to 10

Model	Standard PCNN	ULPCNN	FLSCM
β	0.47	0.47	0.44
α_θ	0.0125	0.015	-
α_F	0.96	-	-
α_L	0.81	-	-
V_θ	20	20	20
V_F	0.21	-	-
V_L	0.36	-	-
W	3x3 gaussian kernel	-	-
M	W	-	-
α_U	-	-	0.49

Table 1. Parameters used for our experiments

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RESULTS

Segmentation Evaluation

- Segmentation evaluated with Dice Score
- Iteration can be stopped if best dice score has been found.
- Fast-linking average running time : **17 seconds**
- Unit-linking average running time : **17 seconds**
- PCNN average running time : **60 seconds**

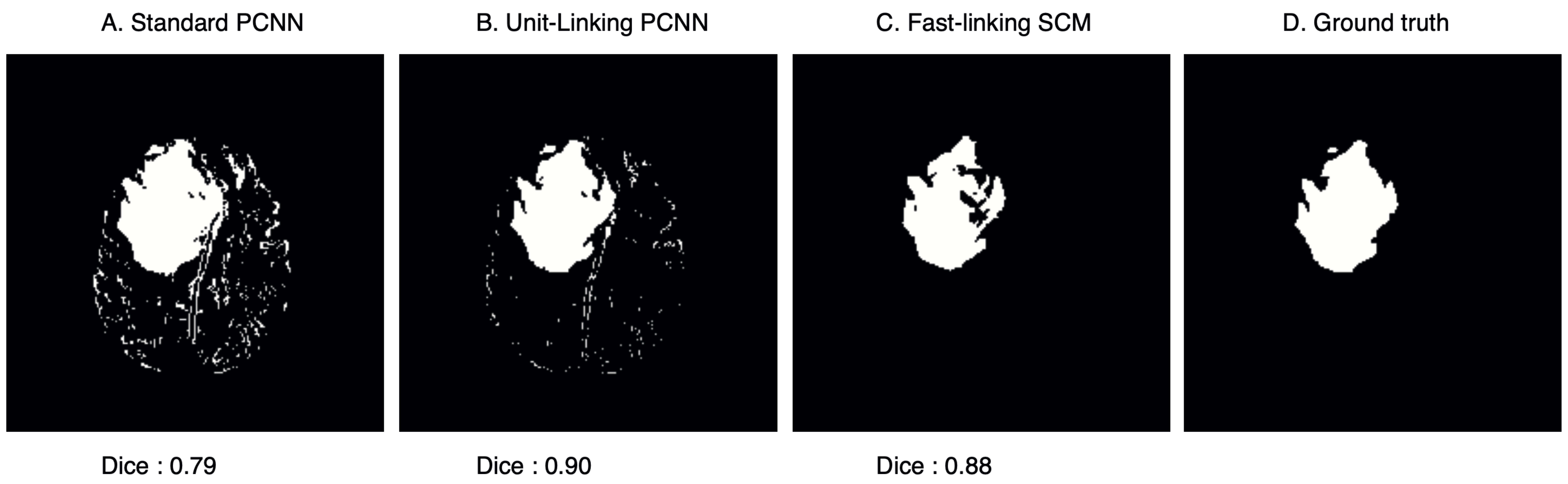

Fig7. Results of PCNN based segmentation

04 CONCLUSION

- Experiments proved the efficiency of PCNN models
- Fast computation makes PCNN a **perfect fit for diagnosis tasks**
- **Differential Evolution** coupled with **Dice Loss** appeared efficient for segmentation parameters optimization

- Multi-channel versions could be use for **semantic segmentation**
- PCNN can be coupled with a **spiking classifier**

Thank you.

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