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EXPLAINABLE DEEP LEARNING MODELS FOR DEMENTIA IDENTIFICATION VIA MAGNETIC RESONANCE IMAGING

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Background

Today, to diagnose dementia, clinicians evaluate cognitive tests performed by patients and briefly analyze brain imaging data to look for biomarkers. While valuable information is present in MRI scans, these latter remain challenging to analyze and interpret. Artificial intelligence models have shown promising results to improve the current practice by supporting practitioners in the evaluation of imaging data. Most developed statistical models are more often than not black-box systems that issue predictions with no clear interpretability, hindering their practical applications.

Methods

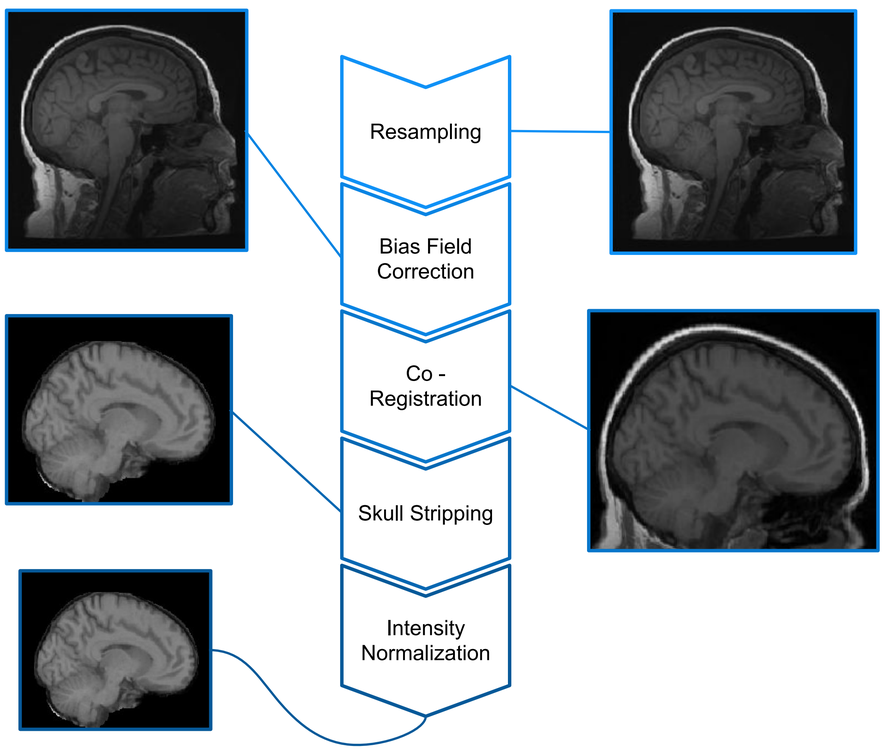

Figure 1: Prepossessing pipeline applied to the raw MRI.

We propose an interpretable method based on deep learning that works on minimally preprocessed (see Figure 1) T1-weighted 3D scans of the brain. Relying on FullGrad [2], we can dissect the predictions of the model given an input scan. Once the model is trained, it can not only give an automated diagnostic but also generate a heatmap highlighting the regions of the brain that our model points to be responsible for its prediction of dementia. To ensure practicality, we integrate our model in a convenient app that can smoothly be run from a browser, as shown in figure 4.

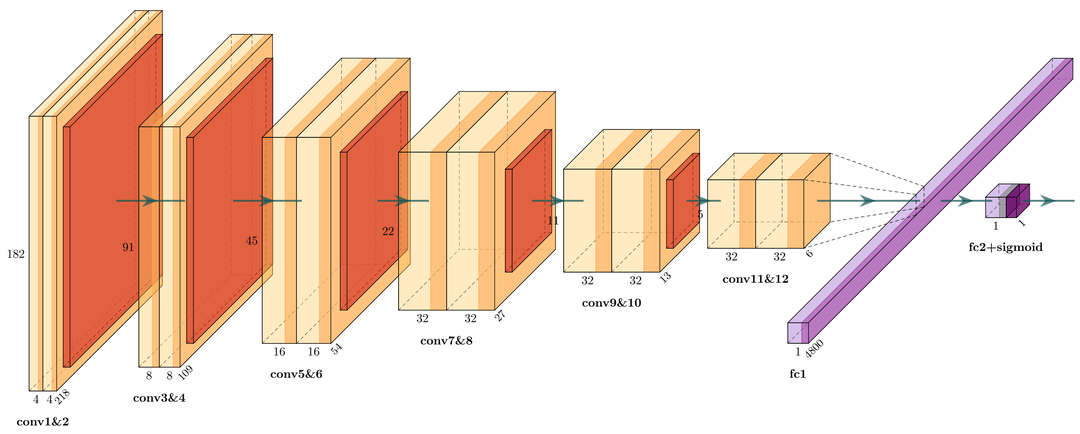

Figure 2: Architecture of the 3D based CNN model used for prediction. For visual purpose the MRI image of shape (182, 218, 182) is represented as an image of shape (182, 218)

Results

We trained and evaluated our model on the OASIS [1] dataset. The specific explanation obtained by our model points at well-known biomarkers, notably by highlighting the voxels of the hippocampus of patients with dementia. Interestingly, as it can be seen in figure 3, we notice that across individuals, our model focuses more on the voxels located in the right hippocampus.

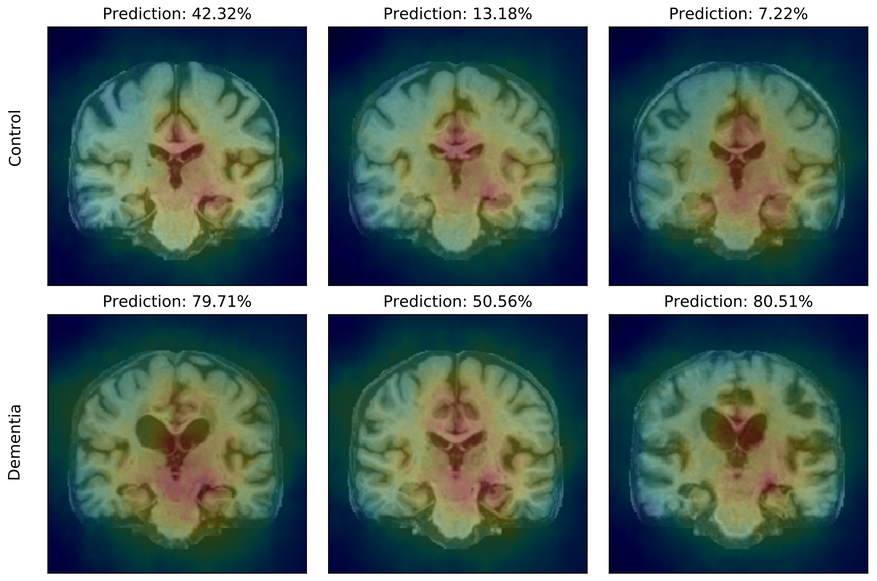

Figure 3: Outputs of the fullgrad algorithm, the first row is composed of control patients and the second one of dementia patients.

Conclusion

In this study, we show how machine learning can identify dementia patients using MRI images while ensuring interpretable decisions of the models. Our tools, including the bespoke "explainer" viewer overlaid on each patient's brain, will enable the development of better and more reliable machine-learning based diagnostics and nurture the trust of practitioners in computer-aided diagnostics. Furthermore, this will help to discover currently unknown biomarkers and thus lead to a better understanding of the disease.

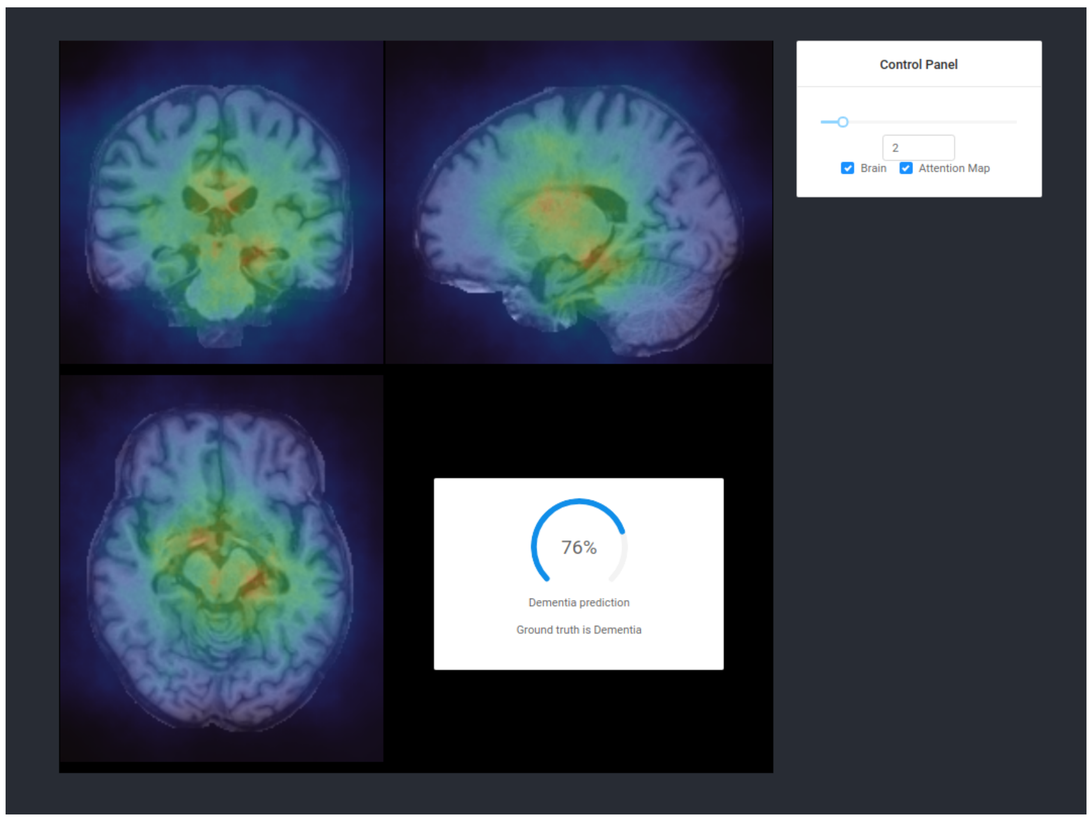

Figure 4: Screenshot of the brain viewer we developed.
More at https://github.com/cgallay/BrainViewer

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References

[1] P. J. LaMontagne, T. L. Benzinger, J. C. Morris, S. Keefe, R. Hornbeck, C. Xiong, E. Grant, J. Hassenstab, K. Moulder, A. Vlassenko, M. E. Raichle, C. Cruchaga, and D. Marcus. Oasis-3: Longitudinal neuroimaging, clinical, and cognitive dataset for normal aging and alzheimer disease. *medRxiv*, 2019.

[2] S. Srinivas and F. Fleuret. Full-gradient representation for neural network visualization, 2019.