MRI to MGMT: Predicting Drug Efficacy for Glioblastoma Patients

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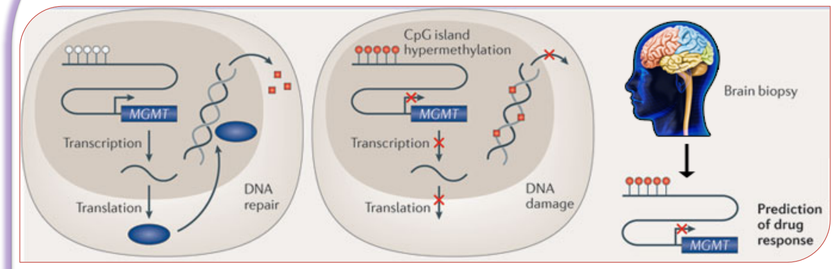
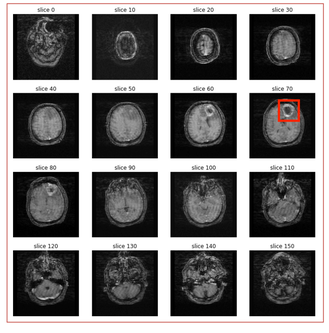
Introduction

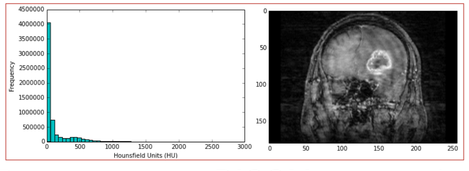


- **Glioblastoma multiforme** (GBM) is an aggressive brain cancer, with a median survival of only 15 months.
- The efficacy of primary chemotherapy treatment, **temozolomide**, is dependent on the methylation of the **O_6-methylguanine methyltransferase (MGMT)** promoter.
- Currently, invasive biopsy procedures are required to determine methylation status and select therapies.
- Genetic changes can manifest as macroscopic changes, detected using **magnetic resonance imaging (MRI).**
- **Previous approaches:** Use of manually-curated features from MRI scans, SVM methods, or simple neural networks.

Datasets

- Brain MRI scans of Glioblastoma patients from **The Cancer Imaging Archive (TCIA)** and methylation data, for those patients, from **The Cancer Genome Atlas (TCGA)**.
- Patient has a 'positive' methylation status if **beta-value > 0.2** at any of three different methylation sites.





Preprocessing: DICOM conversion, Noise removal, Normalization

	Patients	MRI Sessions	Images
Positive	80	623	164,884
Negative	68	628	150,555

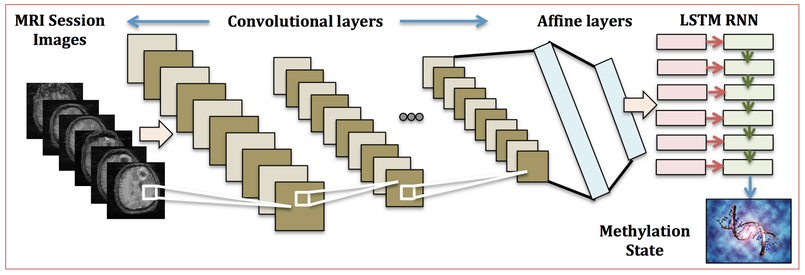
Problem & Intuition

Predict MGMT promoter methylation status in Glioblastoma patients by using different neural network architectures on brain MRI scans from The Cancer Imaging Archive.

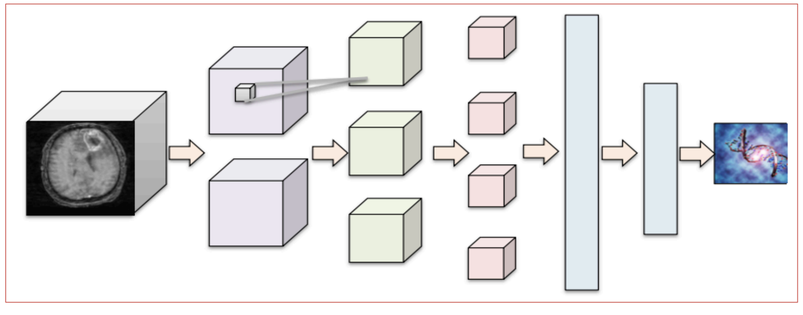
Intuition: MRI scans are 3D-reconstructions of the brain, and can also be treated similar to video objects.

Methods

Convolutional Recurrent Neural Network (CRNN)



3-dimensional Convolutional Neural Network (3D-CNN)



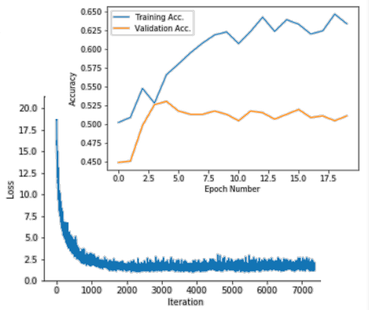
- Variable CNN-ReLU-Batchnorm-Pooling Layers, uni- and bi-directional dynamic RNNs with LSTM or GRU units.
- Optimized for dropout, L2-regularization, learning rates, number of layers, filter sizes and LSTM/GRU state size.

Acknowledgements

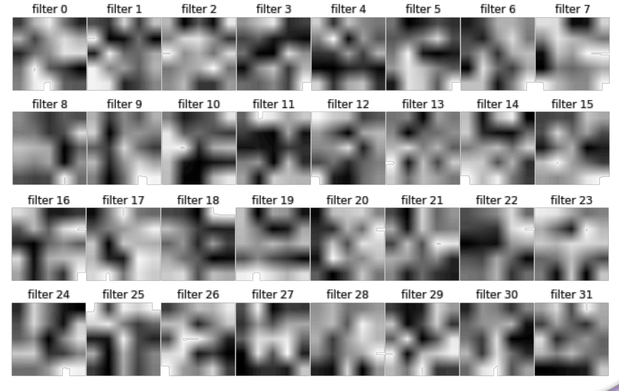
We would like to acknowledge the CS 231N staff.

Evaluation

Method	Train Acc	Val Acc
CNN	0.92	0.61
3DCNN	0.46	0.50
CNN + RNN	0.97	0.52
CNN + LSTM RNN	0.53	0.56
CRNN	0.65	0.56
Bidirectional CRNN	0.65	0.53



Visualization of the filters in the 1st CNN layer



Conclusions

- We applied multiple deep learning architectures to a compendium of 3D brain MRI scans.
- Filters from the first CNN layer appear to depict edges between cerebrospinal fluid and brain matter, with some containing heterogeneous areas that may correspond to tumor edges
- CNN on individual images attained the highest performance. However, many of these images do not contain the tumor. Thus, we believe CRNN has potential for achieving better performance, and will continue to optimize this classifier.