Multimodal Contrastive Learning and Tabular Attention for Automated Alzheimer's Disease Prediction

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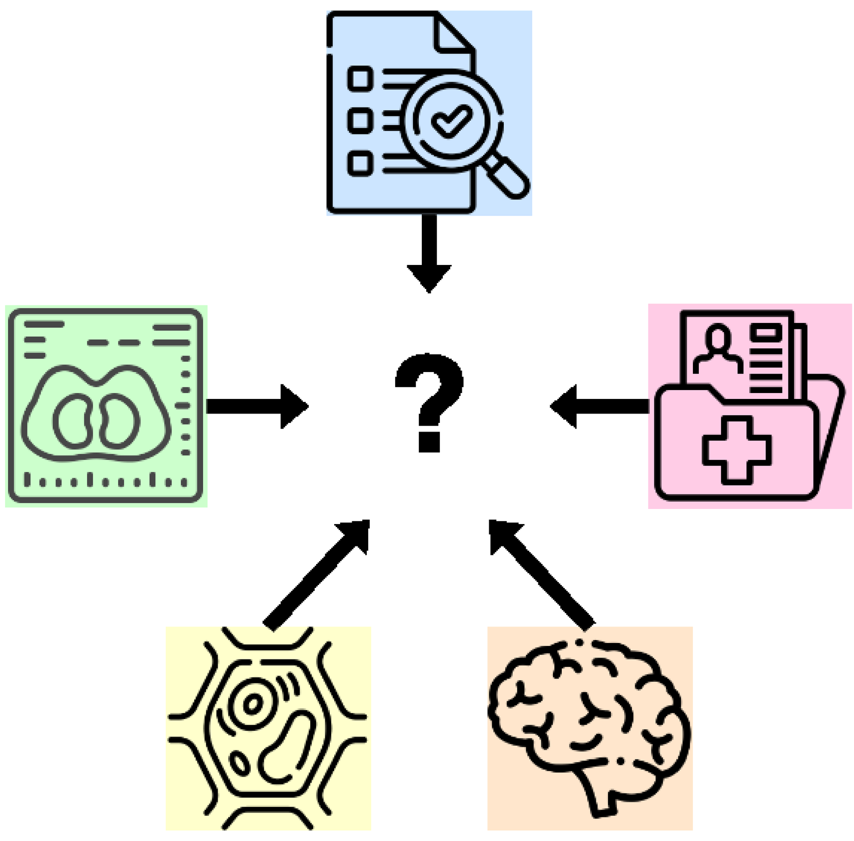
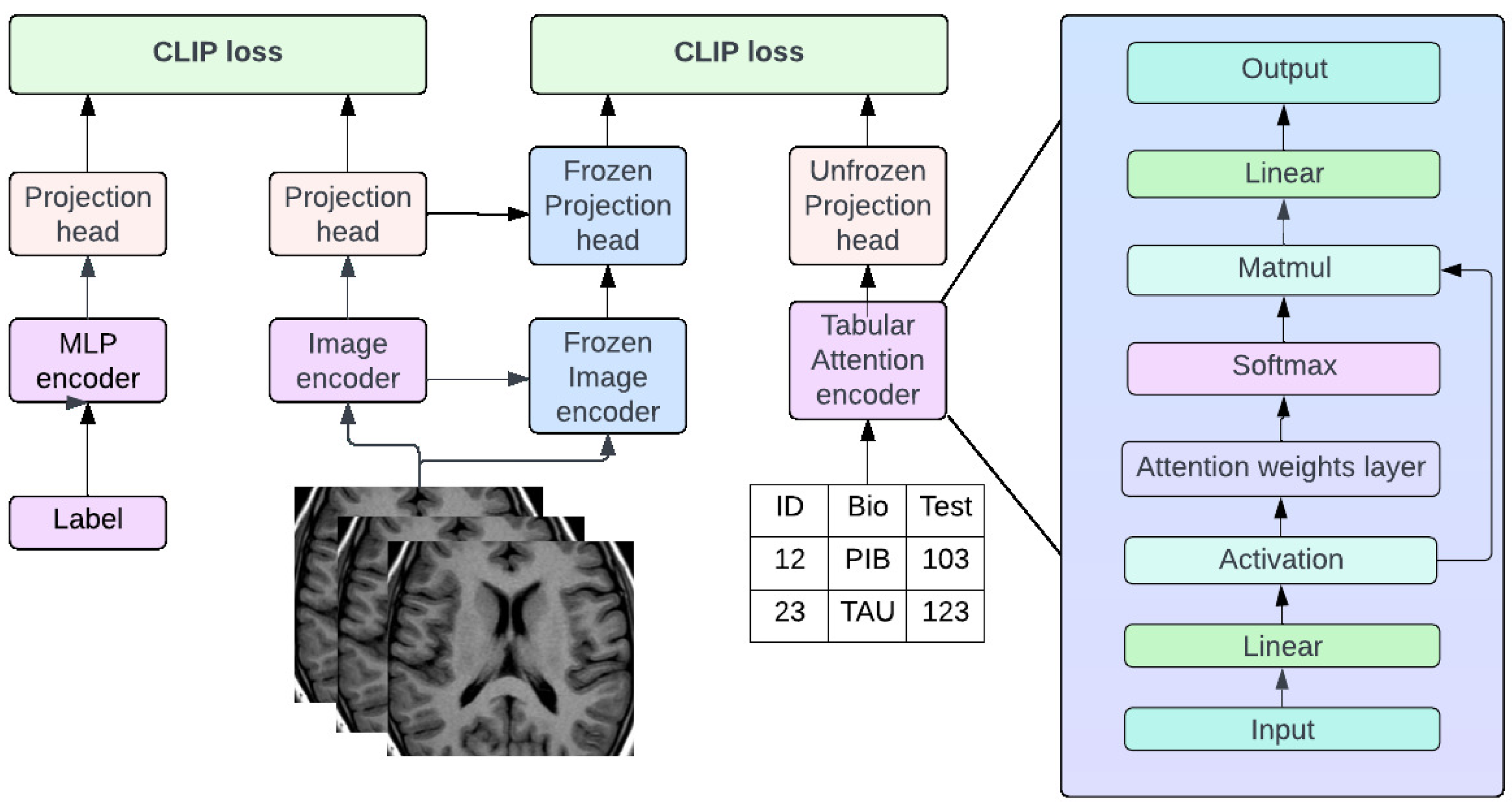
How can Alzhiemer's prediction be augmented with multimodal data?

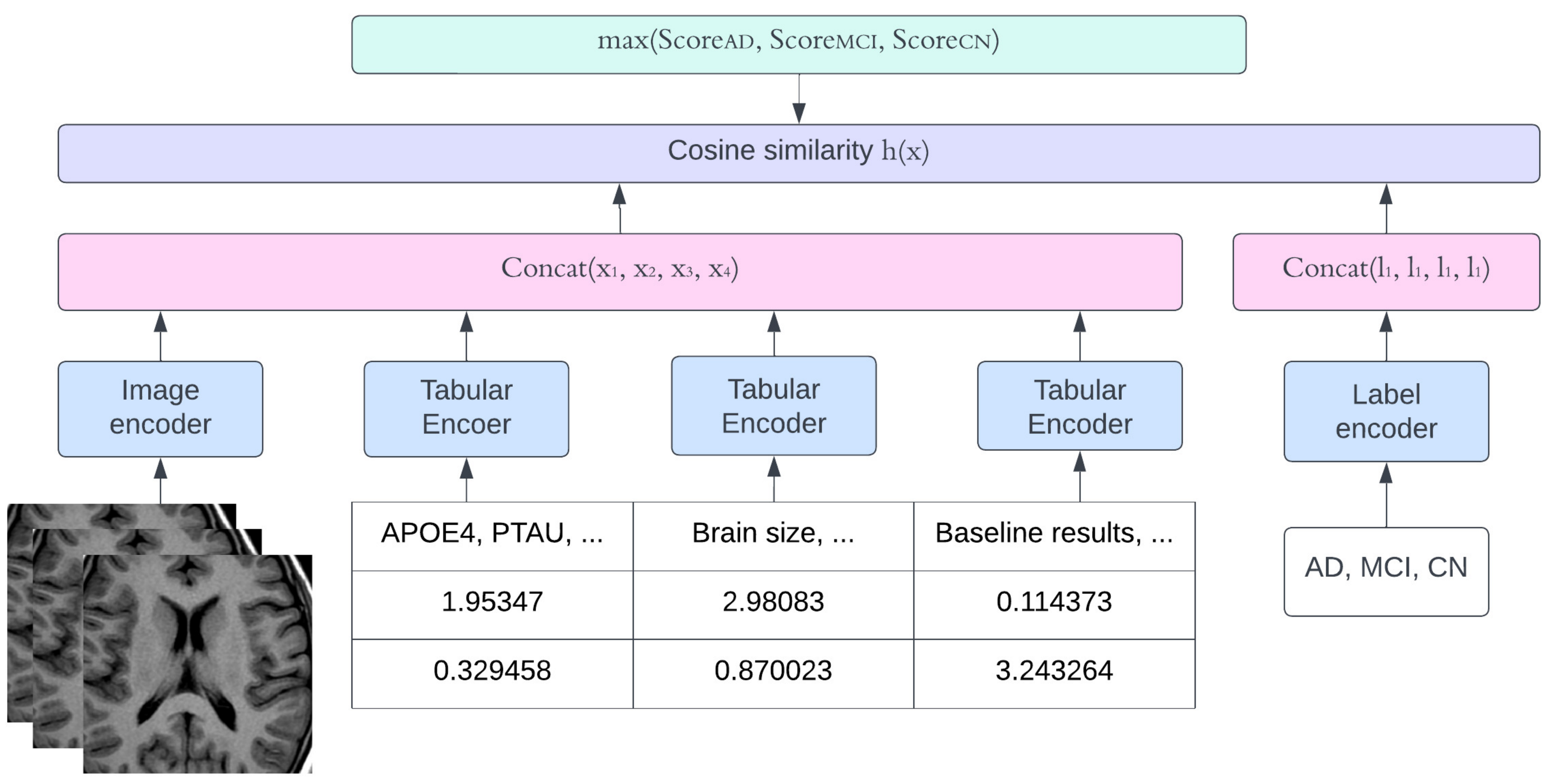
- We present a novel, multimodal, **Contrastive Learning Framework** on ADNI Dataset for the detection of Alzheimer's disease (AD) and mild cognitive impairment (MCI)
- We integrate **Image data** and **Tabular data**, including **MR Images, Biomarkers, Cognitive Assessments, and Medical History**
- We introduce a novel **Tabular Attention** that highlights important tabular features, provides more **Interpretability**
- We experiment with a **Spectrum-based Labelling** and search method to highlight the exact stage of Alzhiemer's disease



Contrastive Learning Framework



Training: We pretrain the image model on the ground-truth label features, and then finetune the tabular data encoders, freezing the image enoder model. We also show the tabular attention module.



Inference: After encoding each of the features, we concatenate them and compute a cosine similarity. The label with the maximum similarity is the output prediction.

Tabular Attention

$$H = \mathrm{ReLU}(X \cdot W_{fc1} + \mathbf{b}_{fc1})$$
$$A = \mathrm{softmax}(H \cdot W_{att} + \mathbf{b}_{att}, \mathrm{dim} = 1)$$
$$O = (X \odot A) \cdot W_{fc2} + \mathbf{b}_{fc2}$$

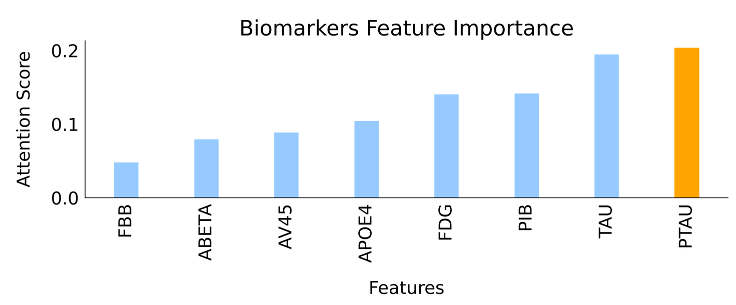
$\mathbf{X}$ = input data, $\mathbf{O}$ = output data
$\mathbf{H}$ = output of hidden layer, $\mathbf{A}$ = attention weights
$\mathbf{W}_{...}$ represent weights and $\mathbf{b}_{...}$ represent biases

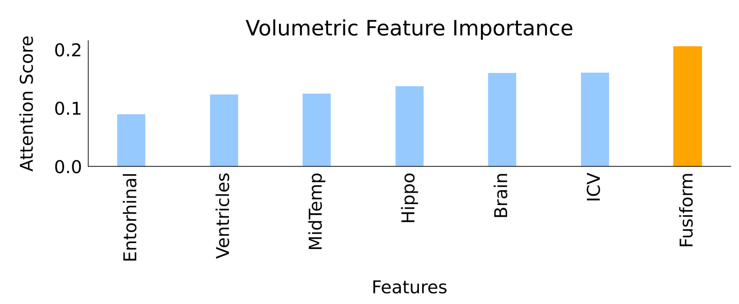
Results

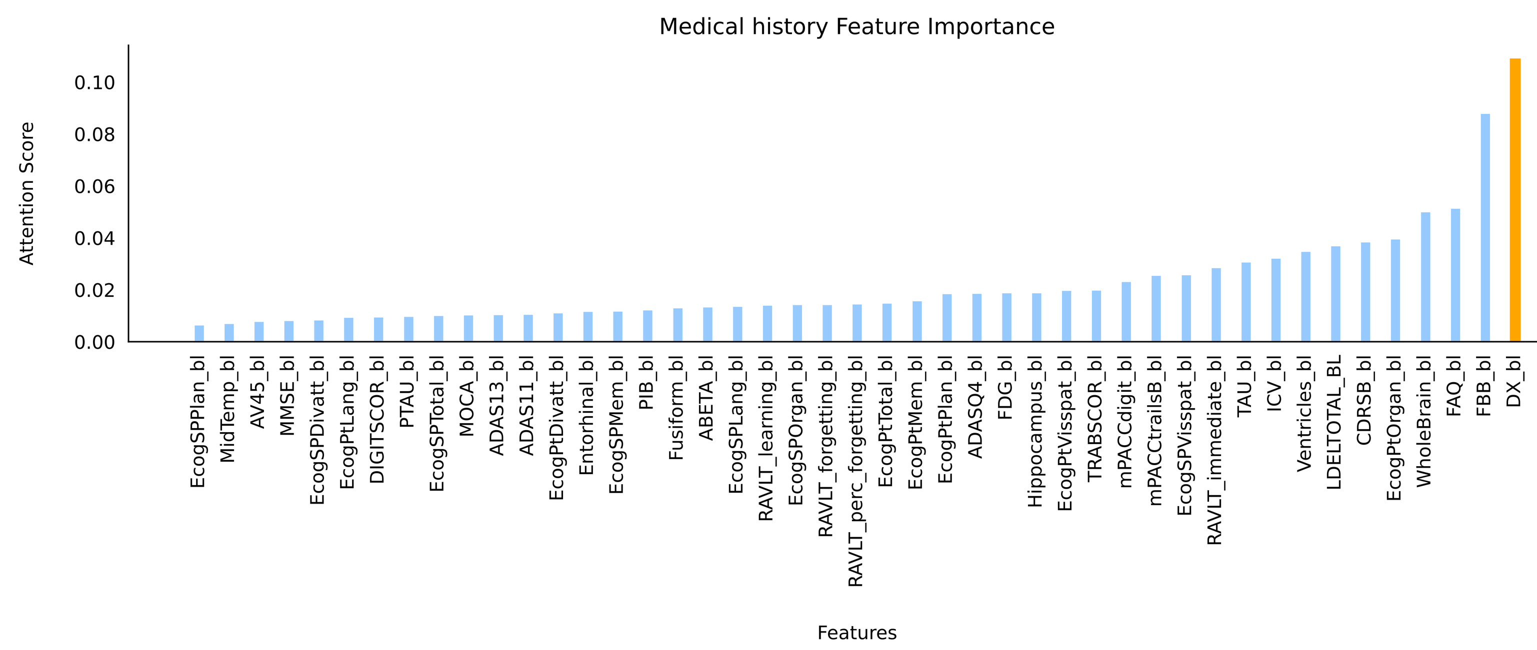
Model	AD vs CN	AD vs MCI vs CN
Biomarkers	0.687 ± 0.159	0.428 ± 0.057
Cognitive Tests	0.914 ± 0.061	0.758 ± 0.024
Volumetric	0.821 ± 0.051	0.516 ± 0.036
Medical Records	0.925 ± 0.865	0.789 ± 0.041
Image	0.885 ± 0.015	0.761 ± 0.014
Multimodal	**0.955 ± 0.017**	**0.838 ± 0.023**
DAFT Tabular Fusion	NA ± NA	0.622 ± 0.044
3D CNN	0.941 ± 0.060	0.745 ± 0.064

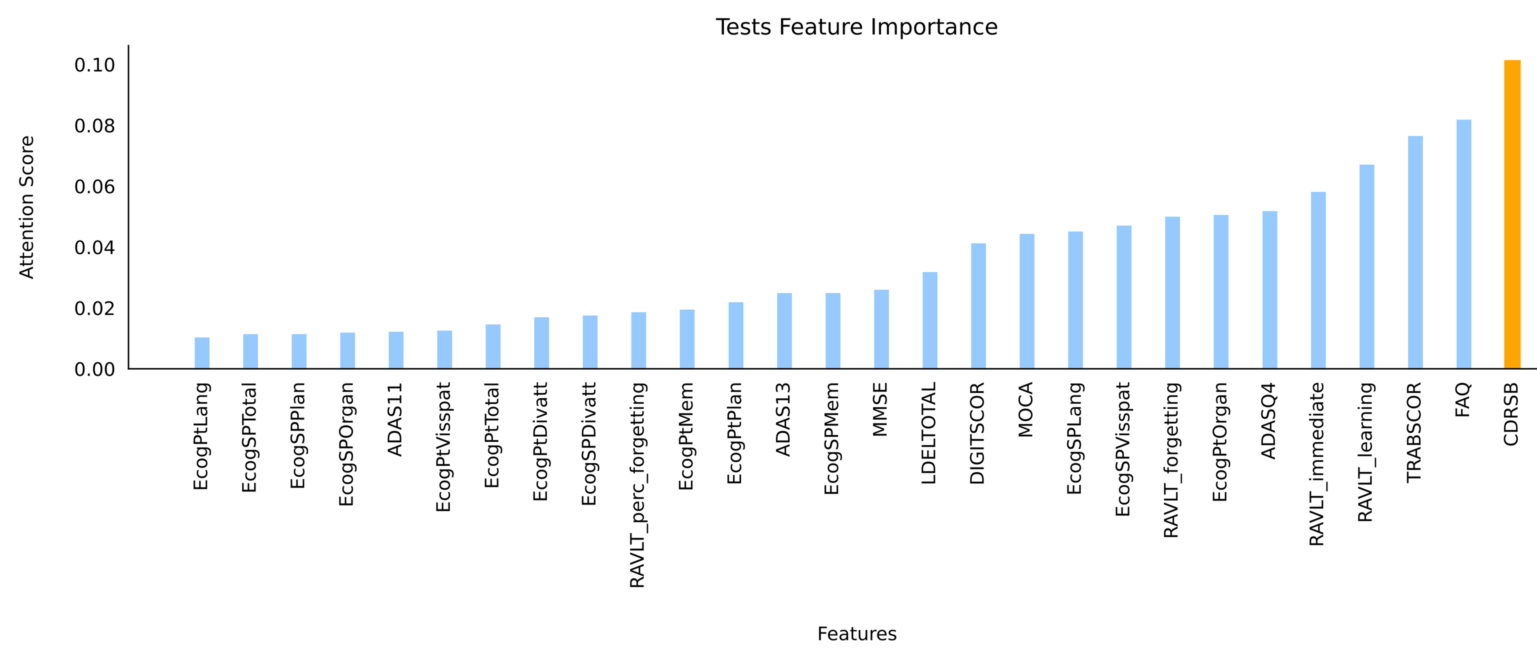
Table 1. Accuracy of our method compared to SOTA.

Features Highlighted by Tabular Attention









Analysis

- SOTA performance achieved comapared to previous methods (increase of over **9.3% accuracy** against previous SOTA and over **21.6% accuracy** against previous tabular method
- Attention scores for biomarkers highlight **PIB-PET-derived beta-amyloid (PIB) and Cerebrospinal Fluid and Plasma Tau (pTau) as significant** for predicting changes and Alzheimer's disease-related processes.
- Accuracy scores for **medical history and image data** point to these modalities as crucial factors in Alzheimer's disease evaluation.
- Note that medical history alone outperforms image data. Many variables, including baseline diagnosis results, cognitive test and others combined in one model performs best.
- However, medical history only captures a snapshot of information in a specific time. The addition of image data provides additional information.

Remarks

We present an **effective and generalizable** framework which outperforms previous state-of-the-art as shown by results. Our novel tabular attention **reveals critical variables** (e.g. biomarkers) for detecting Alzhiemer's disease and mild cognitive impairment.

Future research includes the introduction of other multimodal dataset testing and increased interpretability of the framework.