

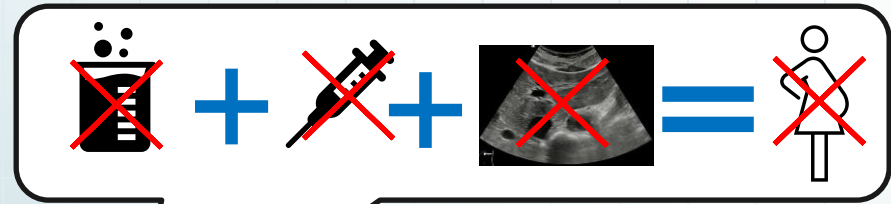
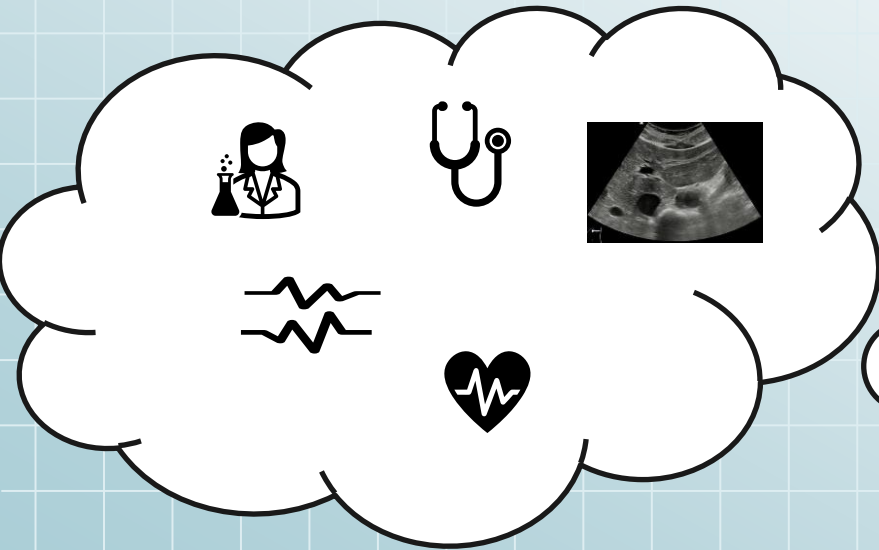
HyperFusion: Imaging-Tabular Data Integration for Predictive Modeling in Healthcare

Daniel Duenias, Tammy Riklin Raviv, Tal Arbel, Brennan Nichyporuk

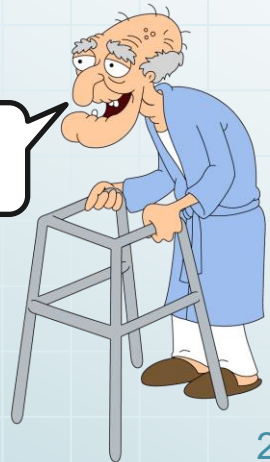


Multi-Modal Fusion

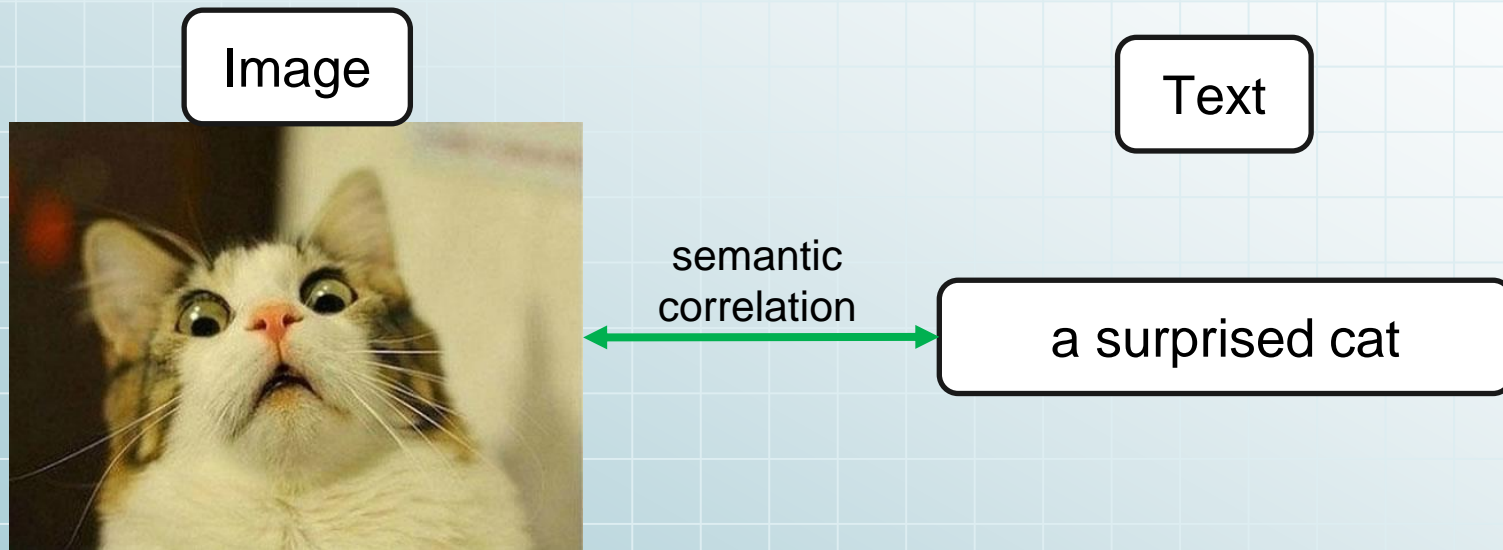
- Doctors intuitively performs multimodal Data fusion



Thanks, Dr. Chris

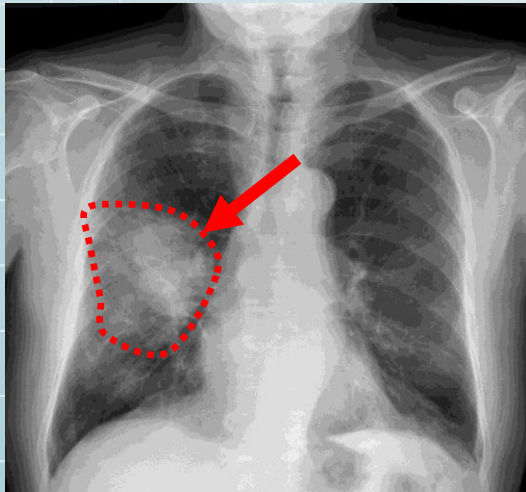


Text-Imaging Data Fusion



Tabular-Imaging Data Fusion

Image



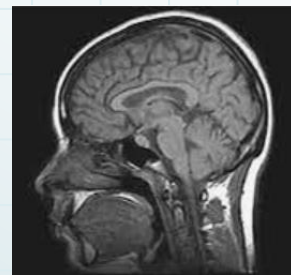
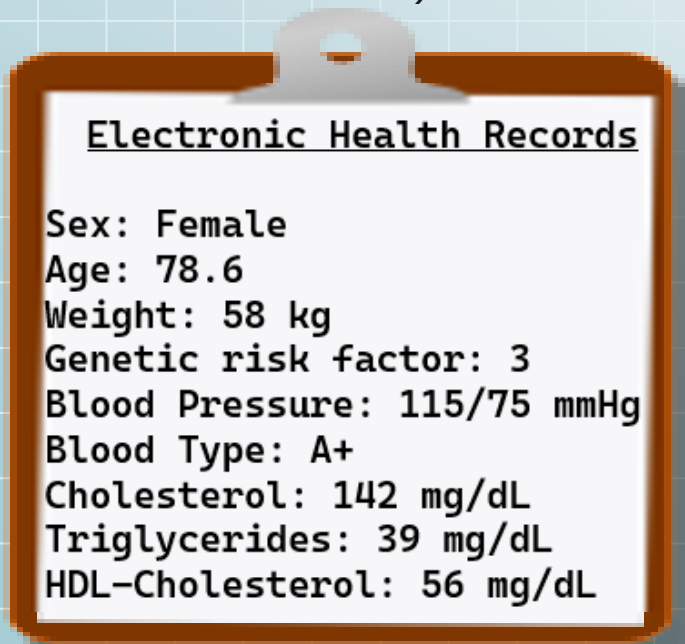
Tabular

Complementary
Information



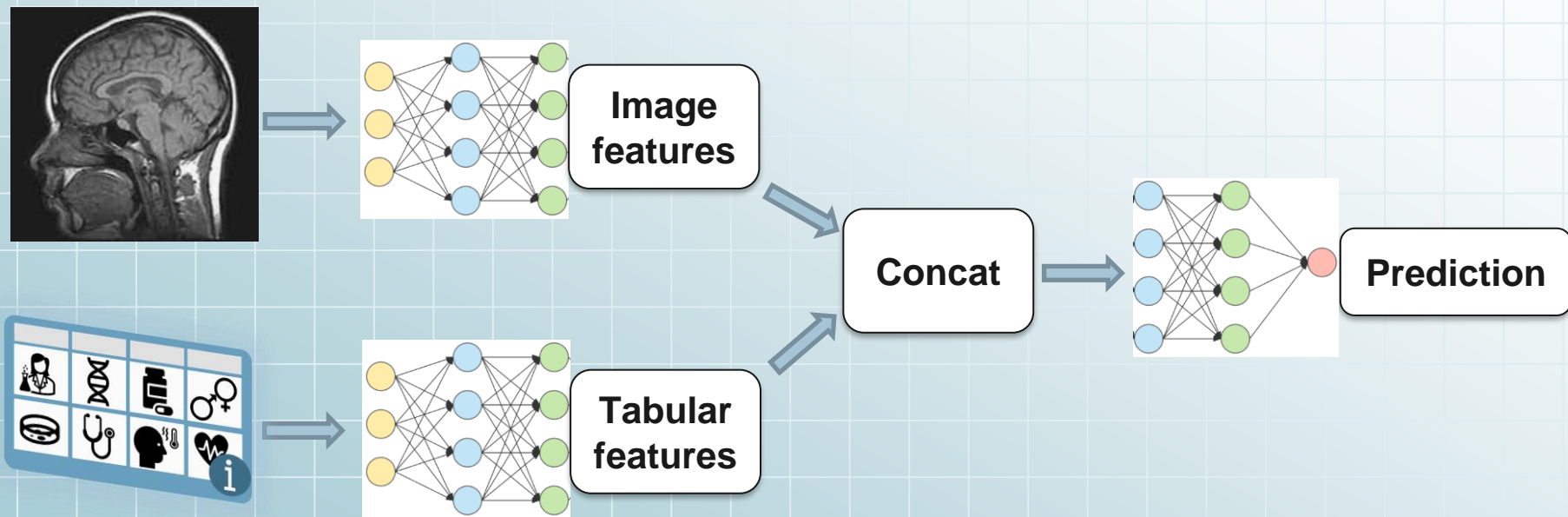
Tabular-Imaging Data Fusion

- Tabular data derived from Electronic Health Record (EHR)
- Contains clinical info, genetics, demographic info, and lab results (such as blood tests)...



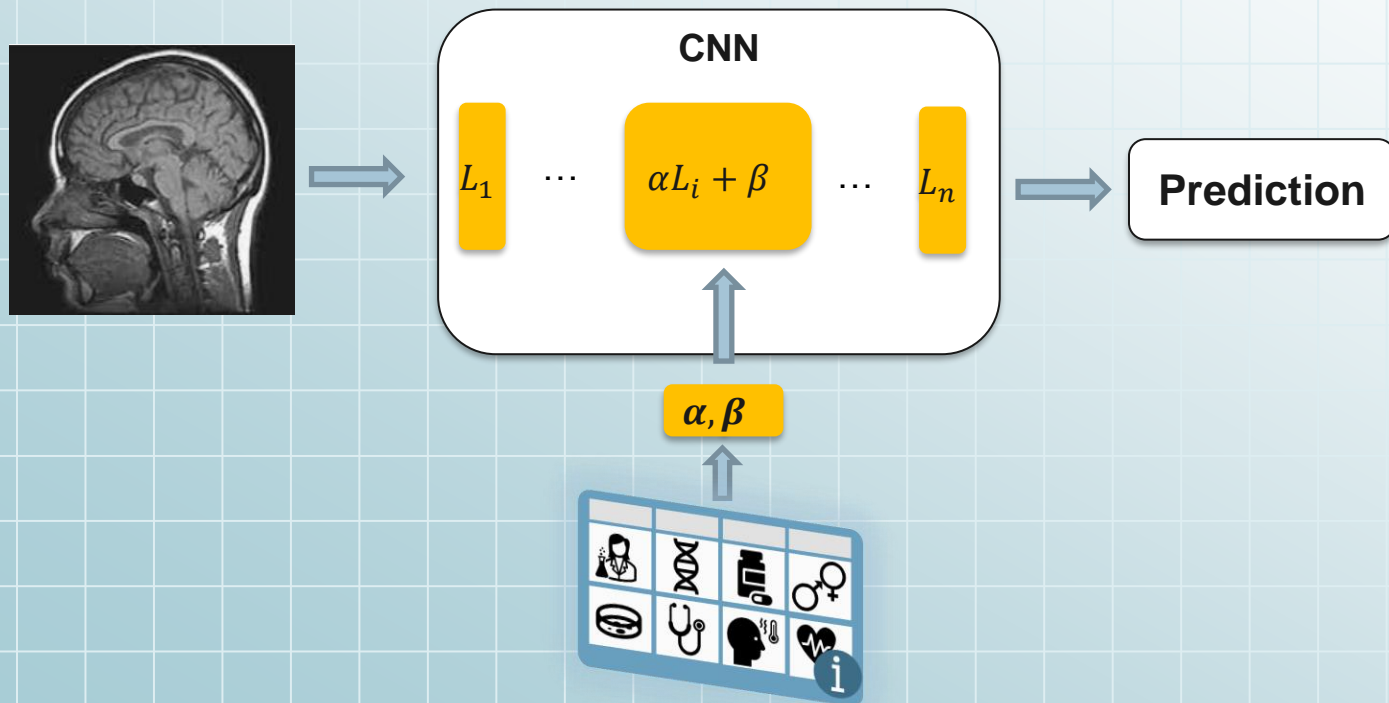
Images - Tabular Data Fusion Approaches

- Straightforward approach - concatenation:

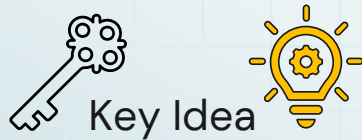


Images - Tabular Data Fusion Approaches

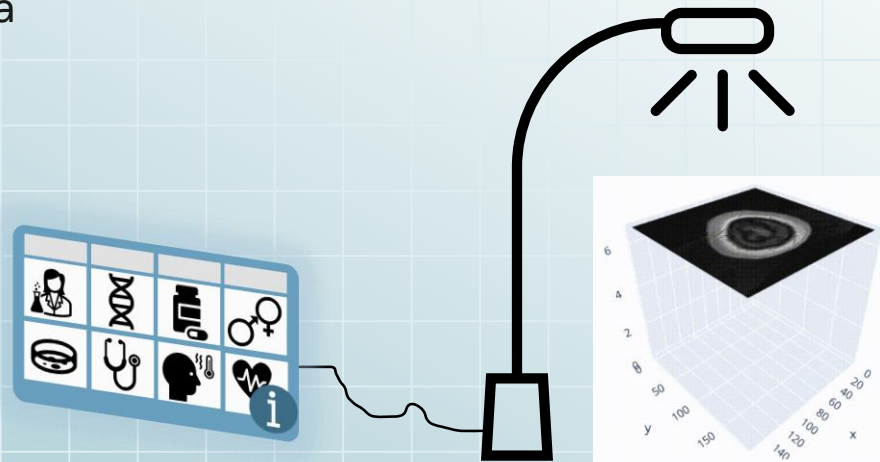
- Affine transformation of the imaging features



Use Hypernetworks For The Tabular-Imaging Fusion



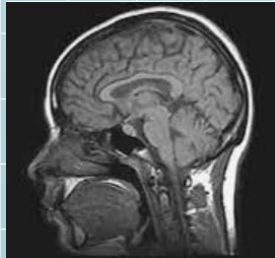
Use Hypernetworks to “look” at the image in the light of the tabular data



Hypernetworks

Clinical Tabular Data

Medical Imaging

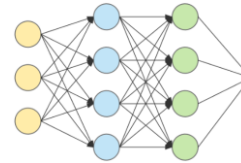


Network compound

Hypernetwork



Primary Network



Prediction

Hypernetworks

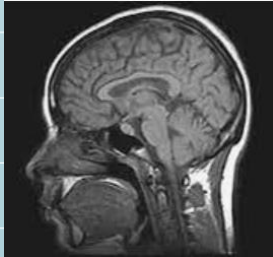
Parameters:

- ϕ - Hypernetwork's internal
- θ_P - Primary network's internal
- θ_H - Primary network's external (generated by the Hypernetwork)

Clinical Tabular Data



Medical Imaging



Network compound

Hypernetwork

\mathcal{H}_ϕ

Primary Network

$\mathcal{P}_{\theta=\{\theta_H, \theta_P\}}$

Prediction

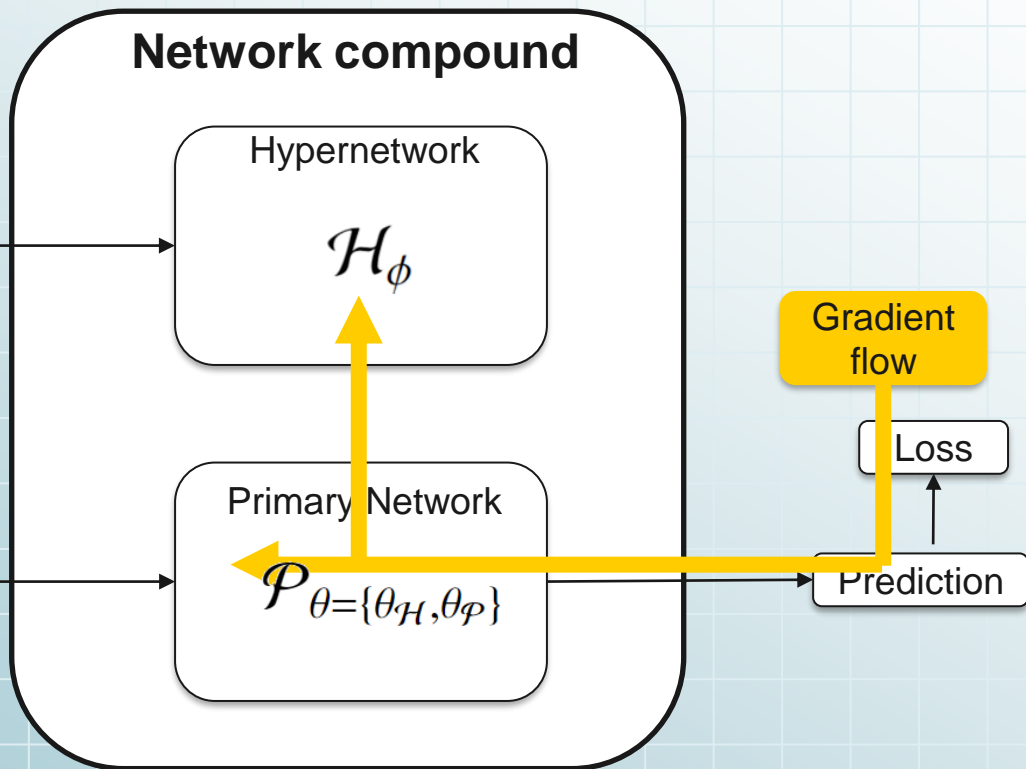
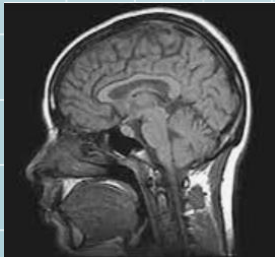
Hypernetworks

Backpropagation – gradient flow

Clinical Tabular Data

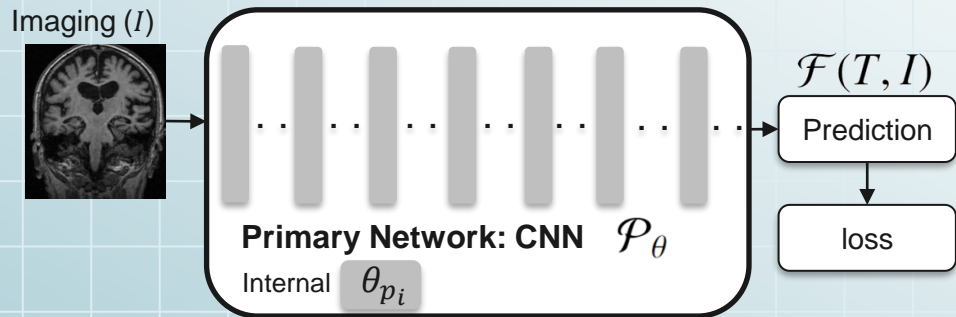


Medical Imaging



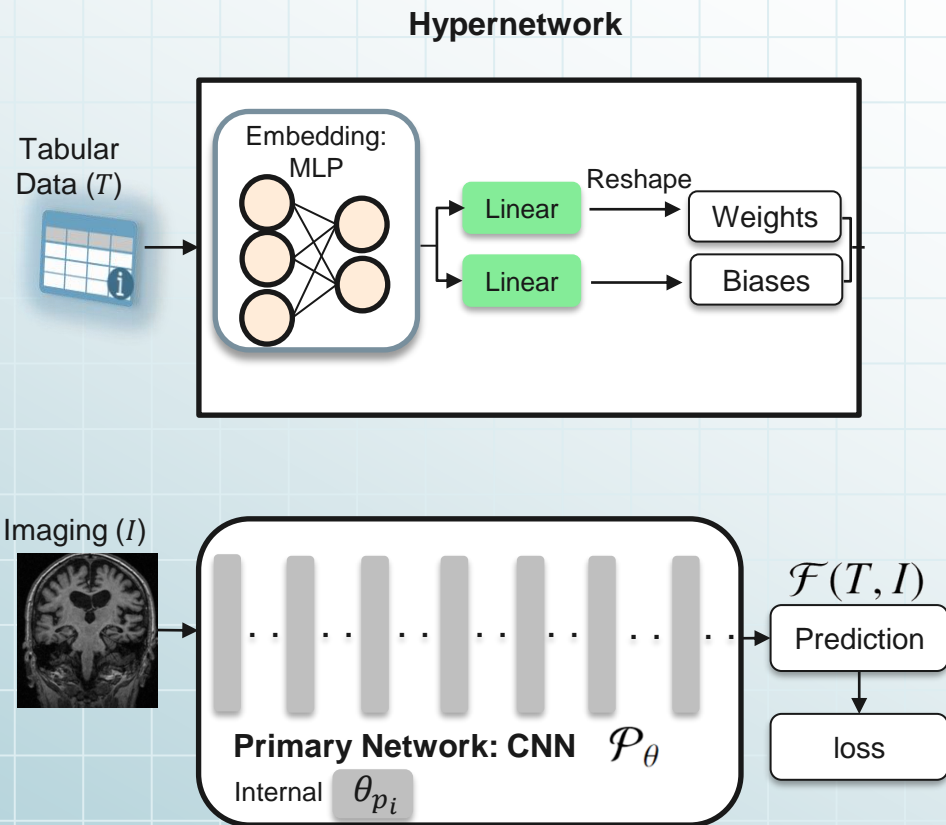
HyperFusion General Architecture

- Primary network – any network (we chose CNN)



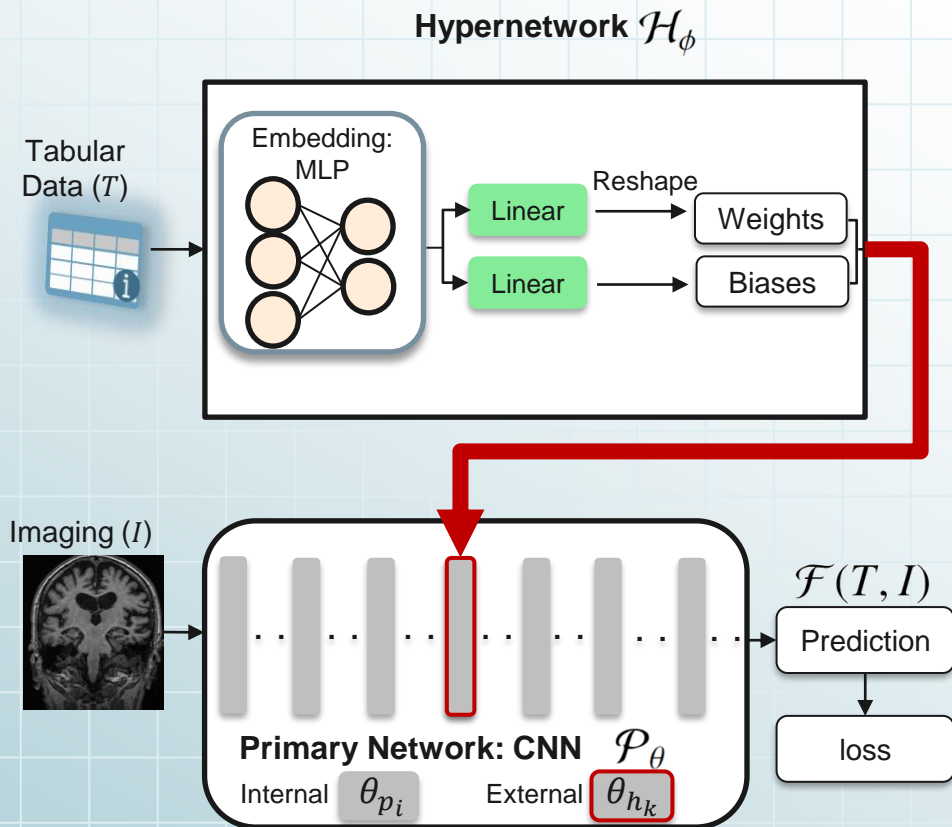
HyperFusion General Architecture

- Primary network – any network (we chose CNN)
- Hypernetwork – any network (we chose MLP)



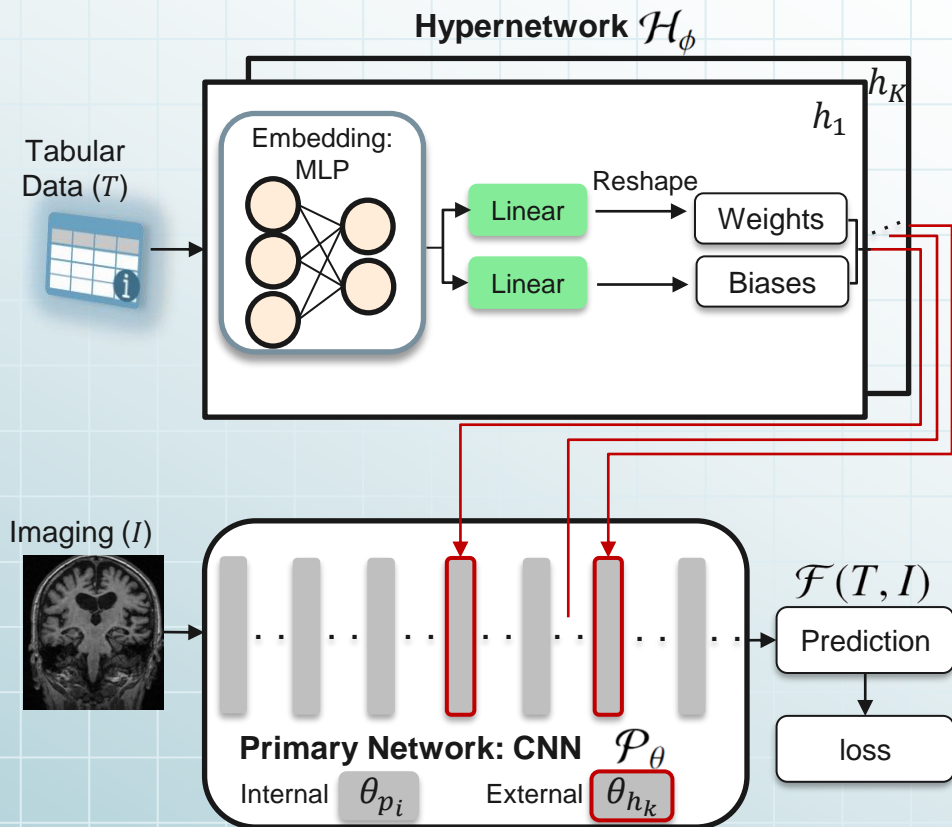
HyperFusion General Architecture

- Hypernetwork – any network (we chose MLP)
- Weights and Biases for a designated layer (any type of operation)



HyperFusion General Architecture

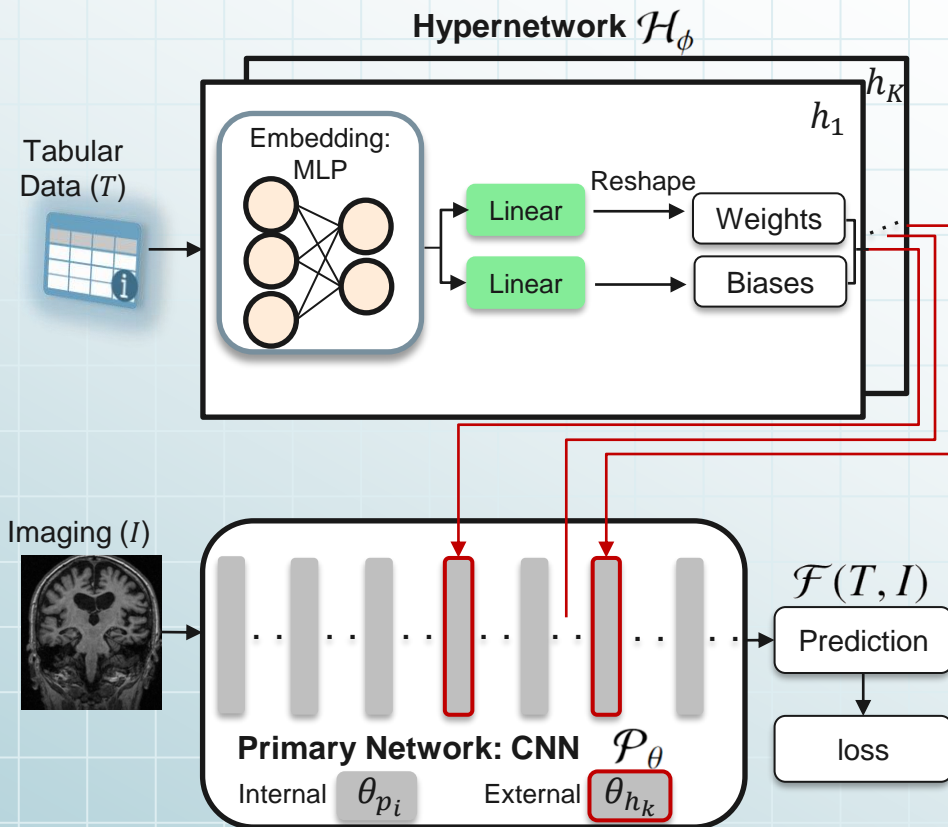
- K hypernetworks for K designated layers
- Which layers should be connected to the hypernetwork?
 - Usually high-level features layer



HyperFusion General Architecture

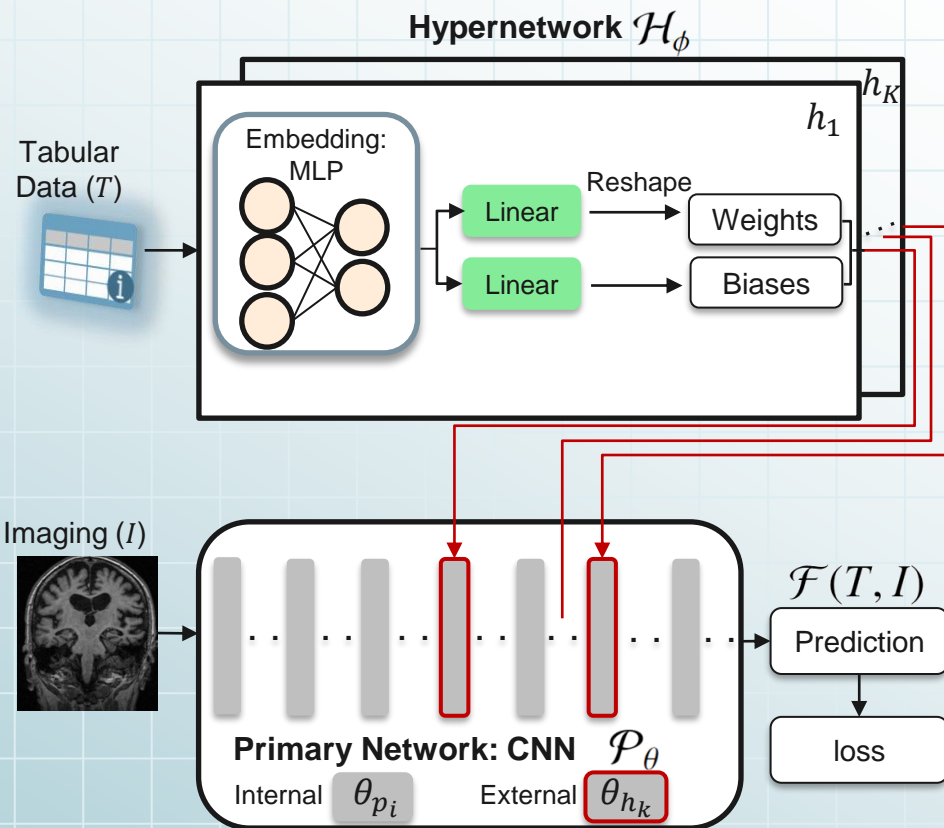
- Loss

$$\mathcal{L}(y, \mathcal{F}(T, I)) = \mathcal{L}_{\text{task}}(y, \mathcal{F}(T, I)) + \mathcal{L}_{\text{reg}}(\{\phi, \theta_p\})$$



Challenges and Other Important topics

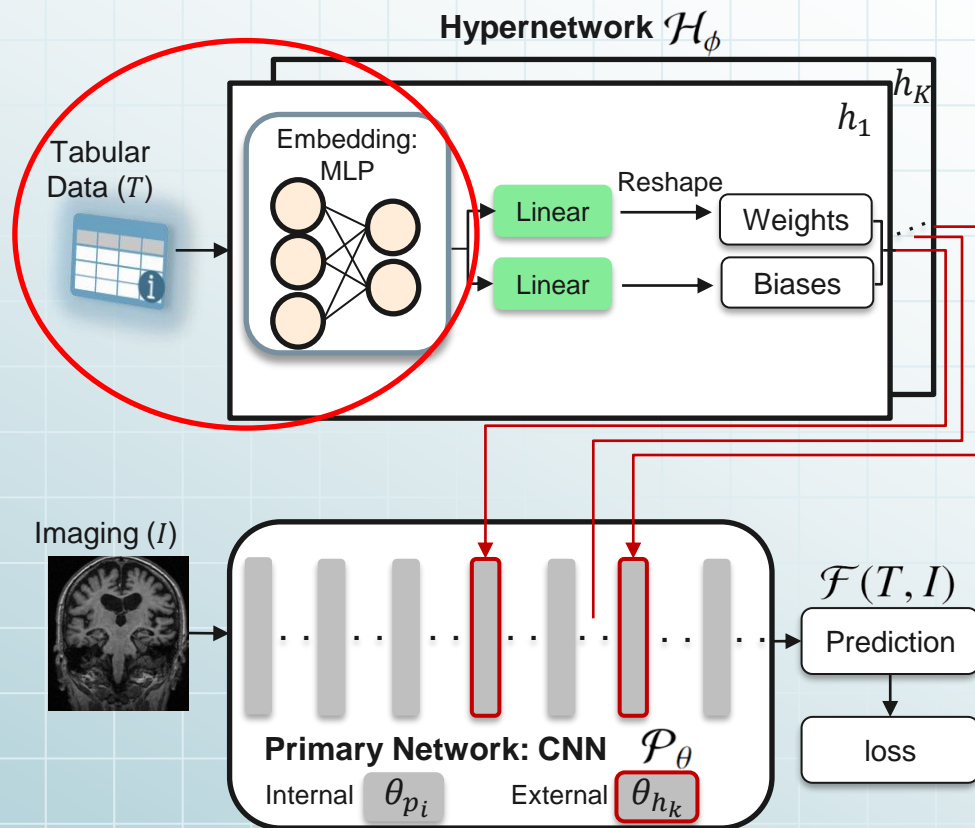
- Embedding
- Weights initialization
- Missing values



*More details in the paper

Challenges and Other Important topics

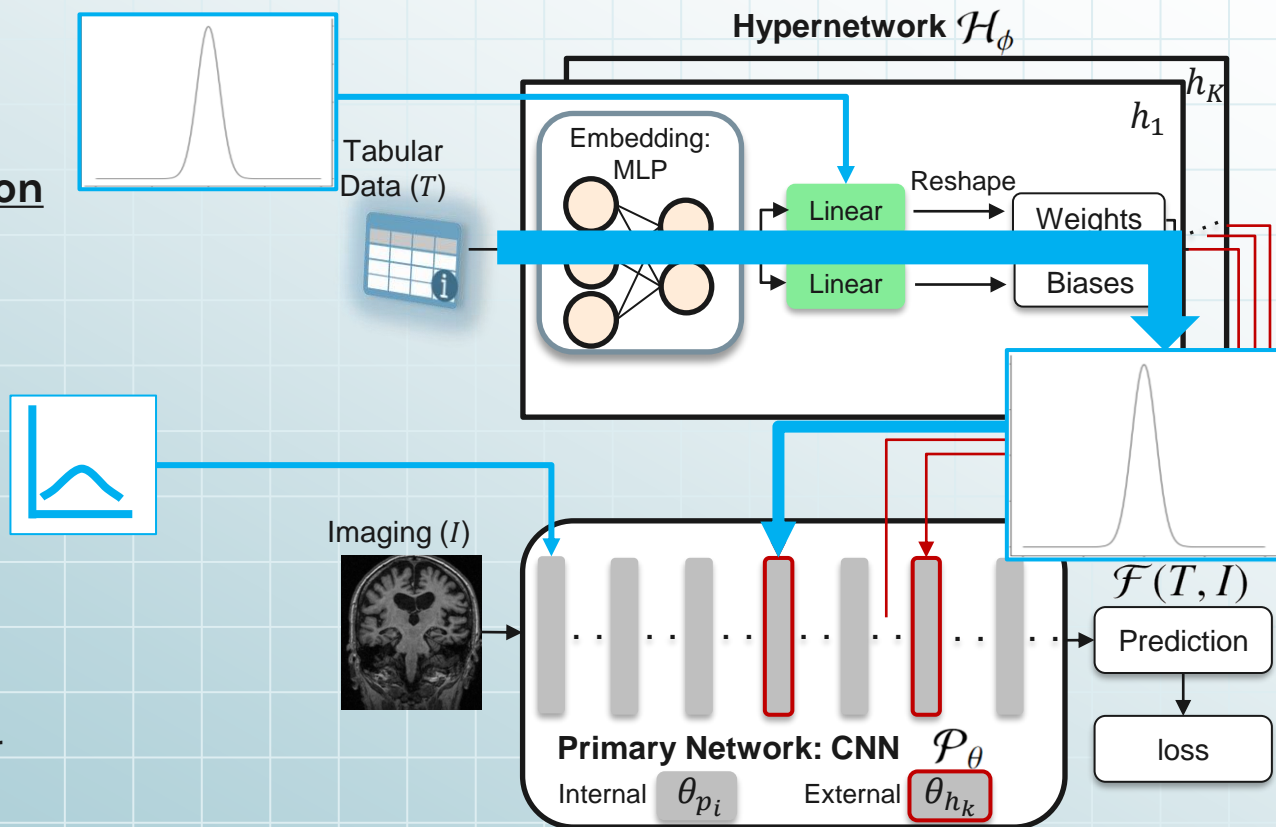
- Embedding
- Weights initialization
- Missing values



*More details in the paper

Challenges and Other Important topics

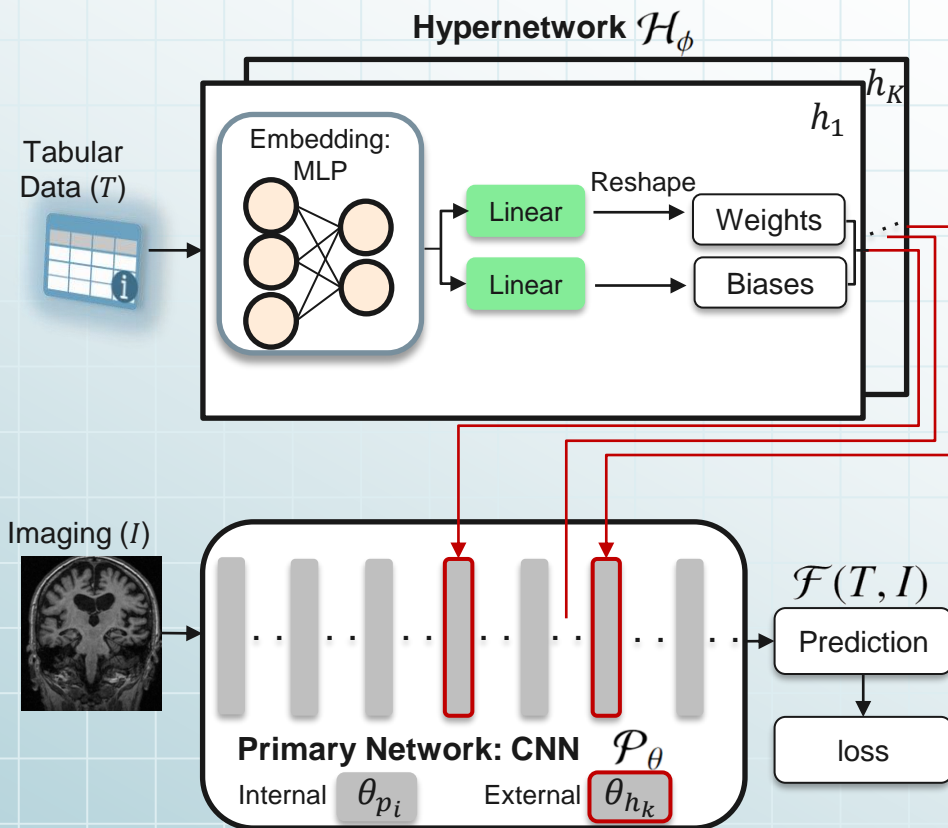
- Embedding
- Weights initialization
- Missing values



*More details in the paper

Challenges and Other Important Stuff

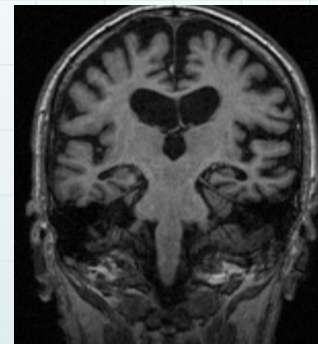
- Embedding
- Weights initialization
- Missing values



*More details in the paper

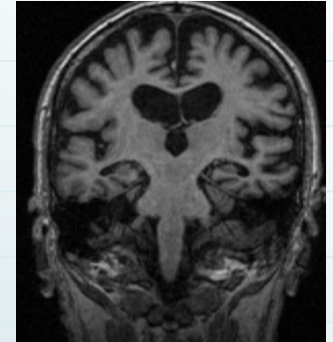
Aging and Alzheimer's

1. Brain Age prediction (regression) – MRI and single tabular attribute (sex)

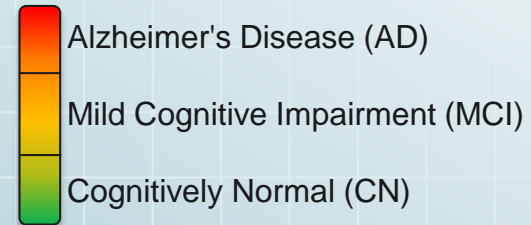
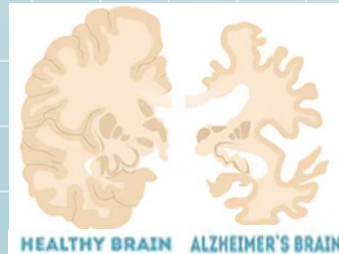
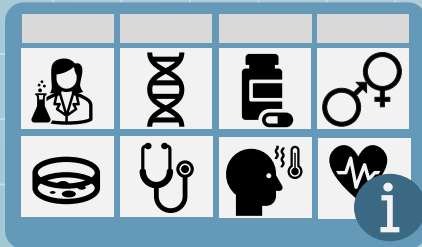


Aging and Alzheimer's

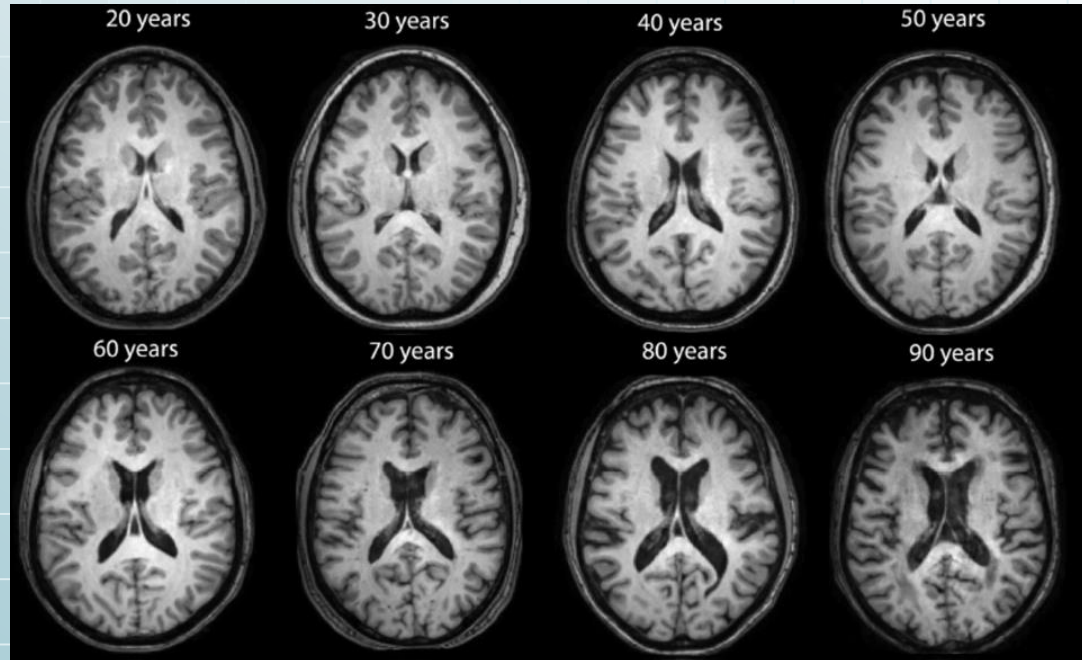
1. Brain Age prediction (regression) – MRI and single tabular attribute (sex)



2. Alzheimer Disease Diagnosis (classification) – MRI and multiple tabular parameters (different attribute types, missing values...)

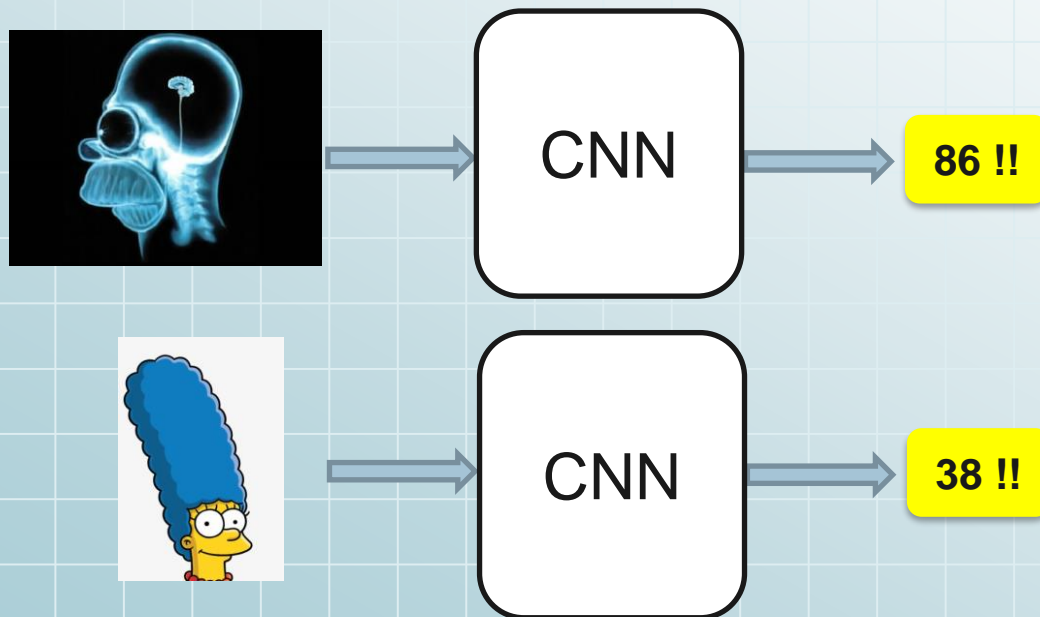


Brain Age Prediction



Brain Age Prediction

- Do males and females age differently?

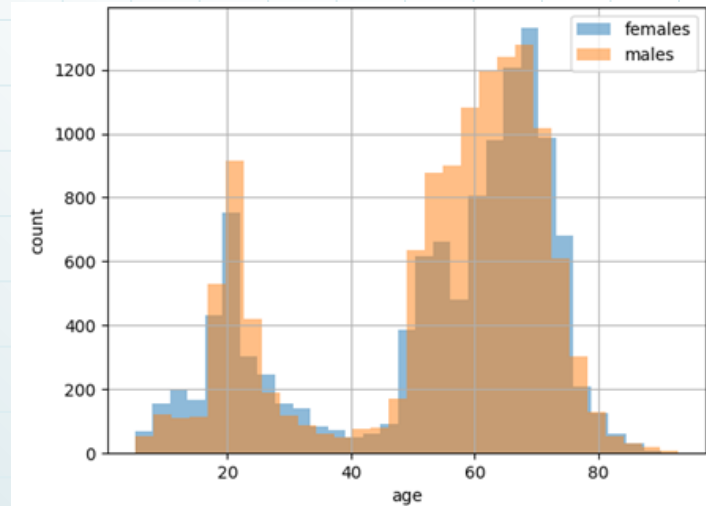


The Data

- ~27K brain images from 19 different datasets
- 49% Males, 51% Females
- Data split – 80% train, 10% validation, 10% test



Enabling scientific discoveries that improve human health



Results HyperFusion vs Imaging only

- Mean Average Error (MAE) – lower is better



Alzheimer Disease Classification

SYMPTOMS OF ALZHEIMER'S



HEALTHY BRAIN



ALZHEIMER'S BRAIN



CONFUSION WITH
TIME OR PLACE



TROUBLE FOLLOWING
CONVERSATION



MEMORY LOSS



TROUBLE WITH
FAMILIAR TASKS



MISPLACING THINGS



CHANGES IN MOOD
OR PERSONALITY



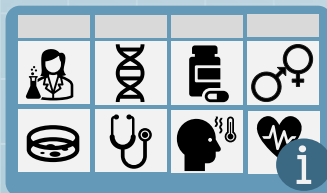
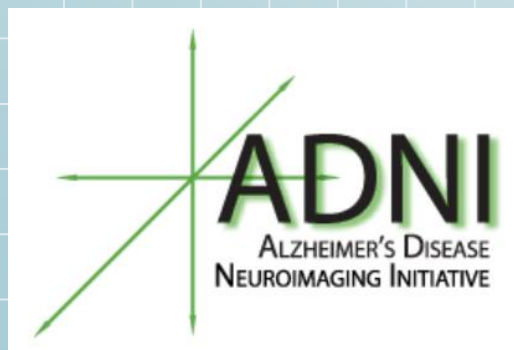
Alzheimer's Disease (AD)

Mild Cognitive Impairment (MCI)

Cognitively Normal (CN)

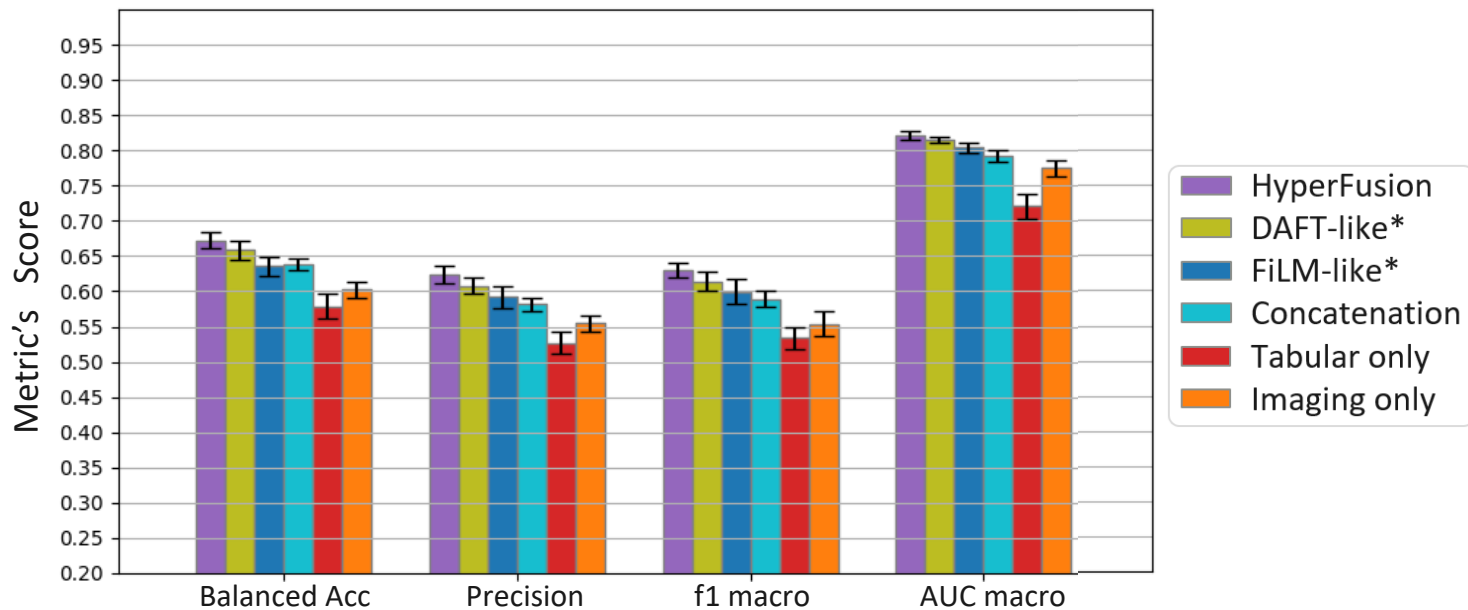
The Data

- The ADNI dataset, ADNI 1, ADNI 2 and ADNI GO, baseline visits
- ~2120 MRI scans – 34% CN , 48% MCI , 17% AD
- Data split: nested cross validation – 20% test and dynamic 20%-60% validation–train
- The Tabular attributes used (9): demographic, genetic, lab results



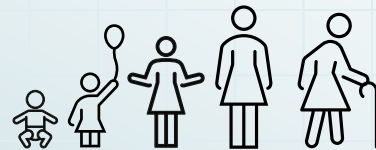
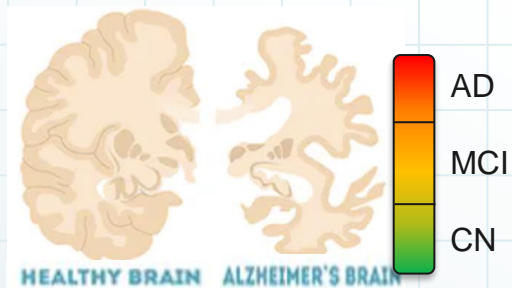
- demographic: Age, Sex, Education (years)
- genetic risk factor: ApoE4
- CSF biomarkers: Abeta42, P-tau181, T-tau
- measures from PET scan: 18F-fluorodeoxyglucose, florbetapir

Results HyperFusion vs Others



Summary

- HyperFusion – a novel hypernetworks approach for multimodal data fusion.
- Key idea – conditioning the image processing by tabular data.
- Versatility – different tasks and architectures
- Outperforms single-modality and existing fusion methods.
- Another step to personalized medical care.



Thanks for Listening!

HyperFusion: A Hypernetwork Approach to Multimodal Integration of Tabular and Medical Imaging Data for Predictive Modeling

Dive into the details on arXiv – scan below



Contact: Duenias@post.bgu.ac.il

