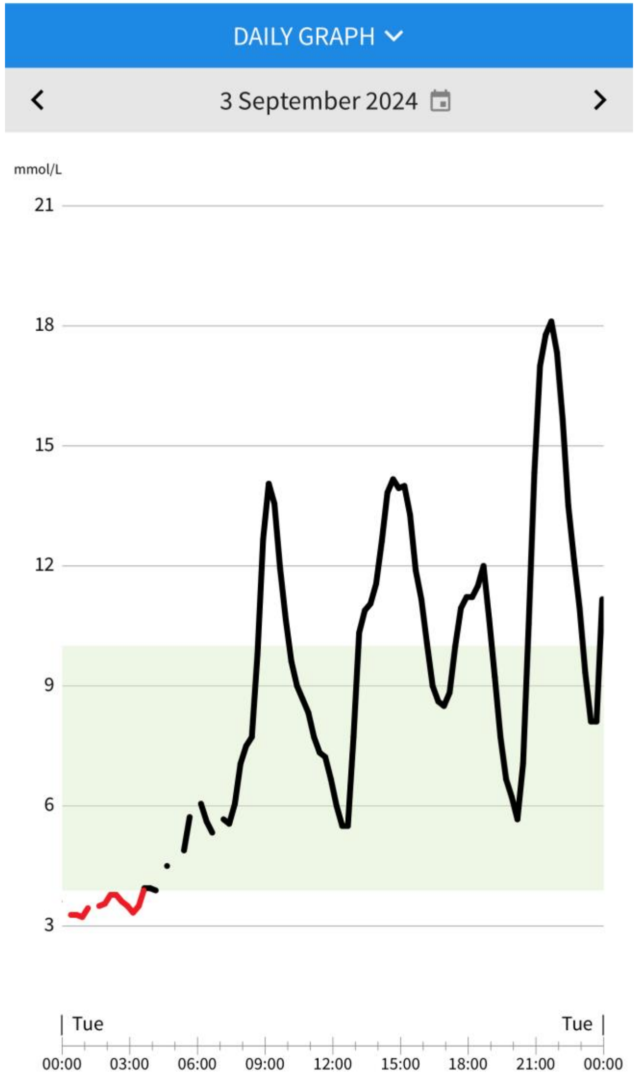
Towards Scalable, Flexible, and Interpretable Self-Supervised Learning for Multiview Biomedical Data

James Chapman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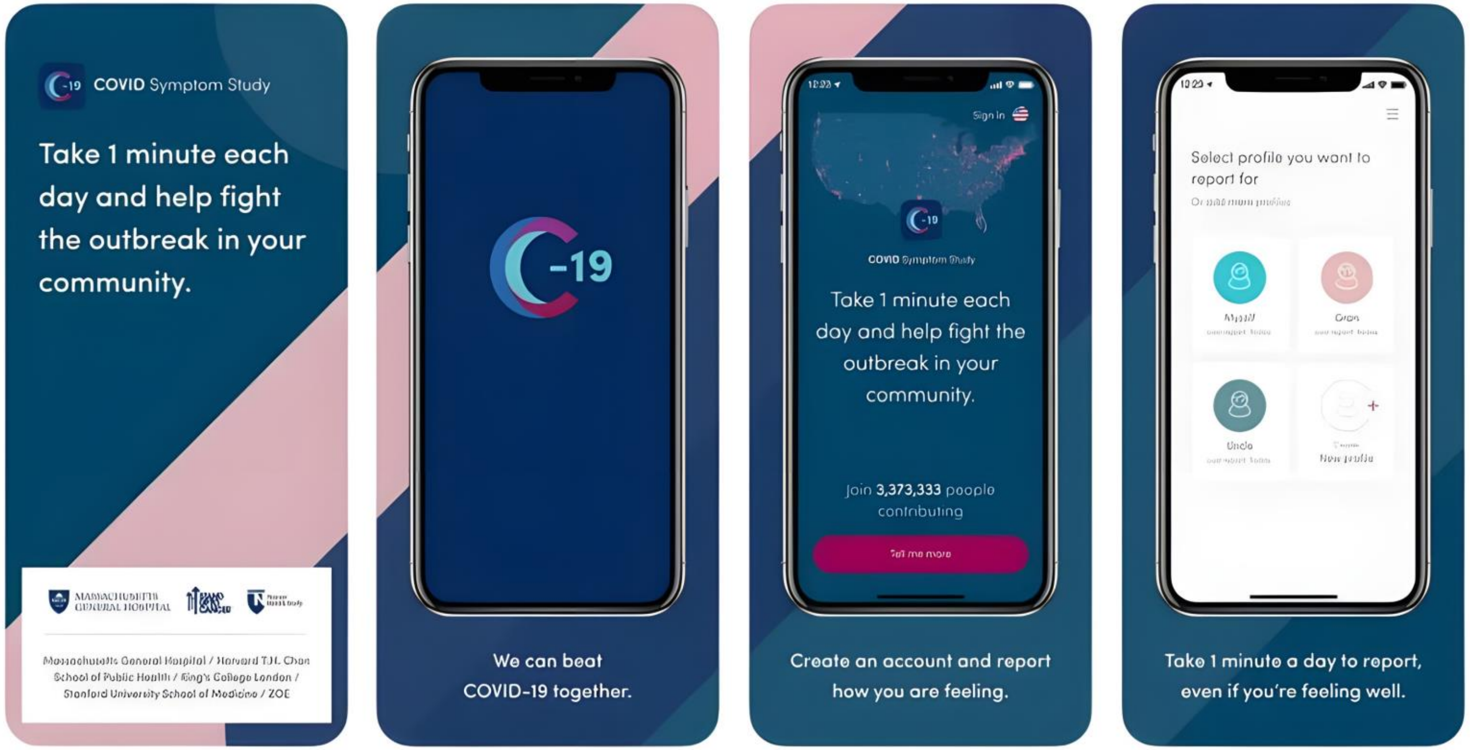
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Take 1 minute each day and help fight the outbreak in your community.
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Take 1 minute a day to report, even if you're feeling well.

Context

- Started working on *Deep Learning for Brain Behaviour Associations*

- Discovered that neuroimaging data is *really* high-dimensional and hard to work with

- And sample sizes are still small… but growing

- … and most of the relevant code was in MATLAB

Research Objectives

•Develop regularized Canonical Correlation Analysis (CCA) methods for improved interpretability

•Create efficient algorithms for large-scale datasets

•Extend CCA to deep learning and self-supervised settings

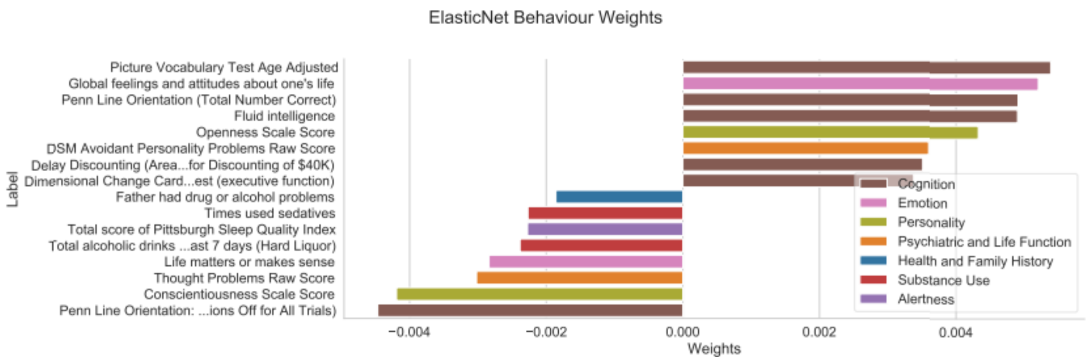
•Provide open-source implementations for the research community

FRALS Framework

- Addresses a known weakness of existing sparse CCA (Partial Least Squares) methods

- Incorporates structured priors into CCA models through regularization (e.g., elastic net)

- Enhances interpretability of CCA models



$$\underset{u^{(i)}}{\operatorname{argmin}} \left\{ \|X^{(i)}u^{(i)} - t\|_2^2 + \lambda_i P_i(u^{(i)}) \right\}$$

Weights & Loadings

- Categorized methods into explicit and implicit latent variable models
- Demonstrated the theoretical and practical robustness of loadings
- Produced meaningful multiview simulated data with known ground truth at the scale of neuroimaging studies

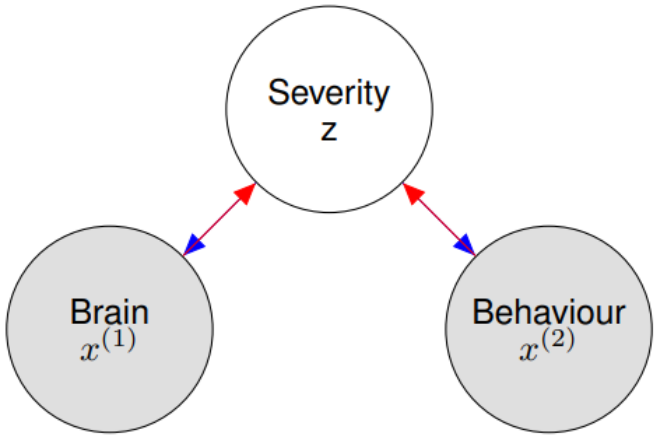


Figure IV.1: ***Forward and Backward Multiview Models:*** The generative/forward and discriminative/backward approaches in CCA.

GEP-EY Algorithm

- Efficient solution for generalized eigenvalue problems

- Enables application of CCA and PLS to large-scale datasets (e.g., UK Biobank)

- Outperforms existing methods in terms of scalability and convergence

Figure V.1: Comparison of the time taken to solve CCA using `eigh` and our CCA-EY method.

Deep Learning Extensions

- DCCA-EY: Novel formulation of Deep CCA for stochastic settings

- SSL-EY: New self-supervised learning method competitive with state-of-the-art with less tuning

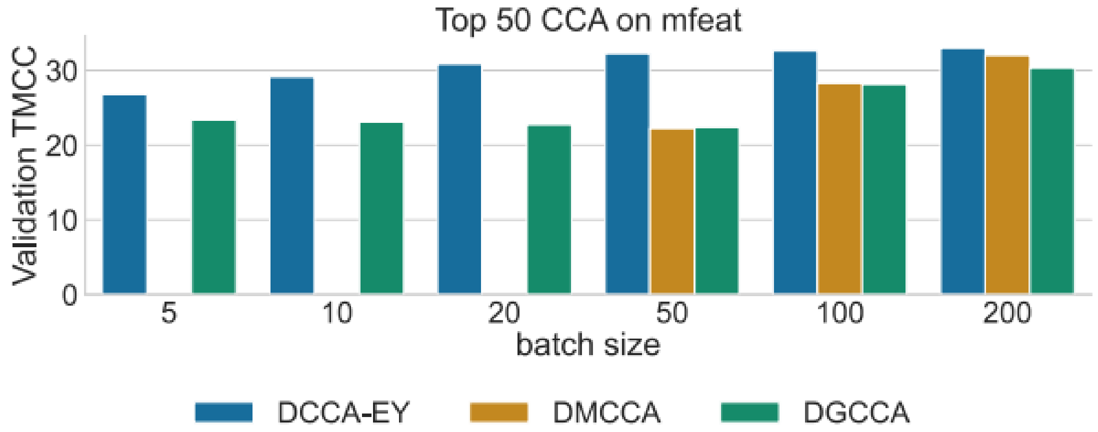
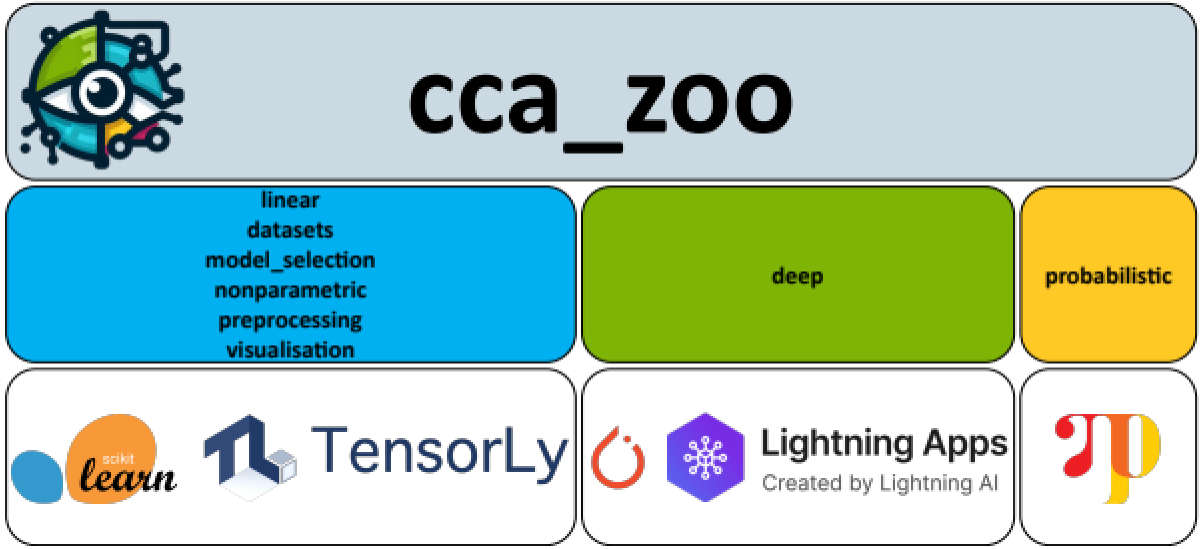


Figure VI.8: Deep Multi-view CCA on mfeat: Comparison across various mini-batch sizes using the Validation TMCC metric.

CCA-Zoo Software

- Comprehensive Python library for multiview learning methods
- Implements various CCA, PLS, and related techniques
- Facilitates broader adoption and innovation in the research community



Impact

- Can run (Multiview) CCA on UK Biobank on your laptop
- Can run Deep (Multiview) CCA on a single GPU
- 190 stars on GitHub from people who have built on my small contributions