### Idea #1: Image Processing for Glaucoma Detection

##### **Problem**

Glaucoma, a leading cause of irreversible blindness affecting over 80 million people globally, often progresses silently until late in its course. Early detection relies on clinical history, diagnostic tests, and imaging, particularly Optical Coherence Tomography (OCT).  While early machine learning models performed well on OCT data, many struggled to differentiate between glaucoma and severe myopia—two conditions with overlapping features on imaging. Recent work has improved this using multimodal models that combine OCT with fundus images and clinical data, but challenges remain in generalizability, performance, and interpretability.  This project aims to replicate and extend current deep learning models for glaucoma detection, starting with OCT data and potentially incorporating multimodal inputs.

##### **Dataset(s)**

The project will begin with one or more of the following publicly available datasets:

* [**Kaggle: Glaucoma Detection**](https://www.kaggle.com/datasets/sshikamaru/glaucoma-detection)**:** 650 fundus images, labeled as healthy (482) or glaucomatous (168).
* [**OCT Volumes for Glaucoma Detection**](https://zenodo.org/records/1481223)**:** 1,110 OCT volumes stored as NumPy arrays (64×128×64), with a split of 263 normal and 847 glaucoma cases.
* [**Composite Retinal Fundus and OCT Dataset**](https://data.mendeley.com/datasets/trghs22fpg/3)**:** Combines labeled OCT and fundus images for various glaucomatous disorders.

Additional datasets for potential multimodal model development include:

* [**PAPILA**](https://figshare.com/articles/dataset/PAPILA/14798004?file=35013982)**:** includes fundus images along with clinical demographic data (age/gender), segmentations, IOP, corneal thickness, and other relevant measurements ([Nature](https://www.nature.com/articles/s41597-022-01388-1), 2022).
* [**GRAPE**](https://springernature.figshare.com/collections/GRAPE_A_multi-modal_glaucoma_dataset_of_follow-up_visual_field_and_fundus_images_for_glaucoma_management/6406319/1)**:** 1115 records including current visual field, visual field progression, fundus images, OCT measurements, segmentations ([Nature](https://www.nature.com/articles/s41597-023-02424-4" \l "ref-CR36), 2023).

##### **Objectives**

* Primary:
  + Reproduce results from an existing deep learning pipeline for glaucoma classification using OCT image data.
  + Assess model performance across a basic unimodal setup and evaluate generalizability on underrepresented subpopulations (e.g., high myopes).
* If time permits, extend the model to a multi-modal classification framework by integrating OCT data with fundus photography and other clinical variables.
  + Experiment with different architectures and training approaches to improve model performance and interpretability.
  + Contribute code and results to the open-source community for further research replication and validation.

### Idea #2: Latent Dimensions of Peripartum Risk

##### **Description**

Peripartum complications—such as preterm birth, fetal distress, or acidosis—often arise in patients without obvious warning signs. Medical guidelines provide long lists of loosely associated risk factors, but offer little clarity on causation or predictive structure. This project aims to determine whether high-dimensional physiological and clinical data hold more coherent, statistically discoverable patterns of risk.

##### **Dataset(s)**

* [**Oxford CTG (cardiotocography)** **dataset**](https://arxiv.org/abs/2404.08024): includes over 100,000 recordings of fetal heart rate and uterine activity, each labeled with outcome data and clinical metadata; considered high-quality, well-annotated, and has been used in multiple obstetric AI research papers.
* Public datasets on maternal demographics and birth outcomes (CDC Wonder, WHO) can supplement the analysis.

##### **Objectives**

* Explore whether clusters or latent structures within CTG and clinical data align with specific adverse outcomes.
* Challenge conventional heuristic guidelines by proposing data-driven risk types.
* Provide interpretable prototypes that could influence future clinical triage or labor management systems.

### Idea #3: Transdiagnostic Signatures of Neuropsychiatric Disorders

##### **Description**

Psychiatric conditions like ADHD, autism, and depression often share overlapping symptoms and behavioral traits, but differ in their underlying biology in ways that are still poorly understood. Traditional diagnoses are symptom-based, not rooted in clear biological evidence. This project investigates whether integrating multiple data types—speech, facial expression, and brain imaging—can uncover meaningful distinctions or commonalities that current clinical frameworks miss.

##### **Dataset(s)**

* [**ADHD-200**](https://fcon_1000.projects.nitrc.org/indi/adhd200/)**:** open-access fMRI and structural MRI data across hundreds of patients with metadata (age, symptoms, etc.).
* [**DAIC-WOZ**](https://dcapswoz.ict.usc.edu/)**:** synchronized audio, facial video, and transcripts from psychological interviews.

##### **Objectives**

* Examine whether patterns in brain connectivity and behavioral expression suggest distinct subgroups within or across diagnoses.
* Identify features that might define new transdiagnostic categories or dimensional traits rather than binary labels.
* Offer insights into how psychiatric nosology could evolve if informed by rich biometric data.