An End-to-end Deep Learning Based Disease Prediction Framework

Case Study on Mild Cognitive Impairment

Joe Xing, PhD
Co-Founder & Chief Technology Officer
joe@clighttechnologies.com

Defeating Dementia: New Directions from the Biology of Aging Symposium
April 13, 2023
Berkeley, California

C. LIGHT TECHNOLOGIES

Financial Disclosures

I am a co-founder and employee of C. Light Technologies, Inc.

Defeating Dementia: New Directions from the Biology of Aging Symposium

April 13, 2023

Berkeley, California

INTRODUCING THE C. LIGHT TEAM

THE **BRAINS** BEHIND THE EYE-BRAIN CONNECTION

OUR CORE TEAM

CHRISTY K. SHEEHY, PhD
CEO / Co-Founder

JOE XING, PhD
CTO / Co-Founder

JACQUELINE THEIS, OD
Chief Medical Officer

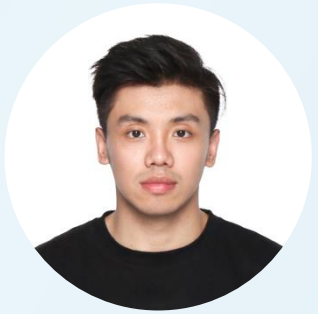
LON DOWELL
Chief Commercial Officer

ANDREW NORTON, PhD
VP, Optical Engineering

Reynaldo Quintana
Head of Mechanical Engineering

TRACY TRAN
Head of PR & Marketing

YIFAN ZHANG
Data Science & ML



Yuxuan Zhao
Data Science

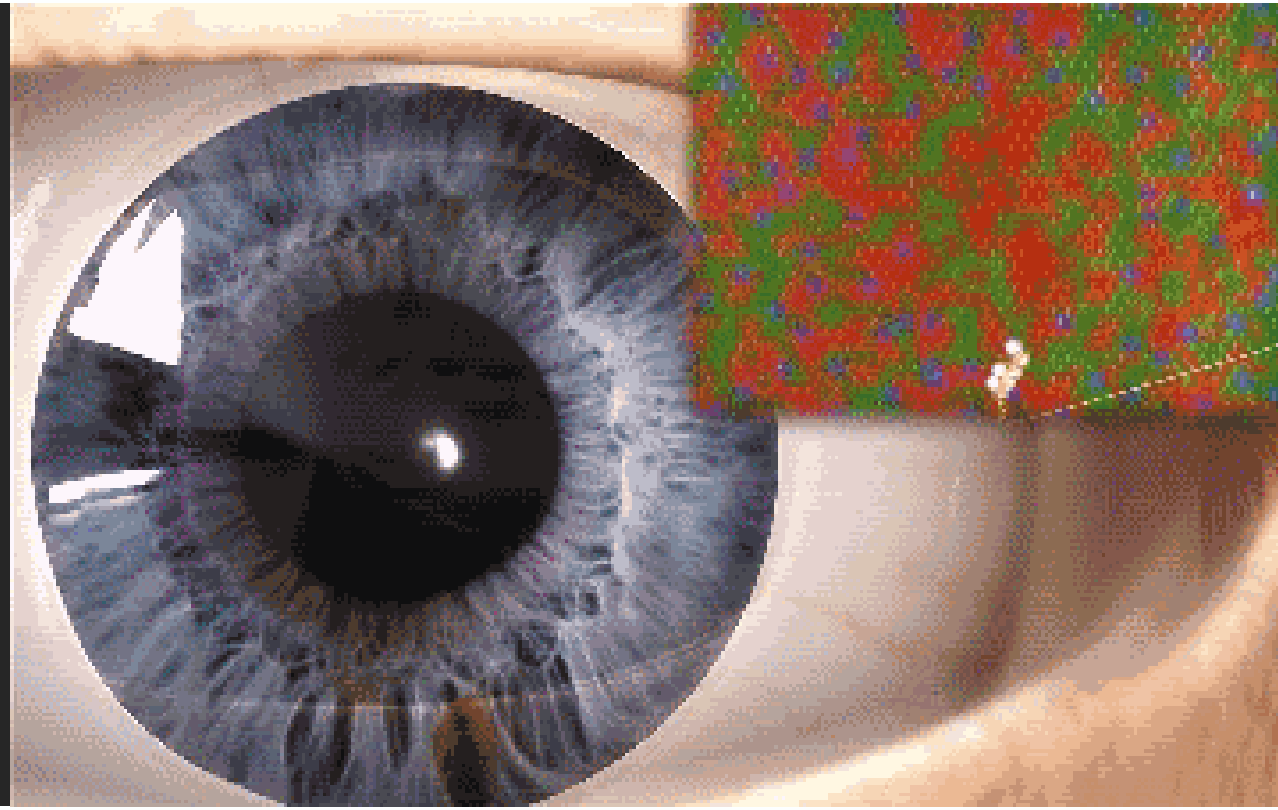
ROHAN BOHRA
Data Science & ML

Background Fixational Eye Motion (FEM)

Fixational eye motion has been shown to be altered in neurologic and retinal diseases, thus making it a potential objective biomarker for future research

COMPONENTS OF FIXATION

- **DRIFT** - low amplitude & low velocity
- **MICROSACCADES** – amplitude up to 2°, low frequency ~1 Hz
- **TREMOR** - low amplitude (< 1 arcmin), high frequency ~ 80Hz

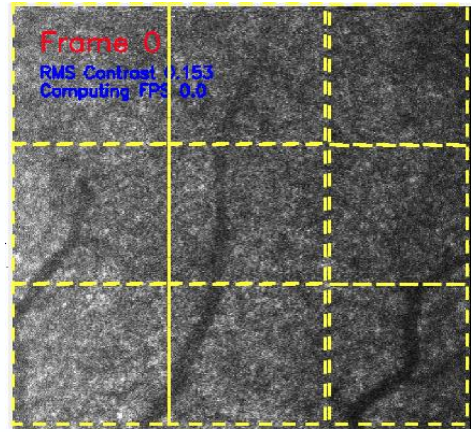


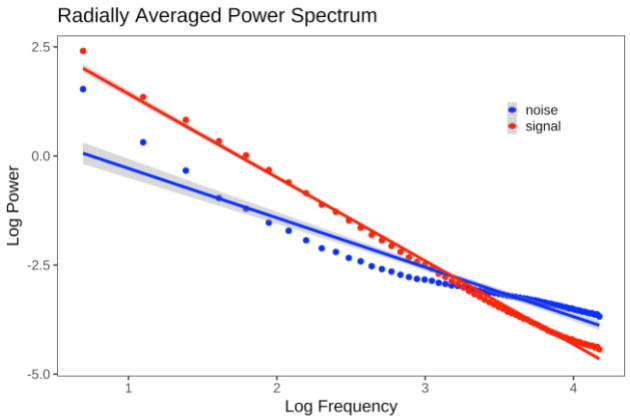
Experimental setup MCI Data Cohort

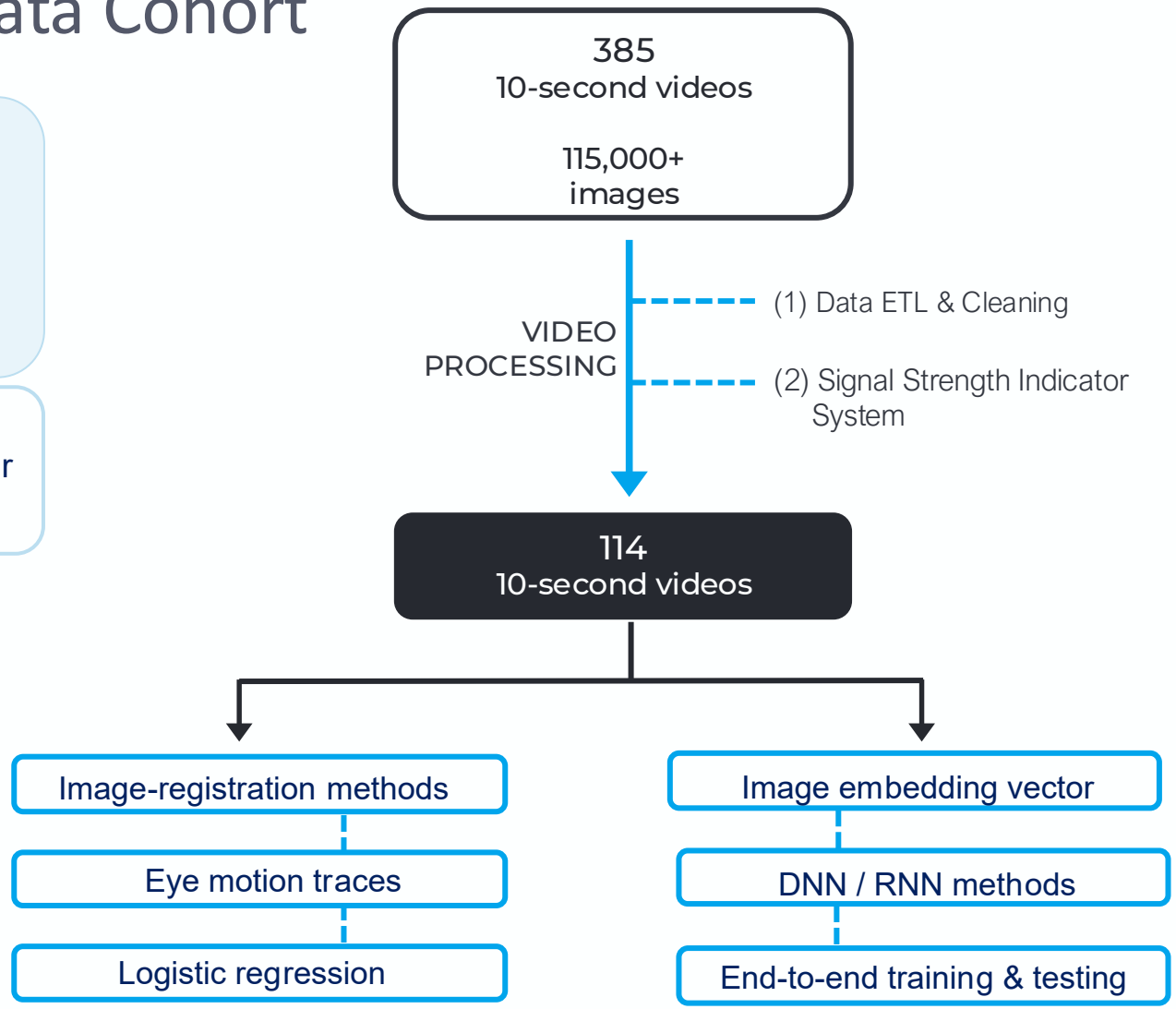
Current Dataset

- 11 diagnosed MCI patients / 23 healthy controls
- Each scanned multiple times with SLO device generating 48 (MCI) vs 66 (Control) x 10-second video sequences
- ~ 4% of scans have zero involuntary saccades / motions

Using our **Signal Strength Indicator System** to remove low quality (Cataract, AMD, etc.) video data resulted in **114 videos** for training & testing of our AI prediction system



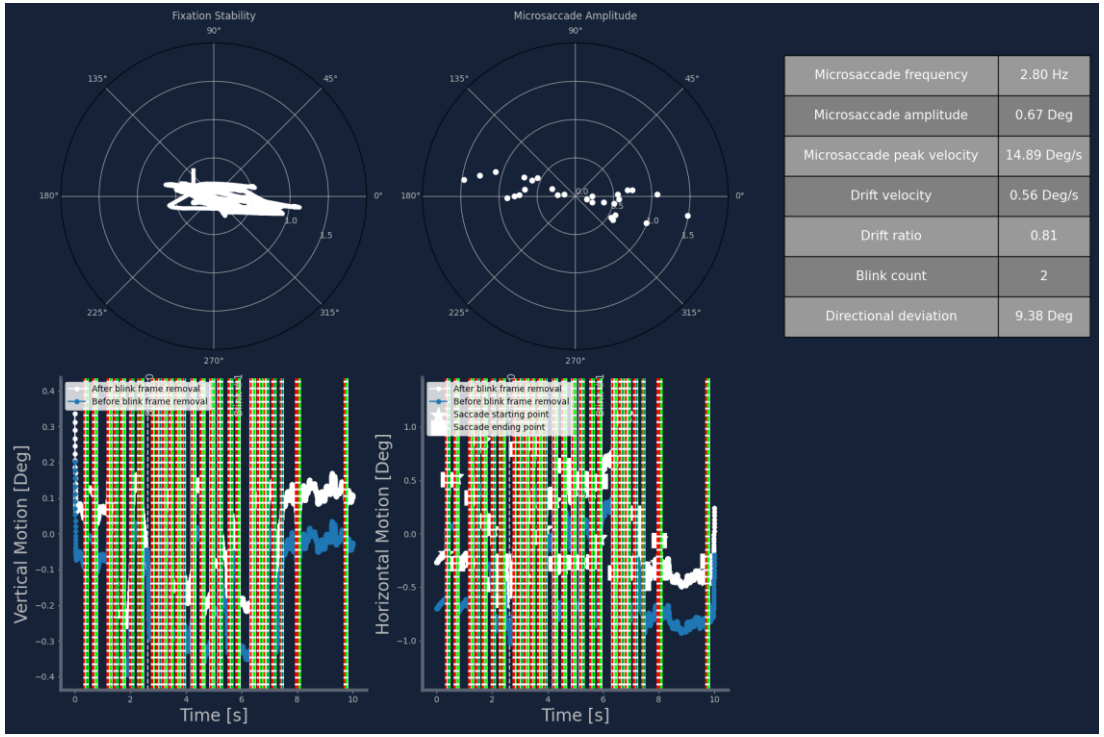




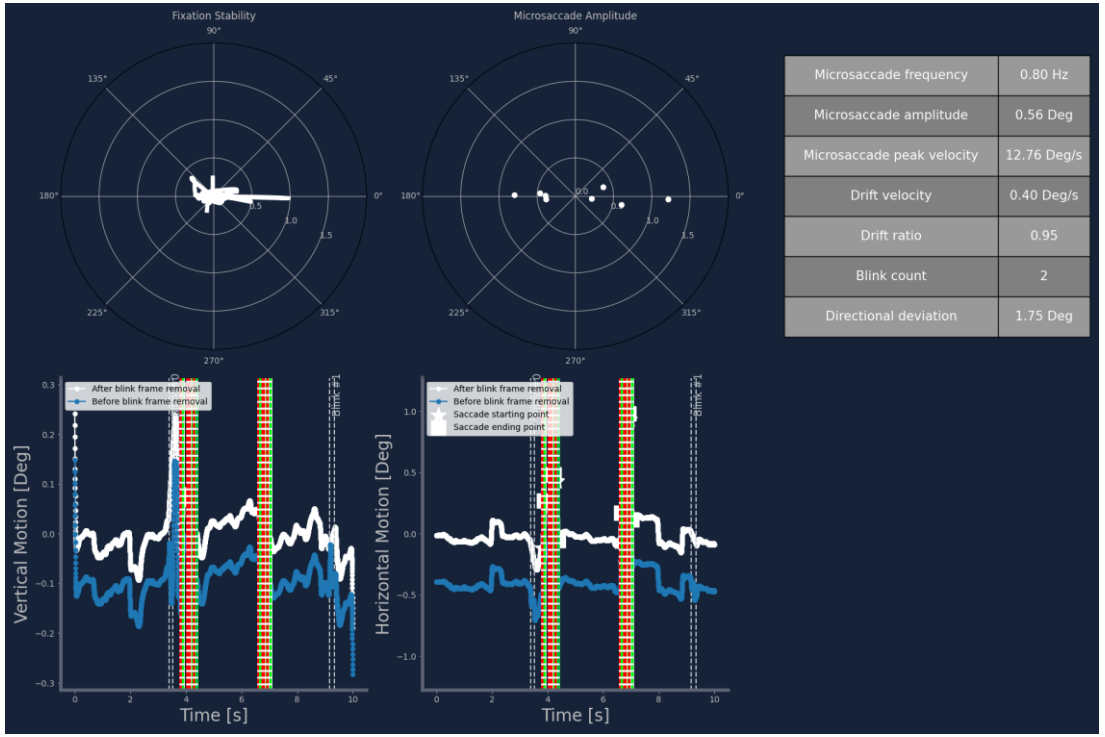
Motion Analysis

- **Velocity Thresholding (VT)** used to detect a saccade / eye motion
- We explicitly look for various indicators for MCI such as **directional deviation**, motion amplitude, velocity, frequency, blink count / rate, drift characteristics

MCI



Healthy Control



REPRESENTATION LEARNING

Temporal Correlations

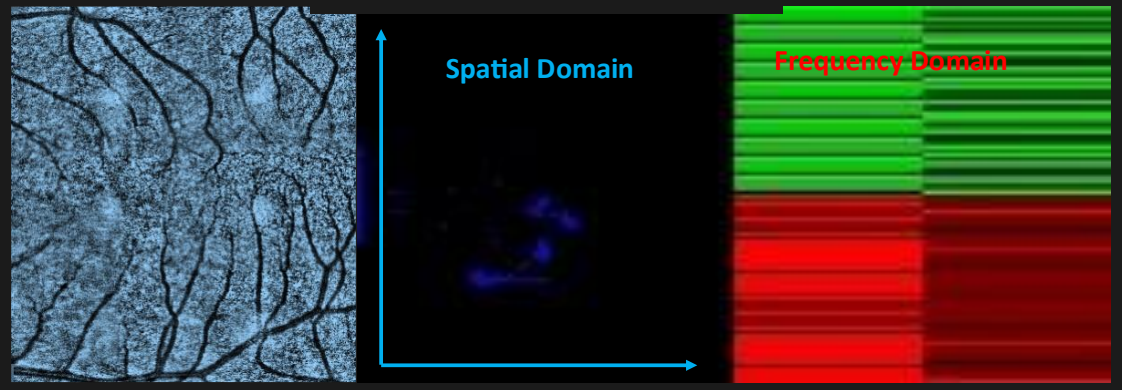
DEFINITION

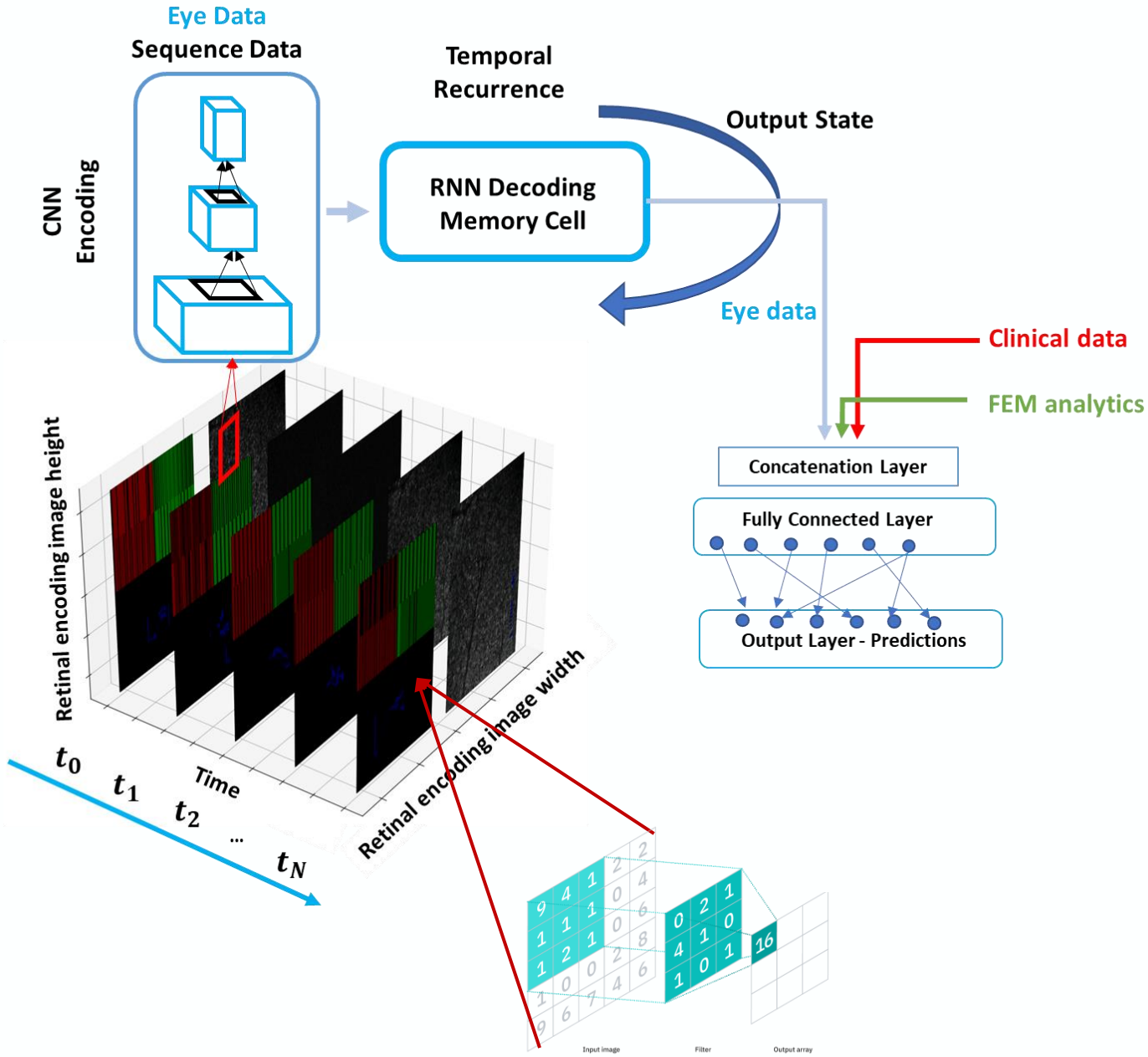
A **Recurrent Neural Network** (RNN) based model is built to capture & learn temporal correlations embedded in video sequences

PROPOSAL

We propose to use **Retinal Coding** which is a “hyper image” that encodes all temporal, frequency domain as well as spatial domain information of the raw video data

RETINAL ENCODING





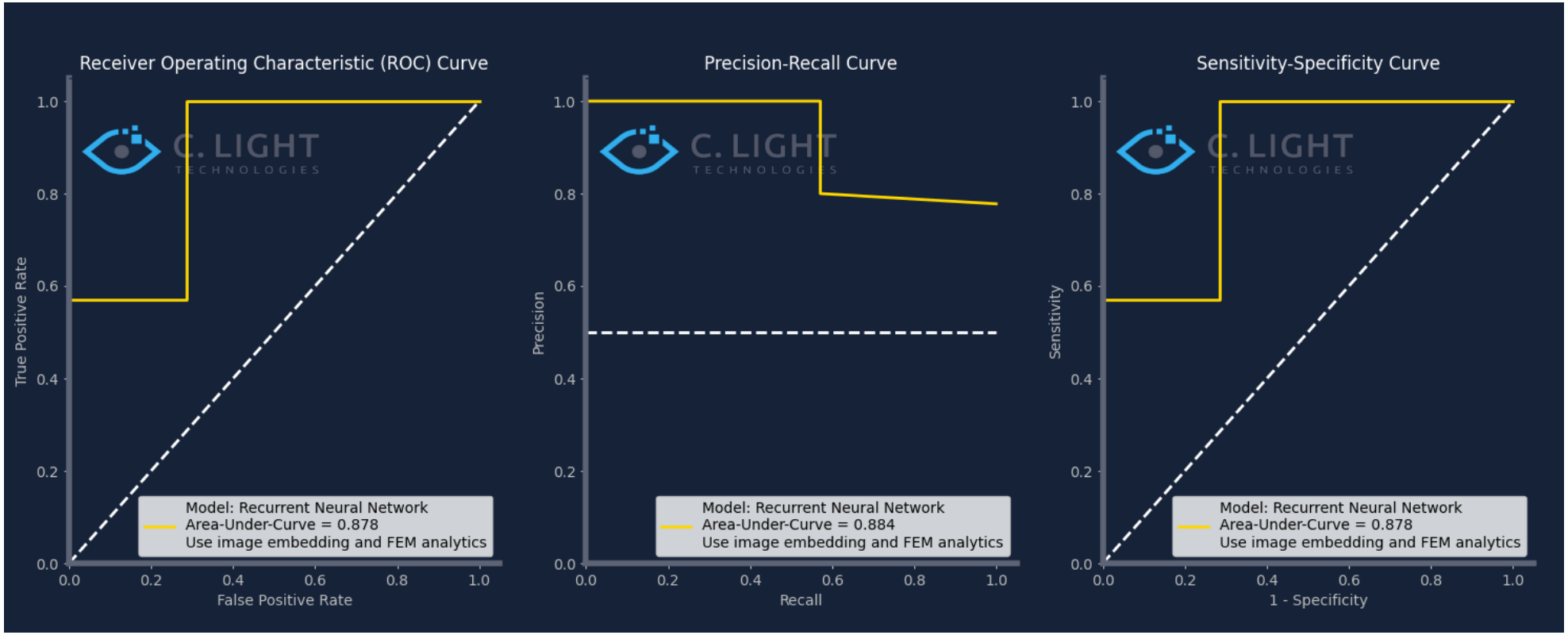
Preliminary Results MCI Prediction

PARAMETERS

- Train-validation splitting: 20%-80%
- Sequence length: 5
- Data augmentation used in training

OBSERVATIONS

We used the same model as the one used in Multiple-Sclerosis study. The model right now is putting more attention on precision of detections, as compared to the recall (FN) due to limited data volume

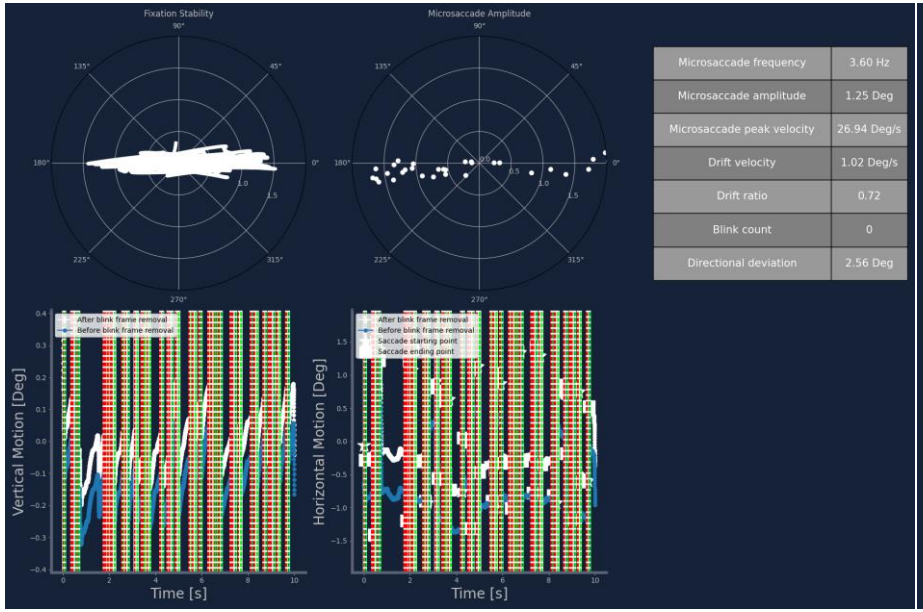


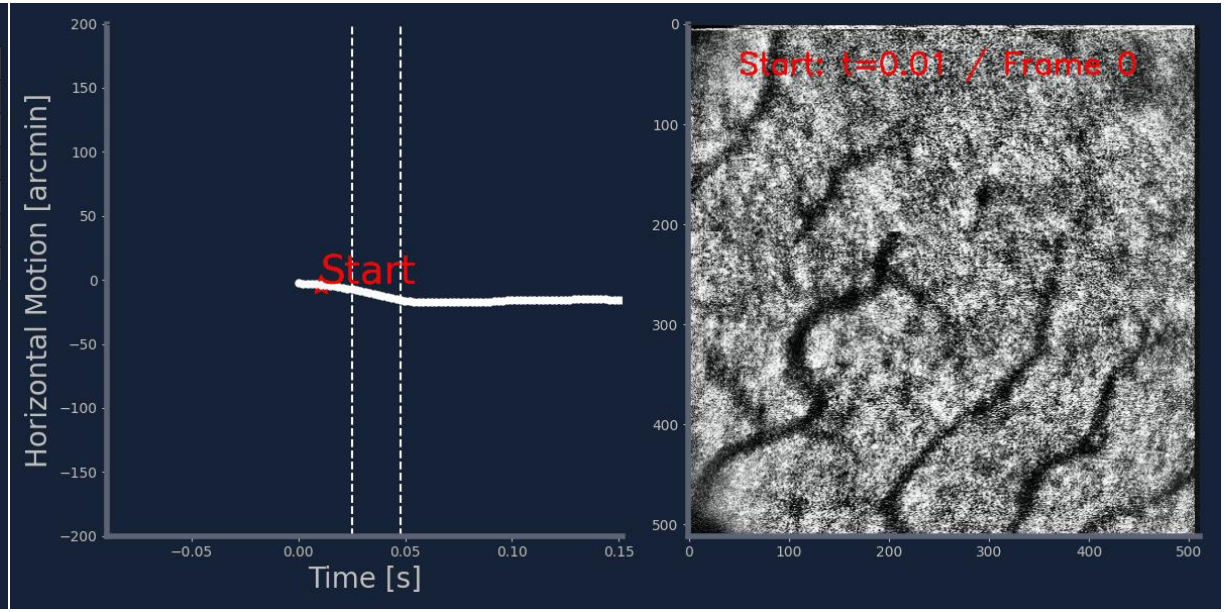
Conclusion

Using AI to perform end-to-end prediction leverages all information (latent) embedded in data, thus a powerful tool for disease predictions relying on medical images, video sequences

- We experimented on MCI data with the same AI prediction system used in previous study of Multiple Sclerosis
- We observe promosing results on model‘s predictive power, model‘s performance on Reall currently limited by the data volume
- Work-in-progress on collecting more data, as well as cleaning and sorting out the control sample where it contains behaviors such as **Nystagmus**

- **Trains of square-wave-jerks**
- **Up-beat vertical motions**





C. LIGHT TECHNOLOGIES

C. LIGHT TECHNOLOGIES

THANK YOU

WE'RE HIRING!

JOIN OUR TEAM

careers@clighttechnologies.com

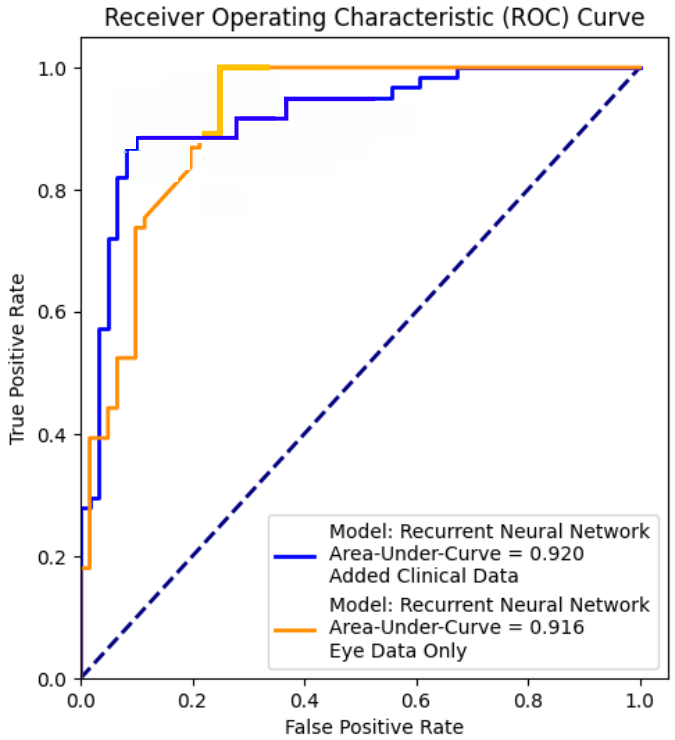
Preliminary Results Multiple-Sclerosis Prediction

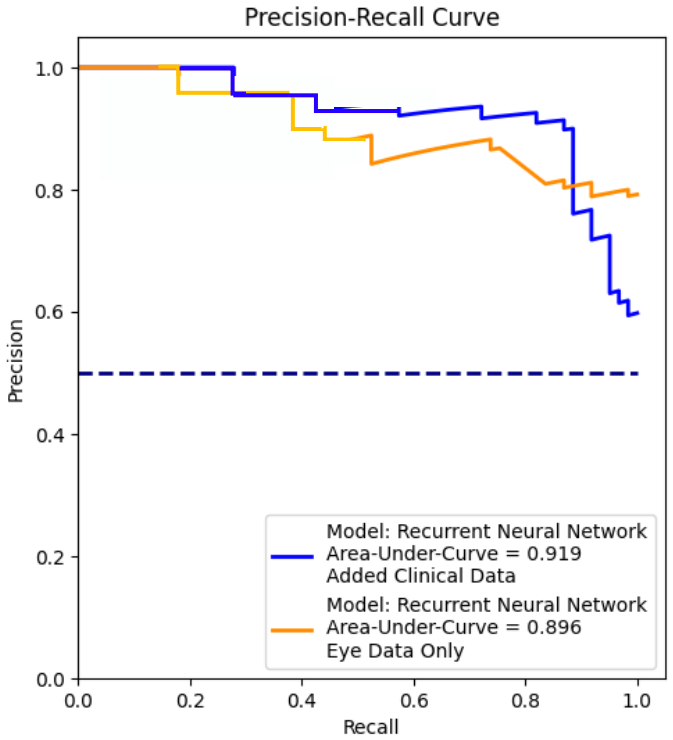
PARAMETERS

- Train-validation splitting: 20%-80
- Different sequence length (3, 4, 5 timesteps) is experimented with RNN for the 10-second-long video sequences

OBSERVATIONS

We observe that the **RNN model outperforms the baseline model by 20%** (in regards to Precision-Recall metrics) using Logistic Regression + Feature Engineering



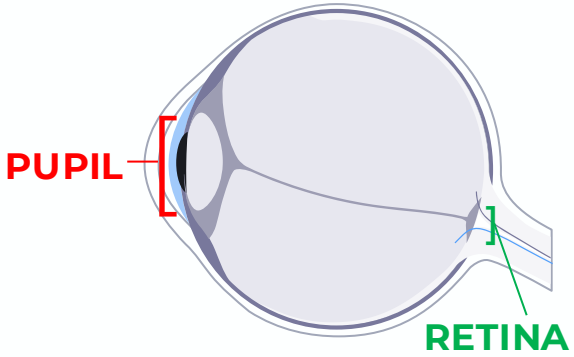


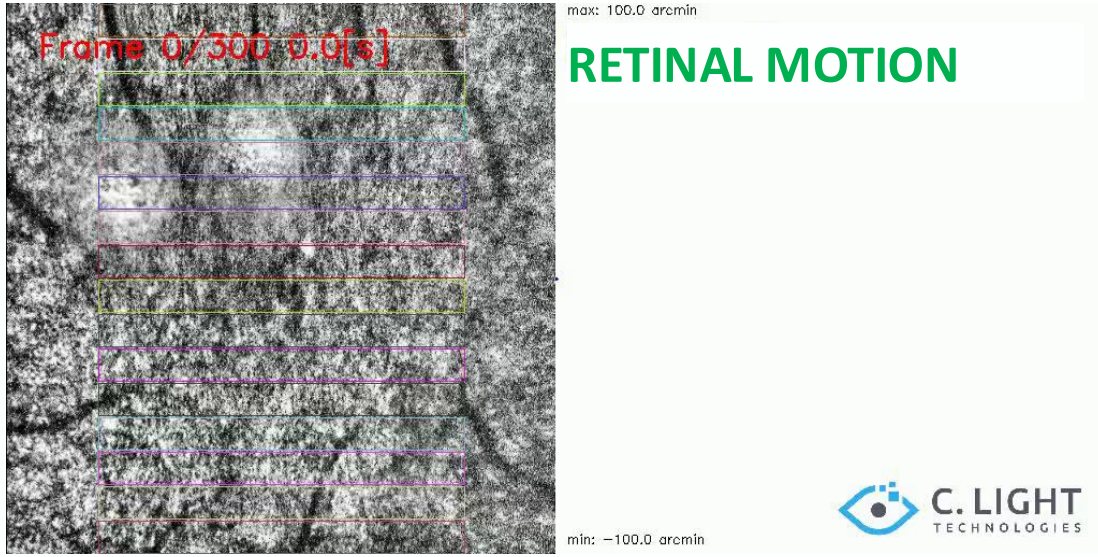
Sequence Length = 5 (10 s)

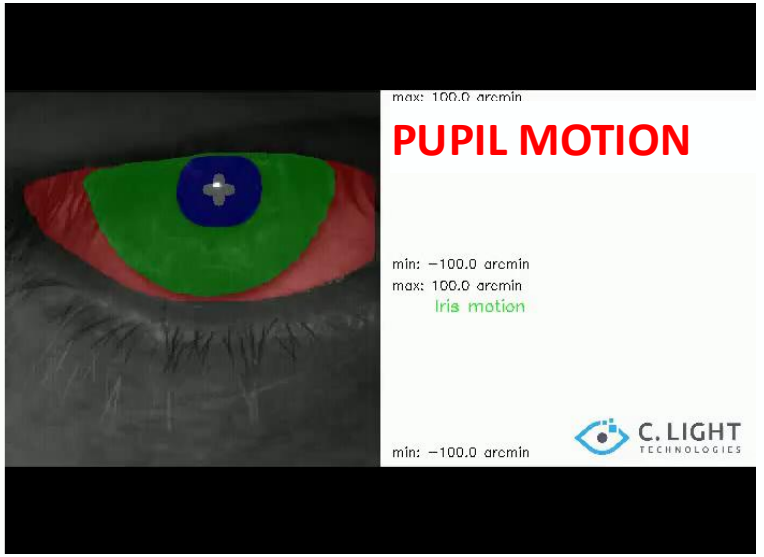
Test Sample	Precision	Recall	F-1 Score
Class 0 (Healthy)	0.89	0.90	0.89
Class 1 (Disease)	0.90	0.89	0.89
AUC - ROC curve		**0.920**	
AUC - PR curve		**0.919**	

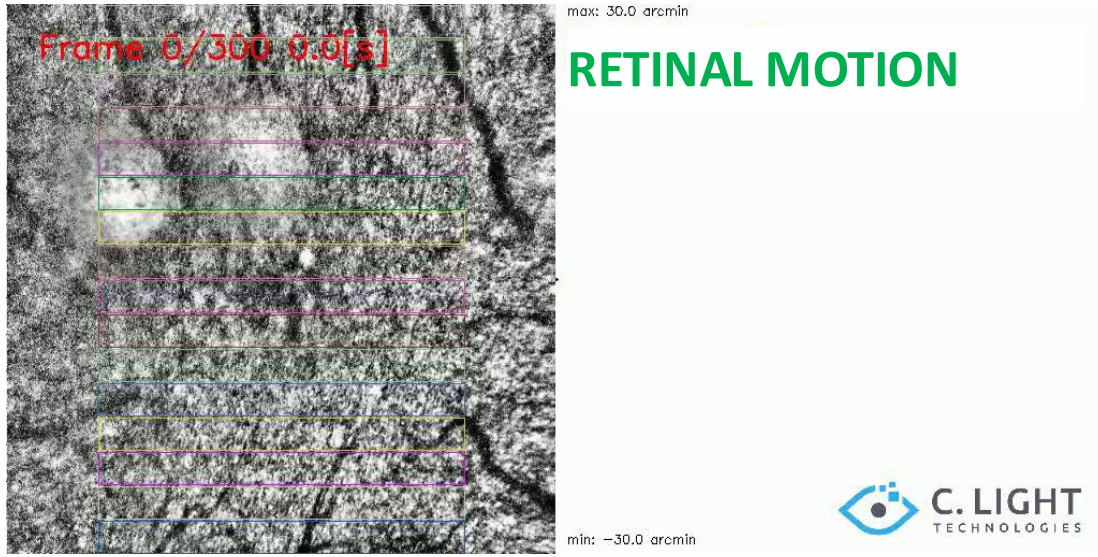
Comparison Pupil vs. Retinal data

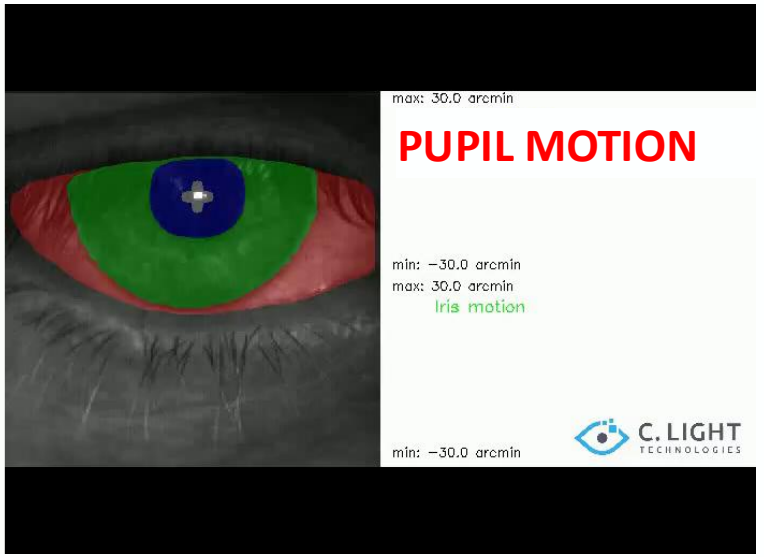
PARAMETERS
- Same eye
- Different camera











Our Product Meet the Retitrack™

CAUTION: Investigational Device. Limited by Federal (or United States) law to investigational use.