A General End-to-End Method for Characterizing Neuropsychiatric Disorders using Free-Viewing Visual Scanning Tasks

HONG YUE SEAN LIU

JONATHAN CHUNG

MOSHE EIZENMAN

UNIVERSITY OF TORONTO

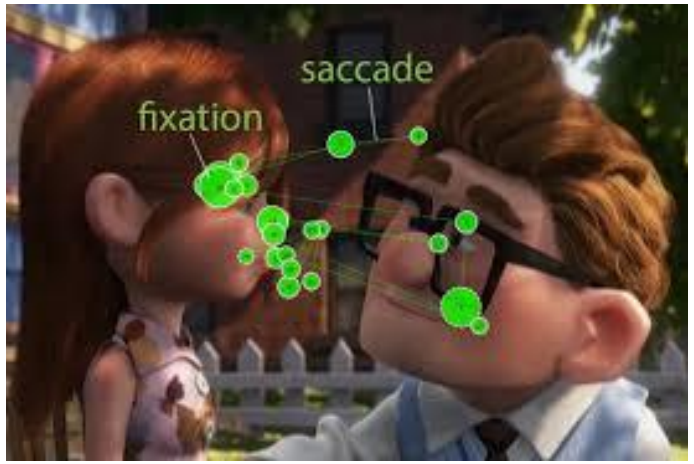
Introduction

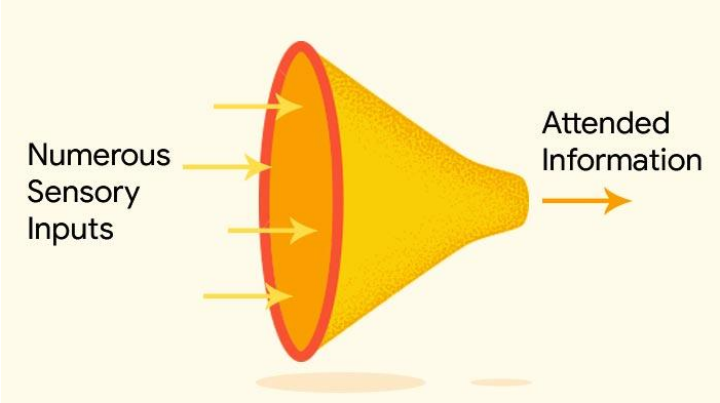
Purpose:

- **Generalizable framework** for analyzing and classifying **data from free-viewing visual scanning tests** used with diagnosing/monitoring neuropsychiatric disorders

Background

- Visual scanning tests collect **visual scanning behaviour (VSB)** through **gaze-tracking** to quantify cognition
- VSB are sequences of fixations and saccades
- Extractable metric from VSB: **attentional bias**
  - Humans have a limited capacity for information processing
  - **Selective attention** to certain stimuli





Visual Attention Scanning Technology (VAST)

Relative Fixation Time (RFT)

$$RFT(\boldsymbol{ROI}) = \frac{\sum \text{Time fixated on } \boldsymbol{ROI}}{\sum \text{Time fixated on slide}}$$

ROIs manually defined

- Prone to bias

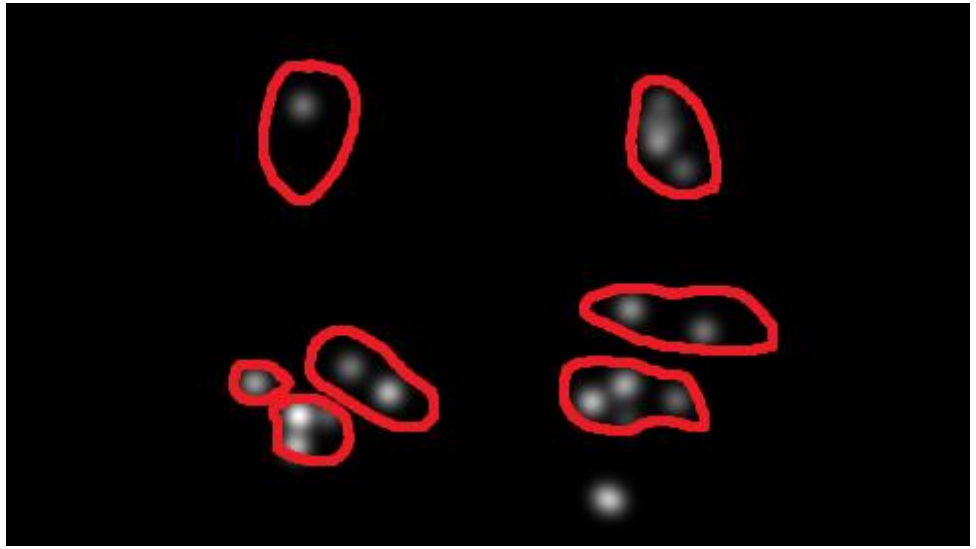
Calculations using point-based fixations

- Not robust to random errors at higher granularities

RFTs with RVAMs (RVAM-RFTs)

Creating a **Relative Visual Attention Map (RVAM)**

1. Get list of fixations on single slide
2. Convert each fixation to 2-D Gaussian
3. Scale each Gaussian by fixation duration
4. Normalize entire map by total fixation time



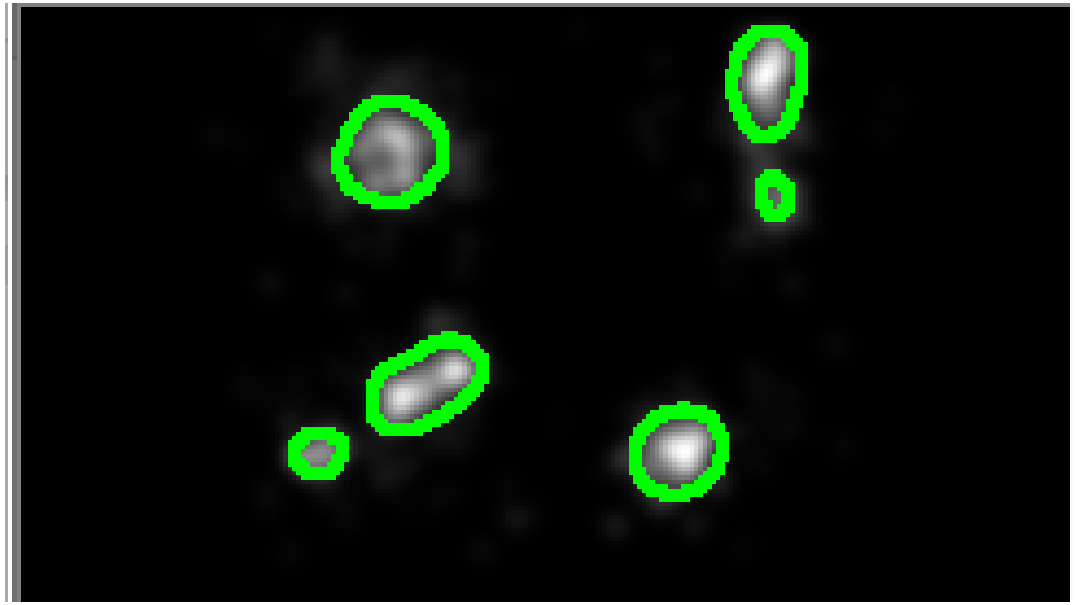
$$RVAM\_RFT(\boldsymbol{ROI}) = \sum_{x}\sum_{y} RVAM$$

$$(x, y) \in \boldsymbol{ROI}$$

Data-driven ROI Segmentation

Use statistical RVAM averages from individuals in training set

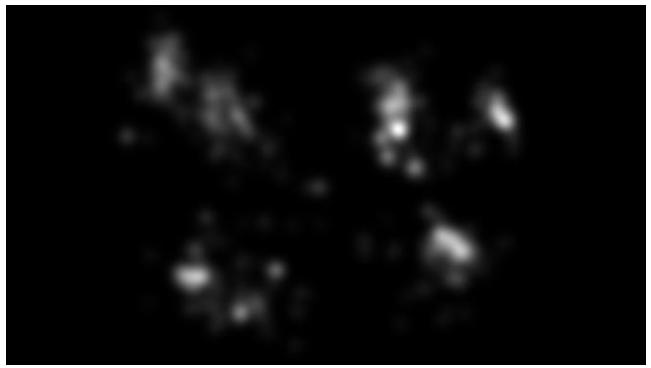
Segment relevant ROIs for RVAM averages on each subject class



1. Threshold
2. Find contours
3. Get ROIs

An average RVAM (aRVAM) from a subject class viewing the same slide

ROI Segmentation Methods

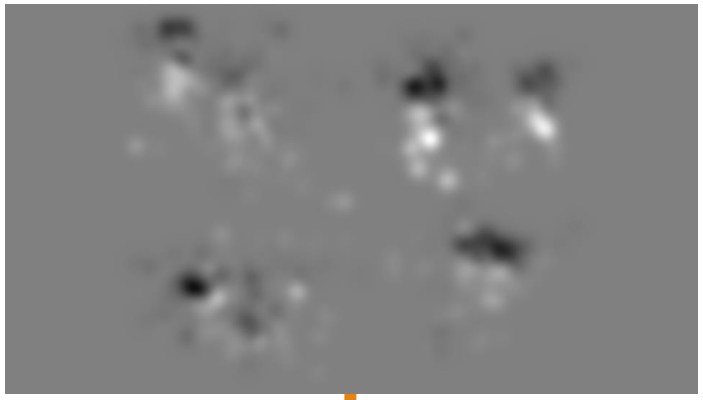


Group 1

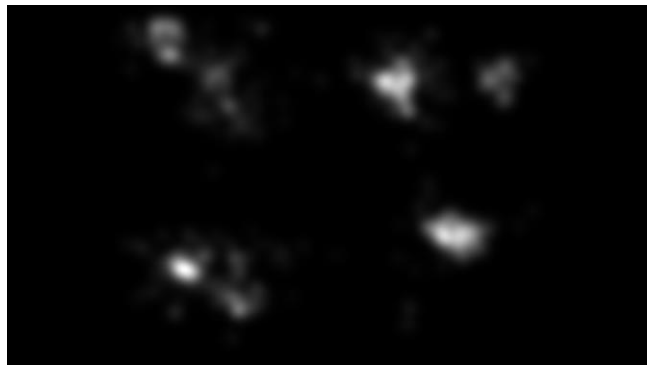
Method 1

Subtract

Method 2

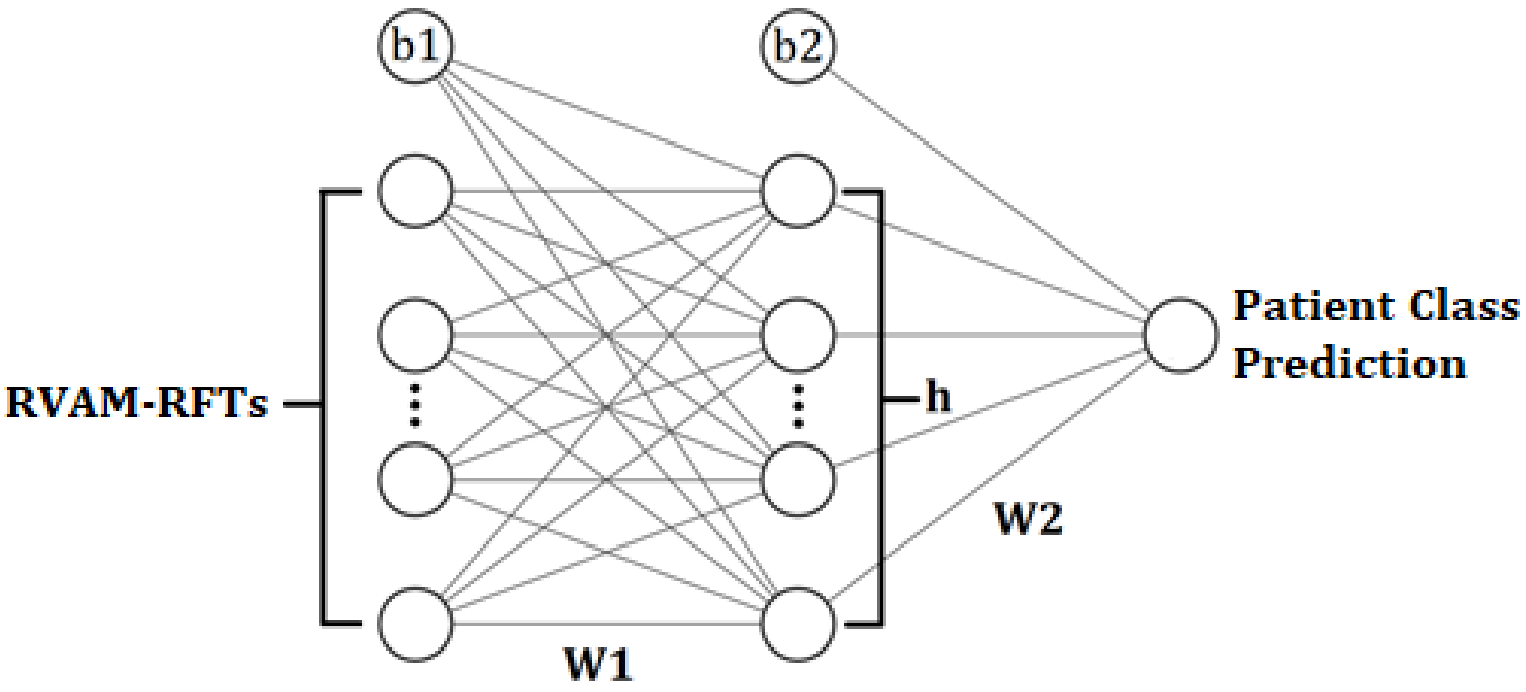


Split positive and negative



Group 2

Classification of RVAM-RFTs



Vanilla Multilayer Perceptron (MLP)

Data, Setup, and Evaluation

Evaluation on 2 visual scanning studies:

- Anorexia Nervosa (AN) study
- Depression study

Vanilla MLP classifier:

- # hidden nodes = ½ number of RVAM-RFT features
- FC layer: 0.001 regularization → batch norm → ReLU → 0.5 dropout
- Training: ADAM w/ 0.001 l.r., batch size 32, 1000 epochs

Comparison against baseline model:

- Similar vanilla MLP classifier using RFT features calculated with raw fixations and image-boundary ROIs

Results

CLASSIFICATION RESULTS AND COMPARISONS

Techniques		AN			BD-MDD		
ROI	RFT	AUROC	Brier Score	Balanced Accuracy	AUROC	Brier Score	Balanced Accuracy
Method 2	RFT_{RVAM}	0.9130	0.1005	0.8851	0.8879	0.1753	0.8187
Method 1	RFT_{RVAM}	0.9348	0.1064	0.7919	0.7954	0.2394	0.6821
Manually defined (4 image boundaries)	RFT_{RVAM}	0.9596	0.0996	0.8137	0.5900	0.3275	0.5753
Baseline							
Manually defined (4 image boundaries)	RFT_{raw}	0.9130	0.1069	0.8571	0.6522	0.2831	0.5859
Past Work [7]							
LRCN					0.879		0.801
RNN w/ 3-by-3 per-image grid ROI					0.823		0.744

Contributions & Future Work

Contributions

- Proposed a general framework for classifying subjects participating in free-viewing visual scanning tests
- Goal is for framework to be a standard baseline method and foundational framework to be built upon

Future Work

- Improve design
  - More sophisticated classifier model
  - Include other eye-movement features (order of fixations, saccadic amplitudes)
- Evaluation on more datasets

Thank you for listening!