Differentiating Patients from Controls by Gazing Patterns

Po-He Tseng[1], Ian Cameron[2], Doug Munoz[2], Laurent Itti[1]

[1]Department of Computer Science, University of Southern California
[2]Centre for Neuroscience, Queen's University

Introduction

Several Studies have shown that eye movements and certain complex visual functions are influenced by diseases such as Attention Deficit Hyperactivity Disorder (ADHD) and Fetal Alcohol Spectrum Disorders (FASD)

Here we examine how bottom-up (stimulus-driven) attentional selection mechanisms may differ between patient and control populations, and we take the advantage of the difference to develop classifiers to differentiate patients from controls

Neurobehavioral Disorder

Attention Deficit Hyperactivity Disorder (ADHD)
Persistent patterns of inattention and/or hyperactivity, poor impulsive controls, etc.

Fetal Alcohol Spectrum Disorders (FASD)
Complex pattern of behavioral or cognitive abnormalities in attention, impulsive control memory, etc.

FASD is often misdiagnosed as **ADHD** because of similar symptoms. However, their causes & treatment are different

Parkinson's Disease (PD)
Slow reaction time, different allocation of attention, difficulties in impulsive control, short-term memory loss, etc.

Experiments

Exp. 1 (Children Populations)
22 **ADHD** (10.9±2.0 yr) vs. 10 **FASD** (12.4±2.1 yr) vs. 18 Control **Children** (10.5±2.0 yr)

Exp. 2 (Elderly Populations)
13 (67.4±6.9 yr) **PD** vs. 23 Control **Elderly** (70.2±7.7 yr)

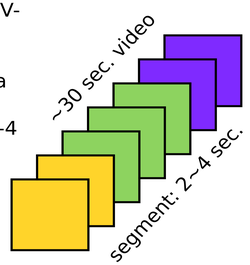
Note: 8 ADHD, 5 FASD, 5 Control Children, 2 PD, and 1 Control Elderly were removed from the experiments for less than 5 minutes of valid eye traces. Another 2 ADHD and 2 FASD children were removed due to medication on the day of the experiment.

Methods

Record Eye-Movement

Stimuli: Natural scene MTV-style videos (20 minutes - 40 videos, ~30 seconds each). MTV-style video is a continuous video whose scene changes for every 2-4 seconds.

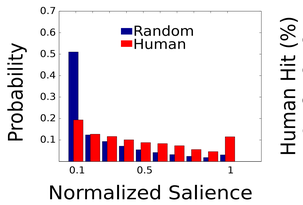
Instruction: "Watch and enjoy the clips"

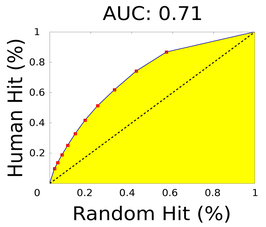


Compute Saliency Map

(Itti & Koch, 2001)

Correlation between Salience & Gaze





- Compare the saliency value at saccade endpoint to randomly sampled values from the saliency map
- Only analyze saccades that are ill-predicted by eye movements of young adults
- Quantify the correlation by ordinal dominance analysis

Classification

Features:
(1) Correlations bewteen salience and gaze
(2) Saccade statistics

Pre-Processing:
(1) Remove features with few saccades
(2) Normalize data (Standard score)

Training Set
[Leave-one-out]

Testing Set

Training SVM (One-vs-One)

Feature Elimination MSVM-RFE

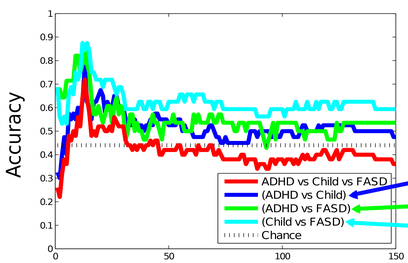
Feature Ranking

Classifying SVM

Control, ADHD, or FASD?

Results

Exp. 1 (ADHD vs FASD vs Control Children)



72%

77.5%
85.7%
87.5%

Feature Ranking

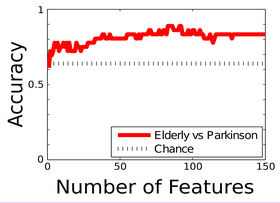
1st: 1.48(1.68), M_hist2_sacidx5
2nd: 4.94(2.93), E_hist2_sacidx4
3rd: 5.74(2.47), F_hist2_sacidx2
4th: 5.86(5.28), sacint_q3_sacidx5
5th: 6.10(2.62), pvel_q1_sacidx5
6th: 6.24(2.70), I_hist2_sacidx4
7th: 6.46(5.52), sacdur_sacidx4
8th: 8.00(4.55), T_hist2_sacidx3
9th: 8.38(3.29), L_hist2_sacidxAll
10th: 9.98(2.06), F_hist2_sacidx4

Exp. 2: (PD vs Control Elderly)

89%

Feature Ranking

1st: 3.92(3.51), sacint_q3_sacidxAll
2nd: 5.08(4.24), sacdur_q3_sacidx2
3rd: 6.78(6.26), amp_q3_sacidx2
4th: 8.42(7.49), X_hist2_sacidx2
5th: 8.94(8.31), O_sacidx4



Summary

Stimulus-driven attentional selection is influenced by diseases (ADHD, FASD, Parkinson) as shown by classification accuracy

The difference can serve as a possible screening/diagnostic tool for clinical applications

An easier (task-free), cheaper, quicker and more natural method to test patients compared to other tests

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