Reading Detection in Real-Time

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ETRA • 2019

Motivation

Goal: To detect reading in real-time across text-heavy stimuli

Example: Web news articles

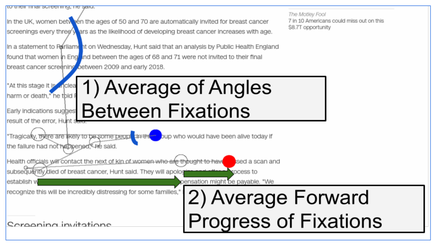
Applicability:

- Find areas of importance in stimuli
- Identify gaps in subject attention
- Predicting cognition from reading

Existing Approach:

-- ***Eye tracking*** --

Features of *fixation windows* have been shown to predict reading vs. skimming behavior



Problems:

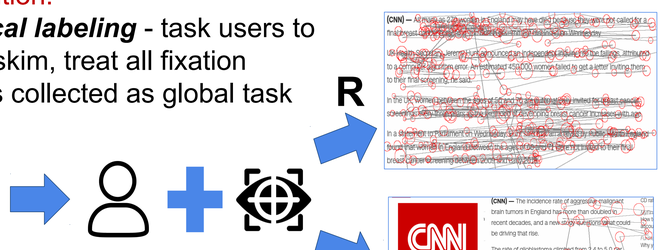
How to collect the ground truth window labels?

Reading? or Skimming?

Hard to label windows!

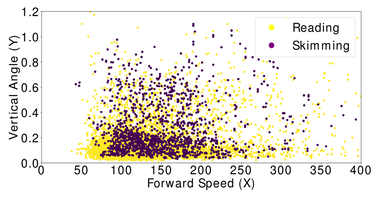
Our solution:

Skip local labeling - task users to read or skim, treat all fixation windows collected as global task label



Challenge:

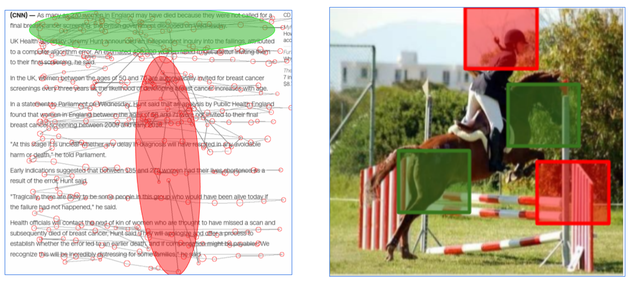
- Real reading contains skimming behavior, and real skimming contains some reading
- Leads to hard to separate data



How to classify windows in presence of noisy labeling?

Methodology

We use RRSVM [1], a method made for classifying image regions from global image labels, to classify fixation windows as reading or skimming given global article labels



Why Region Ranking SVM (RRSVM):

RRSVM combines information **across samples** to counteract noise introduced by propagating global labels to localized areas

Approach intuition:

Just as not all regions of the above image contain a horse, not all windows during text reading indicate reading behavior.

How RRSVM Works:

RRSVM learns a set of weights, **w**, and bias, *b*, as in normal linear classification but introduces sample weights, **s**, to aid in classifying under label propagation

$$\mathbf{w}^T\Gamma(\mathbf{B};\mathbf{w})\mathbf{s} + b.$$

w, b: Weights features on each window as being from reading

s: Influence of each window across *all* articles as being reading or skimming

B: Data matrix containing features for windows of each article

Optimization:

(A) Fix ***w***, optimize with respect to ***s***, *b using* Quadratically Constrained Quadratic Program

(B) Fix ***s***, optimize with respect to ***w***, b using standard regularized SVM

Optimization occurs iteratively; global knowledge in **s** *helps update local knowledge in* **w** *each iteration*

Future Work

WebGaze

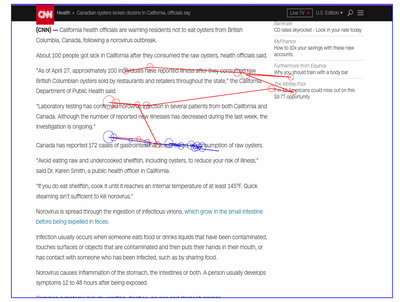
- *http://gaze.cs.stonybrook.edu*
- Optimize Web pages from the user perspective
- Better optimizations based on engagement

Experiments

Final Classification:

RRSVM outputs both window **and** global article predictions

Reading



Skimming

Evaluations:

- We characterize viewing behavior under reading and skimming conditions, and evaluate both locally and globally

Measures (avg)	Reading (n=16)		Skimming (n=16)	
	M	*SD*	*M*	*SD*
Reading Time (sec)	77.94	20.38	9.96	0.28
Fixation Count	288.65	71.56	39.01	5.46
Fixation Duration (ms)	226.68	21.49	225.39	37.23
Saccade Amplitude (°)	3.05	0.36	3.19	0.45
Leftward Saccades (%)	32.06	6.16	32.92	4.22
Accuracy (%)	88.7	11.47	N/A	N/A

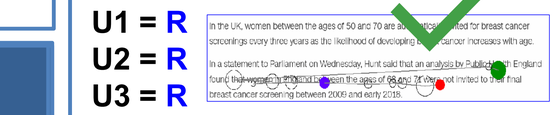
All Eyetracking was performed using an EyeLink 1000 SR Research tracker sampling at 1000hz with fixation filtering

Method	Performance (BCR)	
	Global	*Local*
RRSVM (Locally Optimized)	.751	.951
RRSVM (Globally Optimized)	.825	.720

More iterations of the optimization procedure of RRSVM can be used to tune BCR for global prediction, and vice versa.

We only test against labels in which all raters agreed (75% agreement)

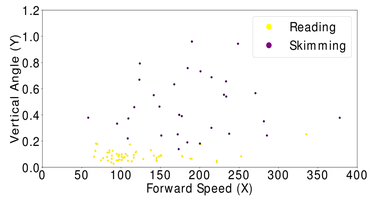
U1 = R
U2 = R
U3 = R



- We task eyetracking experts in our community to label 120 random windows as reading or skimming, *windows were only used for verification*

Findings:

- **Features –** Reading users exhibited less saccade amplitudes and leftward saccades, which is captured by our features
- **Performance –** Local detection means real-time prediction: delays average 1.5 seconds given ~250ms fixation duration and 6 past and future fixations in each window
- **Accuracy –** Balanced Classification Rate (BCR) of up to 95% for local labels



- Resulting local labels from raters who agreed are separable, increasing our confidence in our local evaluation

References: *[1] Wei et al, 2016, Region Ranking SVM for Image Classification, IEEE Conference on Computer Vision and Pattern Recognition, CVPR '16,*

Acknowledgments: *This project is partially supported by the National Science Foundation Award CNS-1718014*