# Fixational Eye Movements as Bio-Markers for Visual Acuity


The Interdisciplinary Computational Vision Laboratory

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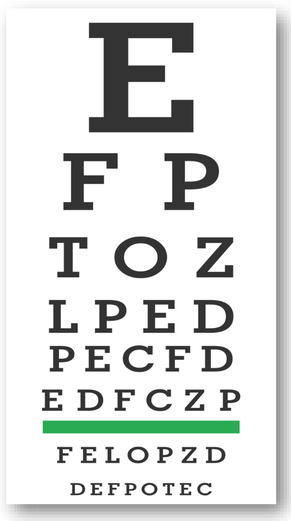
## 1. Motivation

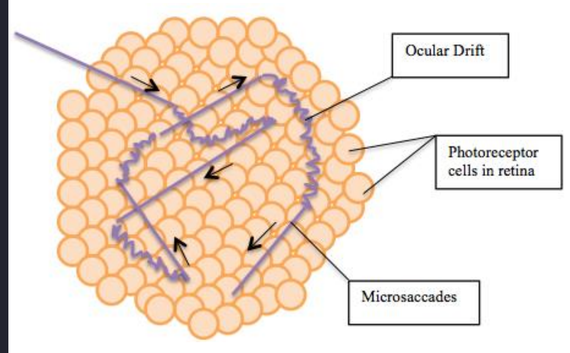
How far away can you accurately read the chart? The Snellen eye chart[1], invented in 1862, remains the widely recognized benchmark for assessing visual acuity.

Nonetheless, it presents several challenges that impede eye-care professionals in their practice.




Snellen Chart

## 2. Fixational Eye Movements




Fixational Eye Movements

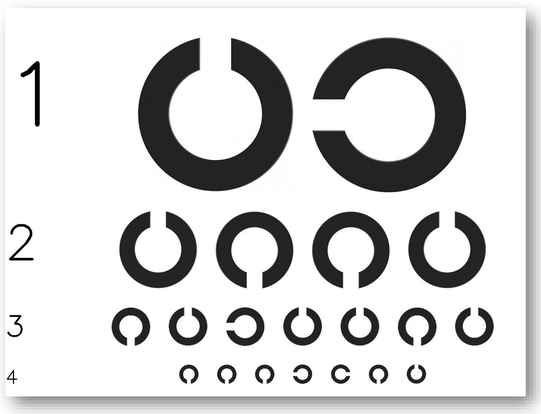
Even when we look at the same point in space, our eyes are never static. These movements are ideal candidates for bio-markers:

1. They are involuntary.
2. We don't depend on the subject's report.
3. They mostly depend on low-level visual function, rather than on higher-order cognitive processes

## Can we use fixational eye movements to predict a subject's visual acuity?

## 3. Experiments

We conducted a series of experiments involving 14 subjects engaging in various tasks while their eye movements were recorded[2]. Some tasks were designed to elicit fixations eye movements on acuity tasks.

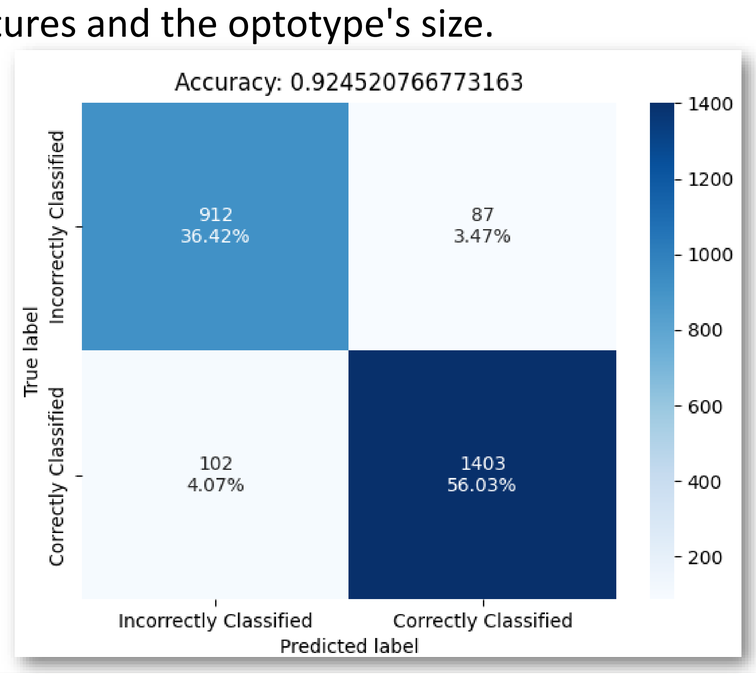



**Exp 1**: Report the orientation of each stimulus
**Goal**: Collect "labeled" data

**Exp 2**: Report level of relaxation after watching the image
**Goal**: Collect fixational eye movements on natural images

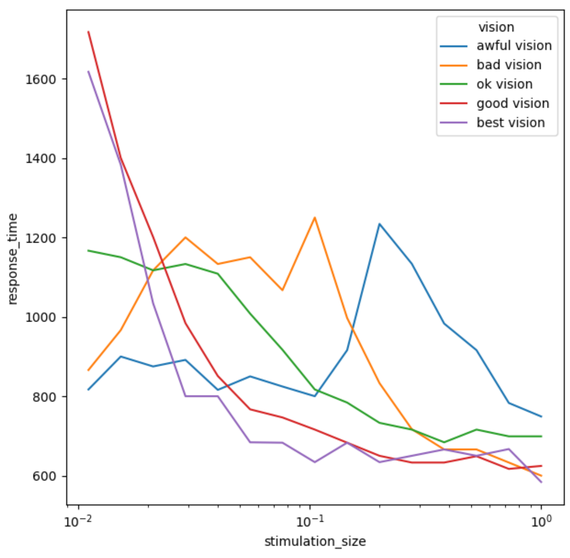
## 4. Methods

For every fixation sequence, a set of descriptive features was derived. Subsequently, a predictive learned model (XGBoost [3]) was constructed, aiming to determine whether the subject accurately identified the direction of the optotype based on the fixation's features and the optotype's size.

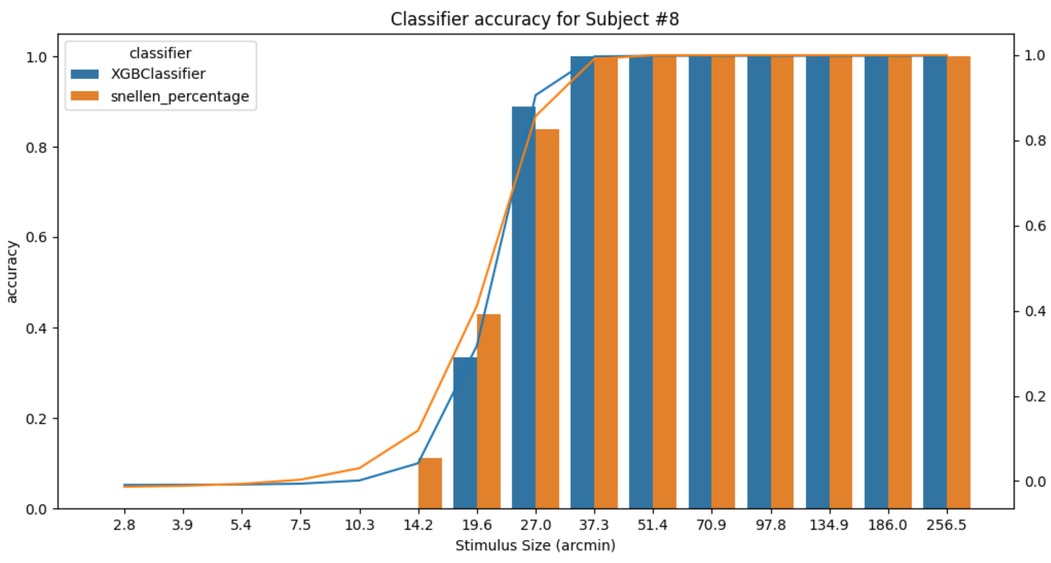



## 5. Results

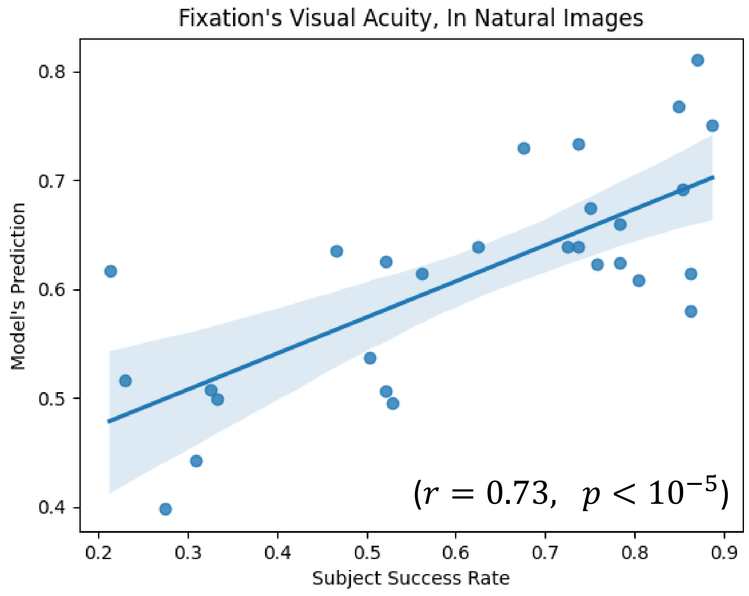
A most indicative feature for visual acuity is response time, likely reflecting a sort of cognitive workload.




The computational model predictive power is comparable to that of the Snellen eye chart in determining the optotypes for which the subject will accurately discern the direction.




The computational model has the capacity to predict the subject's visual acuity using fixations from natural images.




## 5. Summary

1. By leveraging fixational eye movements, it is possible to predict a subject's visual acuity to a degree comparable with the accuracy of the Snellen eye test even from free viewing tasks.
2. With different patterns of fixational eye movements discerned for different acuities in general, potential extensions may allow to explore acuity in the context of *specific* visual features (e.g. color, contrast), generating new tools for vision inspection.

## References


[1] Holladay, J. T. (2004). Visual acuity measurements. *Journal of Cataract & Refractive Surgery*, *30*(2), 287-290.
[2] Participants' eye movements were recorded by an SR Research Eyelink 1000 system at a sampling rate of 1000 Hz.
[3] Chen, T., & Guestrin, C. (2016). XGBoost: A Scalable Tree Boosting System. In *Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (pp. 785–794). New York, NY, USA: ACM. https://doi.org/10.1145/2939672.2939785