## VISUALIZING PREDICTION CORRECTNESS OF EYE TRACKING CLASSIFIERS Martin H.U. Prinzler<sup>1,3</sup>, Christoph Schröder<sup>2</sup>, Sahar Mahdie Klim Al Zaidawi<sup>1</sup>, Gabriel Zachmann<sup>2</sup>, Sebastian Maneth<sup>1</sup>

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## **Classification via Eye Tracking Trajectories**

Eye tracking data is often used for classification tasks. As example, we determine users based on their eye movements (see [1]). Our Method builds on the classification probabilities from fixations and saccades.

Segmentation: To divide the gaze trajectories into fixations and saccades, we implemented the simple *Identification-by-Velocity-Threshold* (IVT) algorithm which is described in slightly different ways in multiple publications (e.g. [1]).
Classification: In our context, classification means to label eye tracking data with the ID of

## **Prediction Correctness Value (PCV)**

For every trajectory segment t of each participant u, our classifier returns a probability p(t, u). The PCV is the difference between the calculated probability of the correct participant  $p_c(t)$ , and the highest probability from any other participant  $p_m(t)$ .

$$PCV(t) = p_c(t) - p_m(t).$$
(1)

In case of a correct prediction, the PCV is positive. If the classifier predicted a wrong participant, the PCV will be negative. The greater the difference from the first to the

a unique participant. As classifiers we use *Random Decision Forests* (RF) (as implemented in [2]) and *Radial Basis Function Networks* (RBFN) as described in [1].

## **Prediction Correctness Heatmap (PCH)**

In Figure 1 we show the positive histograms for the *Prediction Correctness Value* (PCV) of each fixation of 153 participants on a reading stimulus. The top row (a, b) shows results from the test cases with unseen data. We see that different algorithm perform similar and are highlighting the same areas as beneficial for the prediction (good to differentiate between participants). This leads to further research Questions about what makes this regions special: e.g. "Are there specific words which are read very differently by the participants?"

#### THE LANDING

"Just the place for a Snark!" the Bellman cried, As he landed his crew with care; Supporting each man on the top of the tide By a finger entwined in his hair.

"Just the place for a Snark! I have said it twice: That alone should encourage the crew. Just the place for a Snark! I have said it thrice: What I tell you three times is true."

The crew was complete: it included a Boots— A maker of Bonnets and Hoods— A Barrister, brought to arrange their disputes— And a Broker, to value their goods.

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Fig. 2: A simple example for the PCV. Left: Participant 03 is correctly predicted. The second plausible prediction would be participant 01. Right: Mistakenly, the classifier predicts participant 02.

### Datasets

We use two datasets from the 2015 *BioEye competition* [3]. Both contain data obtained from 153 participants, whose tasks were to read a poem, and to observe a randomly moving dot (not featured on this poster).

We thank Oleg Komogortsev for providing the used dataset.

## **Prediction Correctness Trajectory (PCT)**

A Billiard-marker, whose skill was immense, Might perhaps have won more than his share— But a Banker, engaged at enormous expense, Had the whole of their cash in his care.

There was also a Beaver, that paced on the deck, Or would sit making lace in the bow: And had often (the Bellman said) saved them from wreek, Though none of the sailors knew how.

There was one who was famed for the number of things He forgot when he entered the ship: His umbrella, his watch, all his jewels and rings, And the clothes he had bought for the trip.

#### (a) RF on test case

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#### (b) RBFN on test case

#### THE LANDING (part 2)

He had forty-two boxes, all carefully packed, With his name painted clearly on each: But, since he omitted to mention the fact, They were all left behind on the beach.

The loss of his clothes hardly mattered, because He had seven coats on when he came, With three pairs of boots—but the worst of it was, He had wholly forgotten his name.

He would answer to "Hi!" or to any loud cry, Such as "Fry me!" or "Fritter my wig!" To "What-you-may-call-um!" or "What-was-his-name!" But especially "Thing-um-a-jig!"

While, for those who preferred a more forcible word, IIe had different names from these: His intimate friends called him "Candle-ends," And his enemies "Toasted-cheese."

"His form is ungainly—his intellect small—" (So the Bellman would often remark) "But his courage is perfect! And that, after all, Is the thing that one needs with a Snark."

He would joke with hyenas, returning their stare With an impudent wag of the head: And he once went a walk, paw-in-paw, with a bear, "Just to keep up its spirits," he said.

(c) RF on training case

# THE LANDING (part 2)# Fix meanHe had forty-two boxes, all carefully packed,<br/>With his name painted clearly on each:45But, since he omitted to mention the fact,<br/>They were all left behind on the beach.45

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(d) Fixations heatmap

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(r) RBFN on training case

Fig. 1: Example for the *Prediction Correctness Heatmap* (PCH) on a reading stimulus.

In Figure 3 the PCV is shown for all trajectory segments of a participant reading a poem. (a, b) show the test case, where the algorithms have not seen the data before. (c, d) show the training case. With this visualization it is visible that RF (left) is overfitting (it identifies every segment correctly in the training data (c) but not in the test case (a). RBFN performs similarly on the training (d) and on the test data (b). Beside other things, with this visualization, we can see that the outliers are correctly identified in the training data, while they are mistaken for a different participant by both classifiers in the testing cases. In contrast, eye movements in the region of the text are mostly correctly classified.

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The crew was complete it in the u a Boots A maker of Bonnets and Hoods A Bacrister, brought to arrange their Shapures And a Broker, to value their geous.

#### (a) RF on test case





#### (b) RBFN on test case



The bottom row (c, e) (in Figure 1) shows the result on the training data. The overall occurrence of fixation follows a standard density heatmap of the fixations, like shown in (d).

## References

- GEORGE, A., AND ROUTRAY, A. A score level fusion method for eye movement biometrics. *Pattern Recognition Letters 82* (2016), 207–215.
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(c) RF on training case

(d) RBFN on training case

Fig. 3: Example for the *Prediction Correctness Trajectory* on a reading stimulus.



More Information (paper, source code and more) on our webpage: http://wwwdb.informatik.uni-bremen.de/smida\_pcv/

