Classifying Eye-Tracking Data Using Saliency Maps

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PROBLEM DEFINITION

Given eye fixation data of a subject on an image

Eye Tracking Data of a subject on an image

Classify

Subject Group

eg. *age*, *autism syndrome* etc.

or

Visual Perception Task

eg. *free viewing*, *saliency viewing* etc.

ISSUES WITH EXISTING METHODS

- Lack of a general task agnostic solution
- HoGs, Gist, Spatial density, LM filters, CNN feature (VGG,ResNet)
  - Same feature set does not consistently work across problems
- Different problems require to find different aspects of fixation data as distinguishing information
- The learning model cannot get enough supervision from a small amount of fixation data

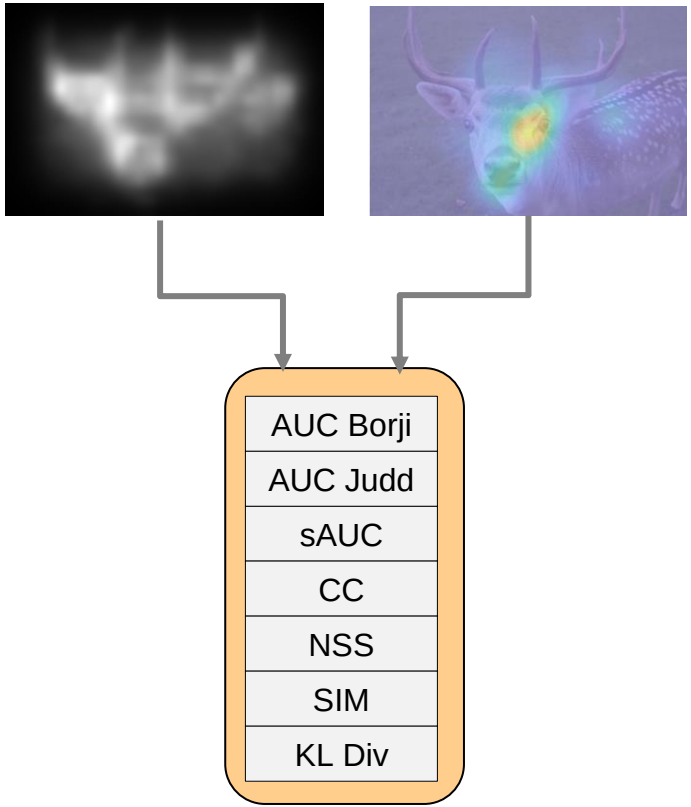
CONTRIBUTIONS

- Novel Feature Extraction method for task agnostic eye-tracking data.
- Use Saliency maps to extract discriminative features for fixation data.
- State-of-the-art performance on three tasks,
  - ASD screening
  - Toddler age prediction
  - Visual perceptual task prediction.

WHY SALIENCY MAPS?

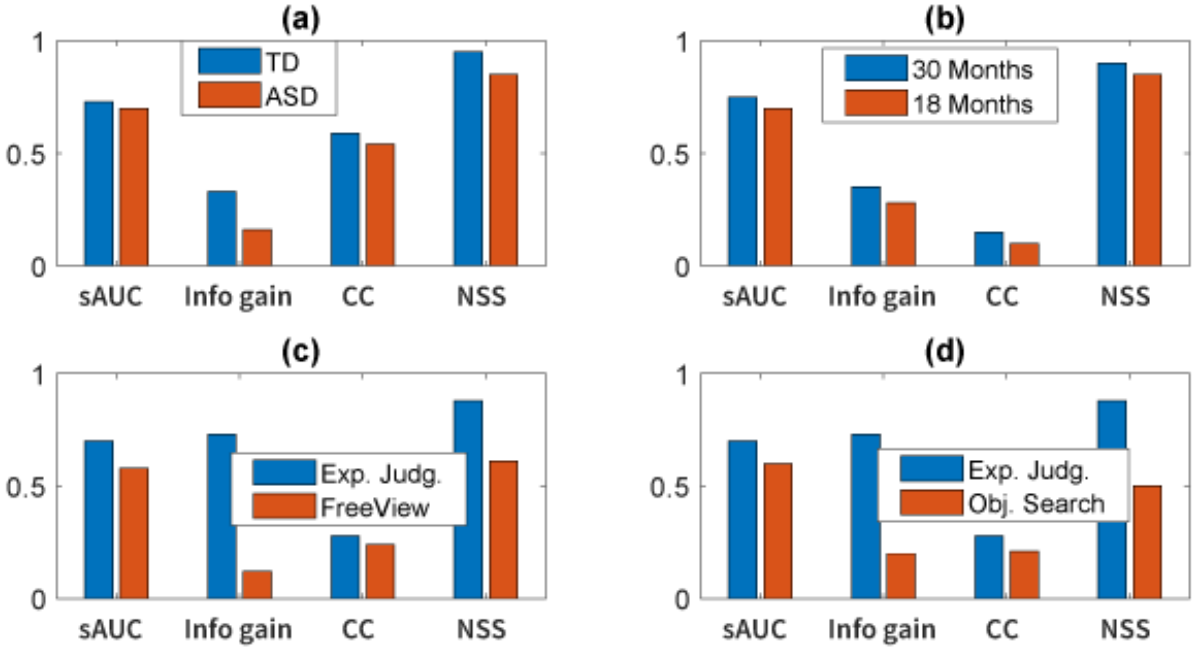
Compare saliency map with fixation data with 8 similarity and dissimilarity metrices:

AUC Borji, AUC Judd, Shuffled AUC, Correlation Coefficient, Similarity, KL Divergence, NSS, Info Gain



WHY SALIENCY MAPS?

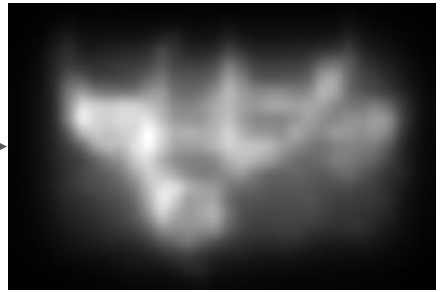
The metrices vary for different classes/tasks



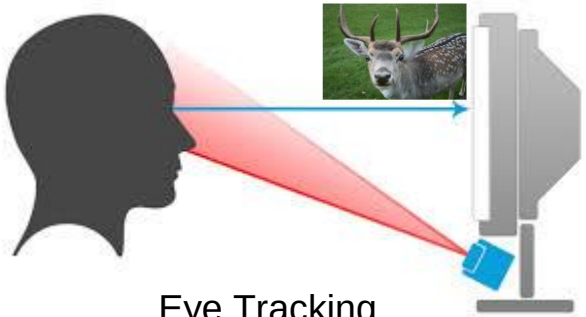
PROPOSED METHOD

Image i

Saliency Prediction Model t



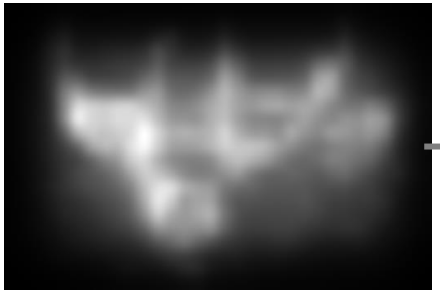
Saliency Map of image i



Eye Tracking

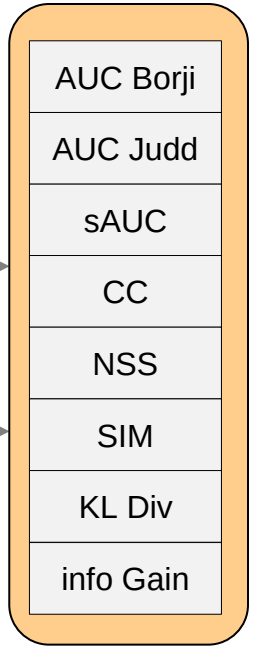
Fixation Map of a subject s on Image i

PROPOSED METHOD

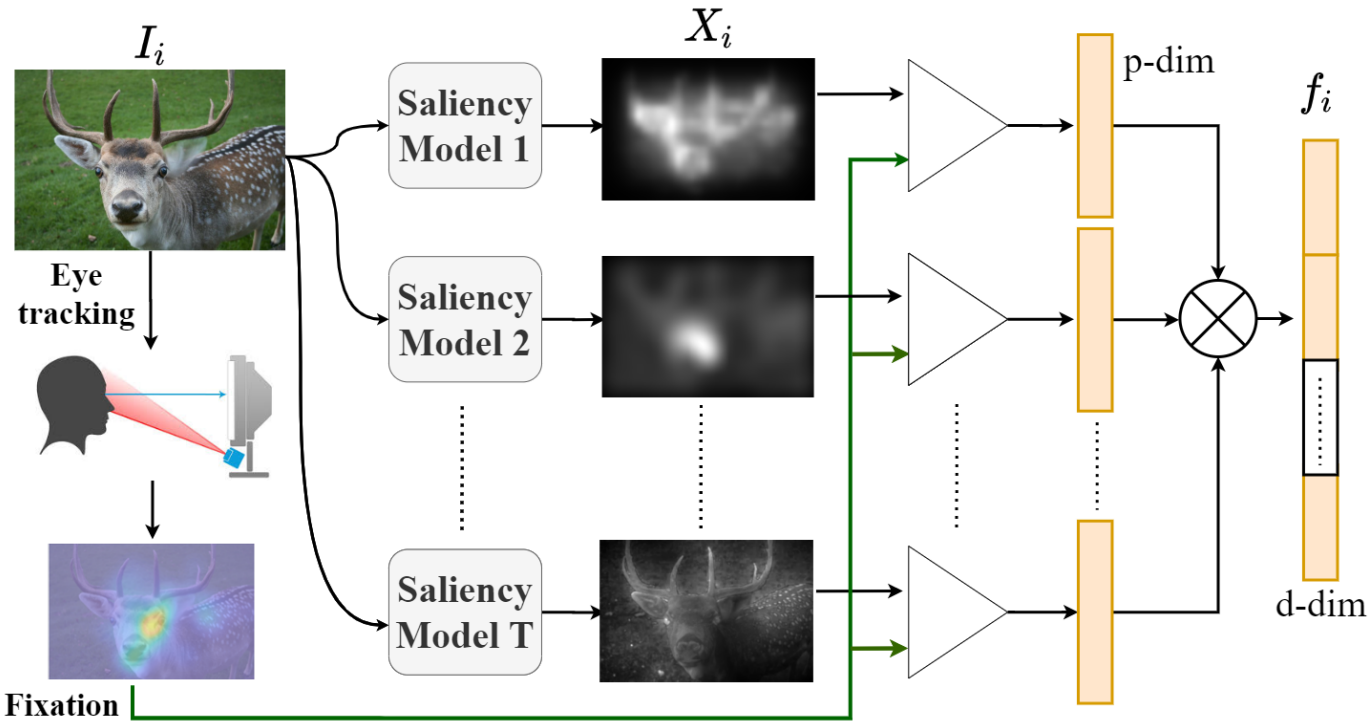


Saliency Map of image i

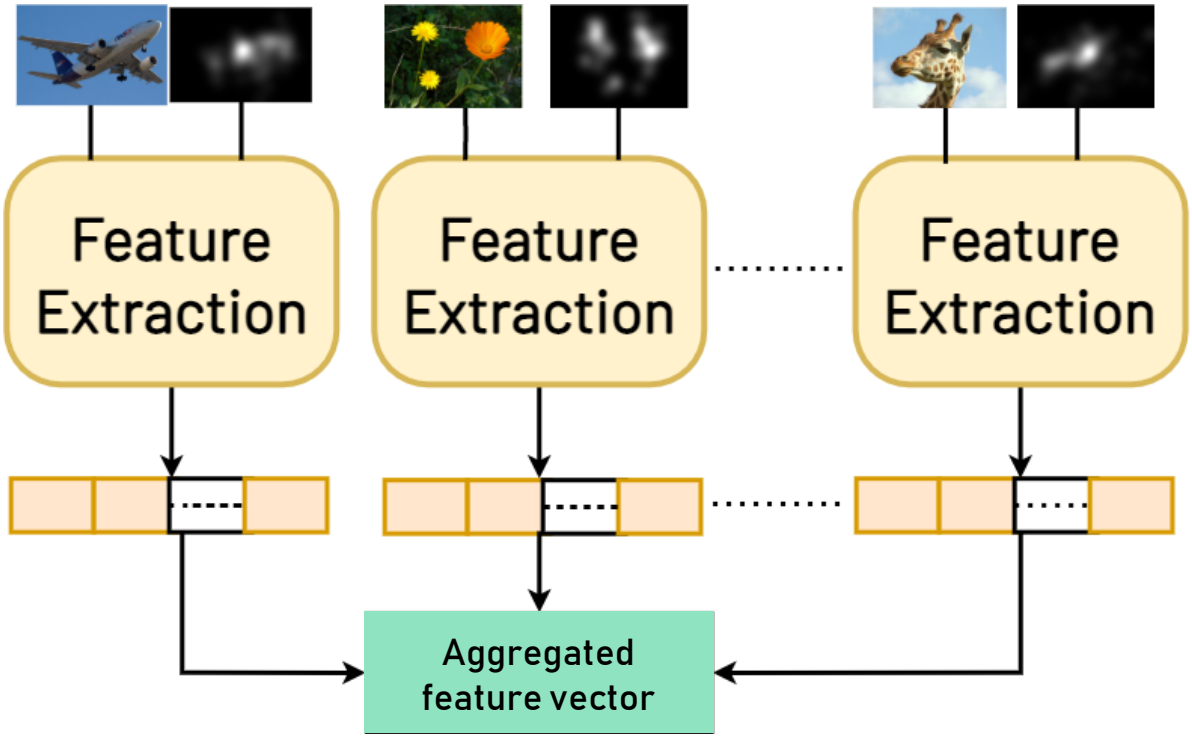
Fixation Map of a subject s on Image i

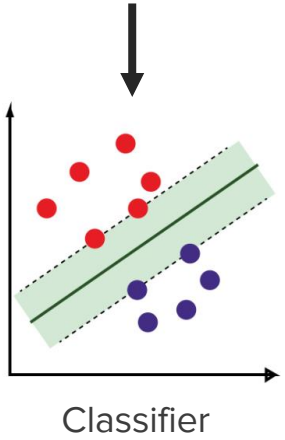


PROPOSED METHOD

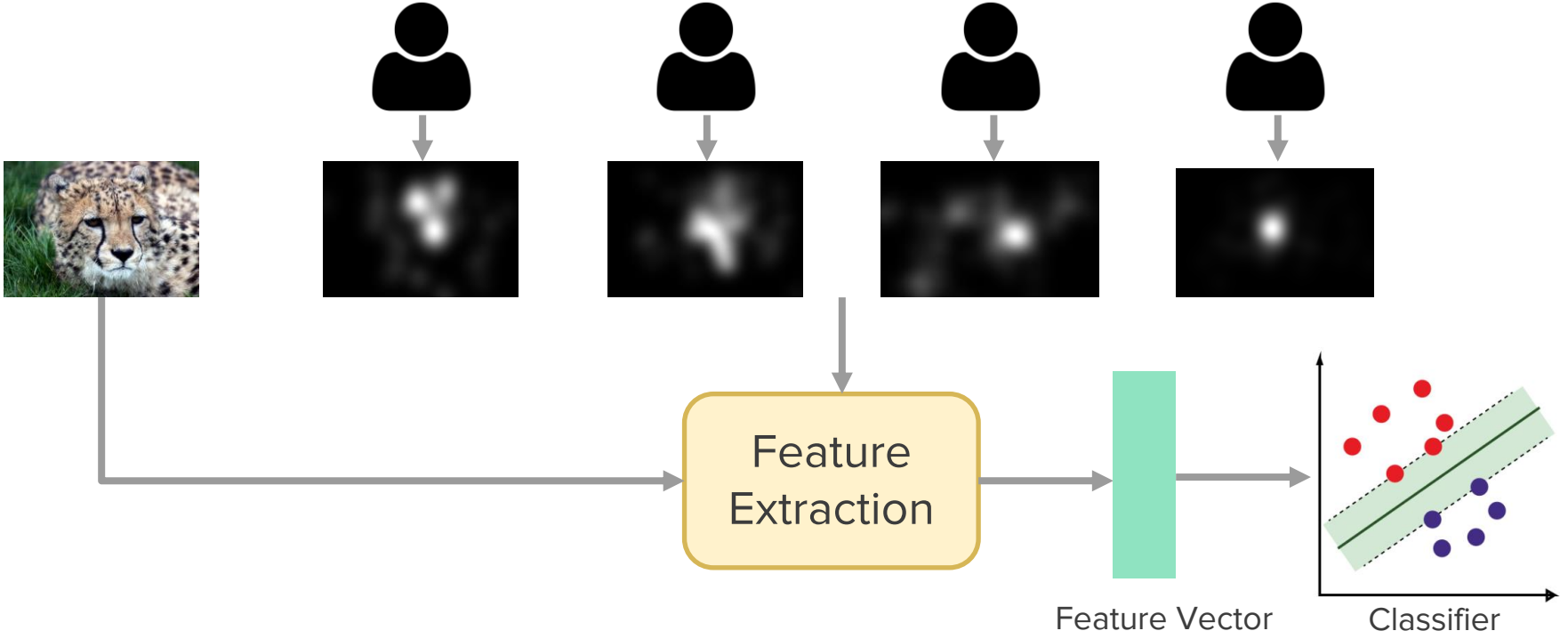


PROPOSED METHOD: SUBJECT CLASSIFICATION





PROPOSED METHOD: TASK CLASSIFICATION



EXPERIMENT 1: ASD SCREENING

- *Saliency4ASD* [1] dataset
- 2 classes: (i)Typically Developed (TD) , (ii) Autism Syndrome Disorder(ASD)
- 300 images shown to 28 children

	Accuracy	Sensitivity	Specificity	AUC
Chen'19 (Independent)	89.00	86.00	93.00	92.00
Chen'19 (Full)	93.00	93.00	93.00	98.00
Ours (SVM)	99.50	96.70	99.30	99.50
Ours (XGBoost)	**99.80**	**100.00**	**99.70**	**99.80**

[1] H. Duan, G. Zhai, X. Min, Z. Che, Y. Fang, X. Yang, J. Gutierrez, and ´ P. L. Callet, "A dataset of eye movements for the children with autism spectrum disorder," in Proceedings of the 10th ACM Multimedia Systems Conference, pp. 255–260, 2019

EXPERIMENT 2: TODDLER'S AGE CLASSIFICATION

- *Dalrymple'19* [2] Dataset
- 100 images shown to 41 toddlers
- 2 classes: (i) 18 months old, (ii) 30 months old

	Accuracy	Sensitivity	Specificity	AUC
Dalrymple'19	**83.00**	**90.00**	81.00	**84.00**
Ours (SVM)	75.60	78.90	72.70	75.80
Ours (XGBoost)	**83.00**	84.20	**81.80**	84.00

[2] K. A. Dalrymple, M. Jiang, Q. Zhao, and J. T. Elison, "Machine learning accurately classifies age of toddlers based on eye tracking," Scientific Reports, vol. 9, april 2019

EXPERIMENT 3: PERCEPTUAL TASK PREDICTION

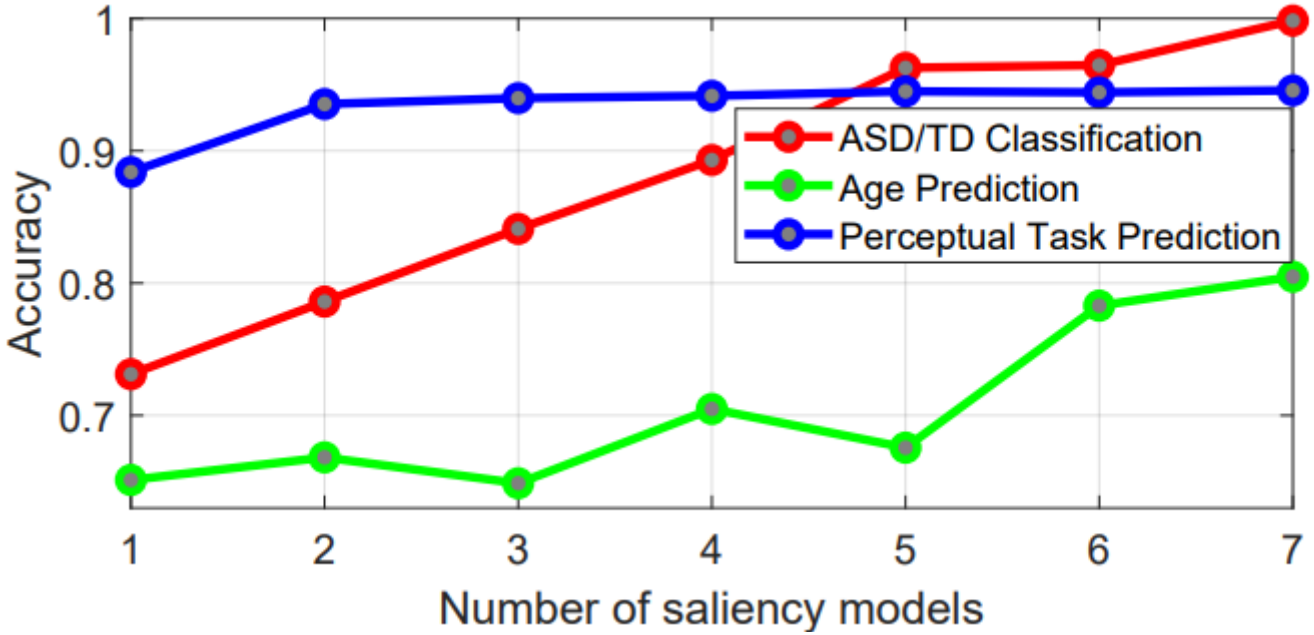
- *Koehler* [3] Dataset
- 4 classes: free-viewing, object search, saliency search, and explicit judgment

	Free/obj	Free/Sal	Free/Exp	Obj/Sal	Obj/Exp	Sal/Exp
All images and subjects						
Boisvert'16 [5]	84.38	66.13	89.75	89.88	97.75	90.00
Ours (SVM)	**86.35**	**78.57**	95.33	**94.70**	**97.80**	**96.20**
Ours (XGBoost)	84.20	74.30	**96.50**	84.25	97.70	96.10
50% images but all subjects						
Boisvert'16 [5]	73.41	59.59	-	71.01	-	-
Ours (SVM)	**79.54**	**71.70**	**86.21**	82.31	**90.20**	**91.56**
Ours (XGBoost)	78.80	69.60	86.13	**82.51**	88.60	90.36
All images but 50% subjects						
Boisvert'16 [5]	79.98	60.16	-	77.85	-	-
Ours (SVM)	**82.30**	**66.25**	**78.77**	**81.33**	**84.57**	**83.18**
Ours (XGBoost)	77.20	64.32	75.13	80.23	79.00	81.50

[3] K. Koehler, F. Guo, S. Zhang, and M. P. Eckstein, "What do saliency models predict?," Journal of Vision, vol. 14, no. 3, pp. 14–14, 2014

ABLATION STUDY

Accuracy of model increases when number of saliency models used increases



SUMMARY

- Existing eye tracking classification methods are not generalized across tasks
- Employ popular Saliency models for feature extraction from fixation data
- Shows significant performance boosts in comparison to similar investigations

Code: https://github.com/atahmeed/eye-tracking-with-saliency