
IEEE VR
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27 MARCH - 3 APRIL • 2021 VIRTUAL
Make Virtual Reality diverse and accessible

FixationNet: Forecasting Eye Fixations in Task-Oriented Virtual Environments

Zhiming Hu[1], Andreas Bulling[2], Sheng Li[1], Guoping Wang[1]

[1]Peking University
[2]University of Stuttgart

Project URL: cranehzm.github.io/FixationNet

Human Visual Attention

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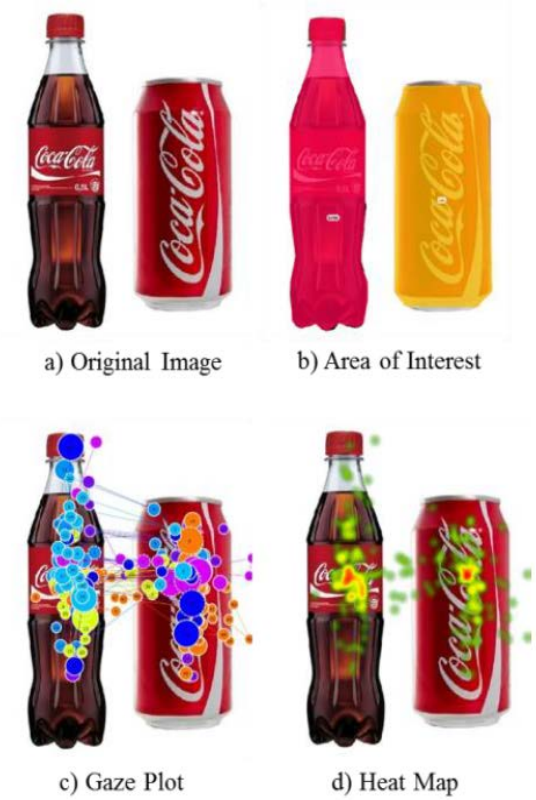
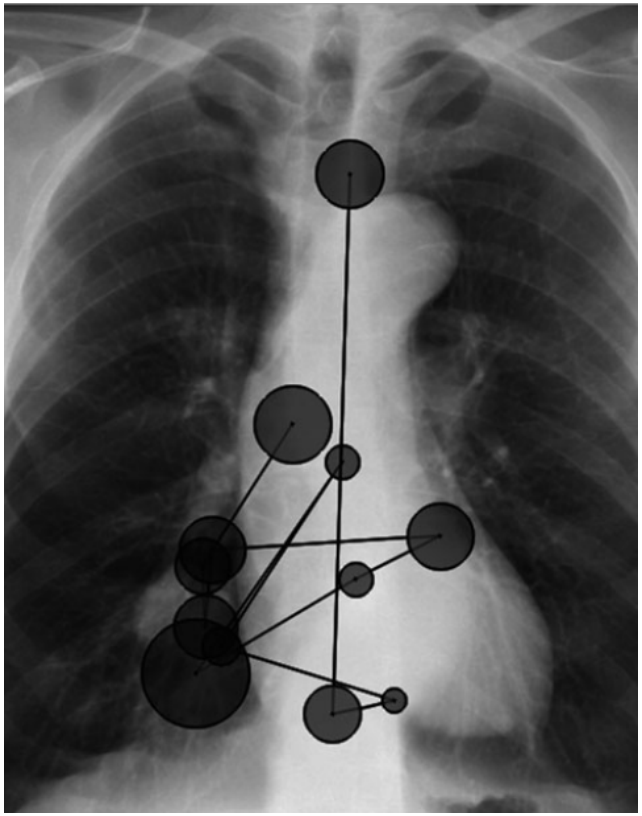
Application of Visual Attention





Marketing Strategy Analysis [Zamani et al. 2016]

Cognitive Research [Kiefer et al. 2017]

Medical Education [Kok et al. 2017]

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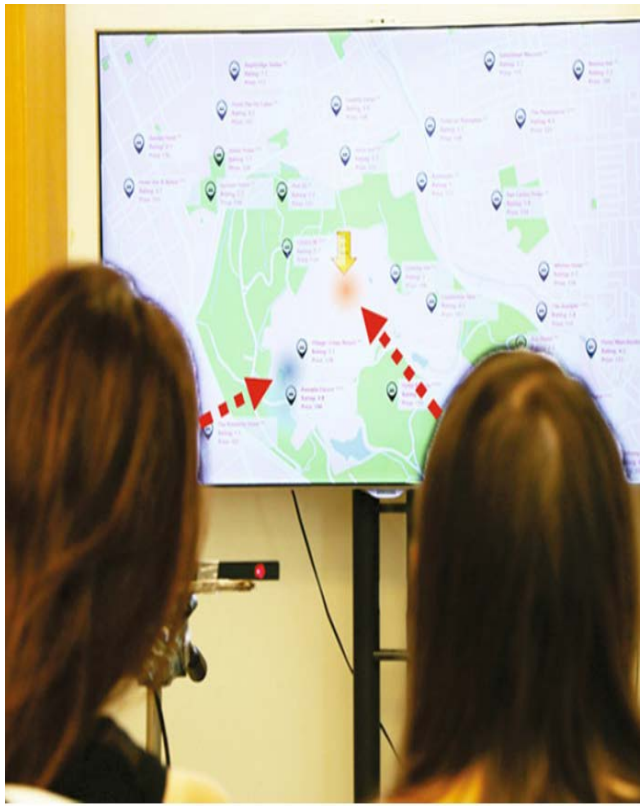
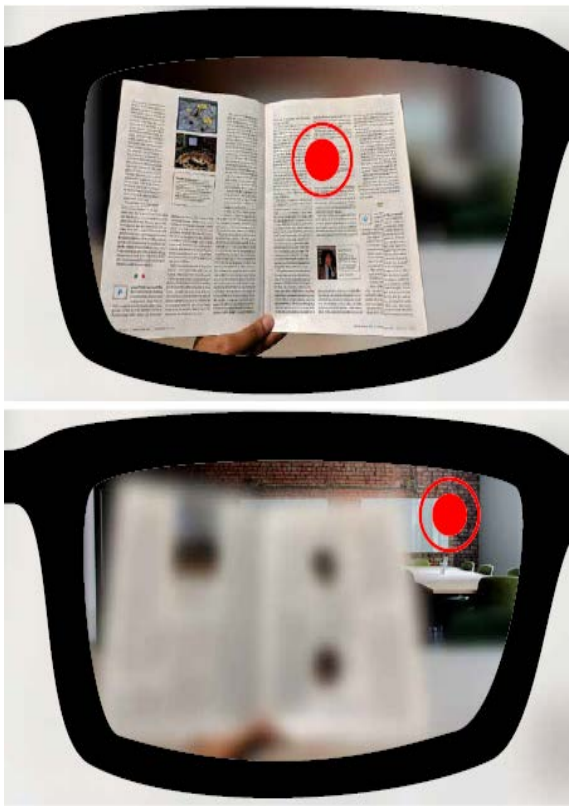
Application of Visual Attention

Gaze-based Interaction
[Pfeiffer et al. 2008]



Collaborative System
[Zhang et al. 2017]



Gaze-contingent Eyeglasses
[Padmanaban et al. 2019]

Background

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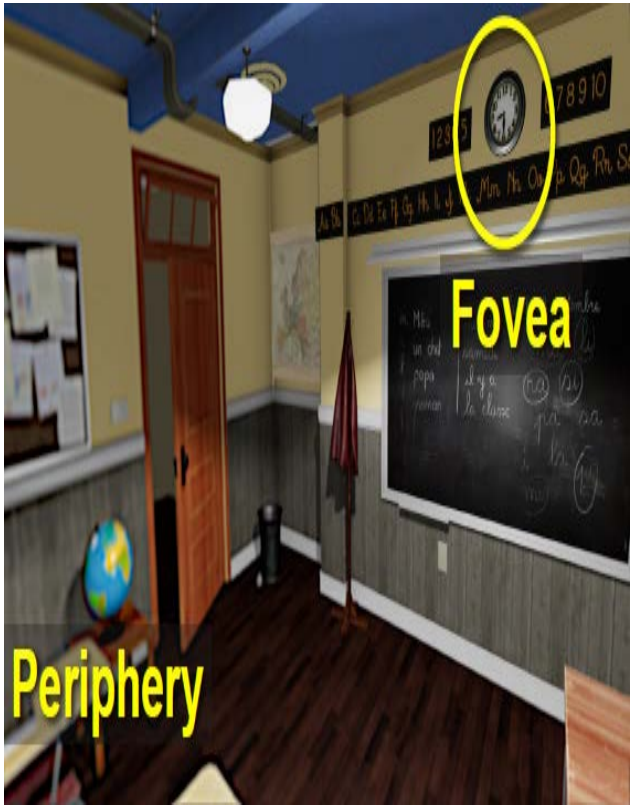
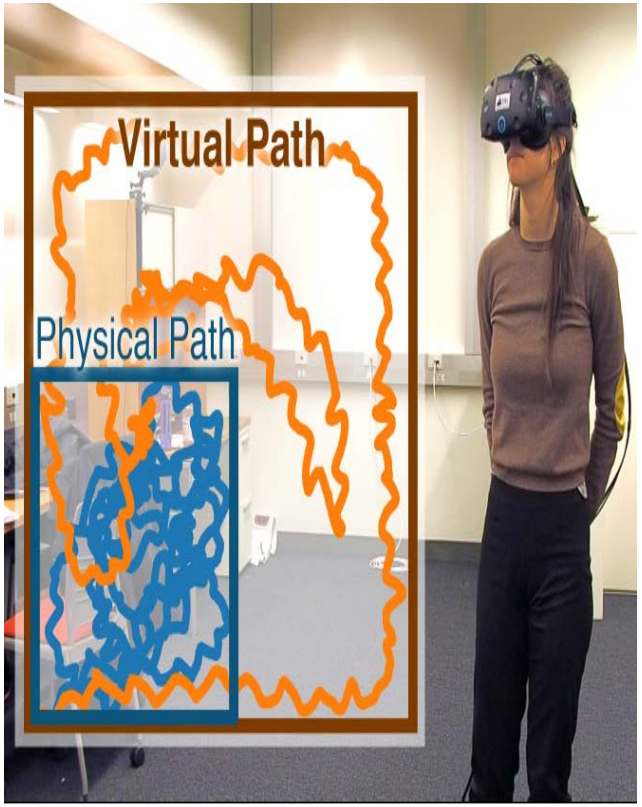
Application of Visual Attention in VR



Gaze-contingent Rendering
[Patney et al. 2016]



Redirected Walking
[Sun et al. 2018]

Layout Optimization
[Alghofaili et al. 2019]

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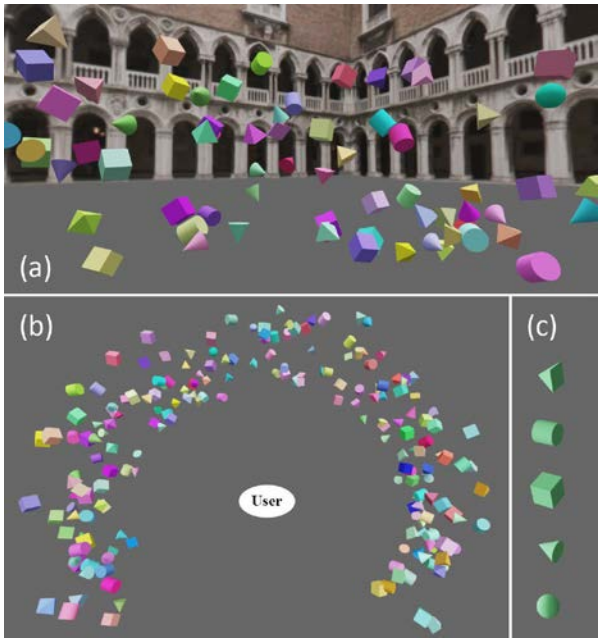
Application of Visual Attention in VR

VR Content Design
[Sitzmann et al. 2018]



Gaze Guidance
[Grogorick et al. 2017]

LOD Management
[Lee et al. 2009]

Background

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Research Goals

- Analyze and reveal the characteristics of users' task-oriented visual attention in virtual reality
- Forecast (temporally predict future) eye fixations based on the characteristics of visual attention

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Salient Object Detection

Top: Original Images; Bottom: Salient Objects

[1] https://mmcheng.net/msra10k/

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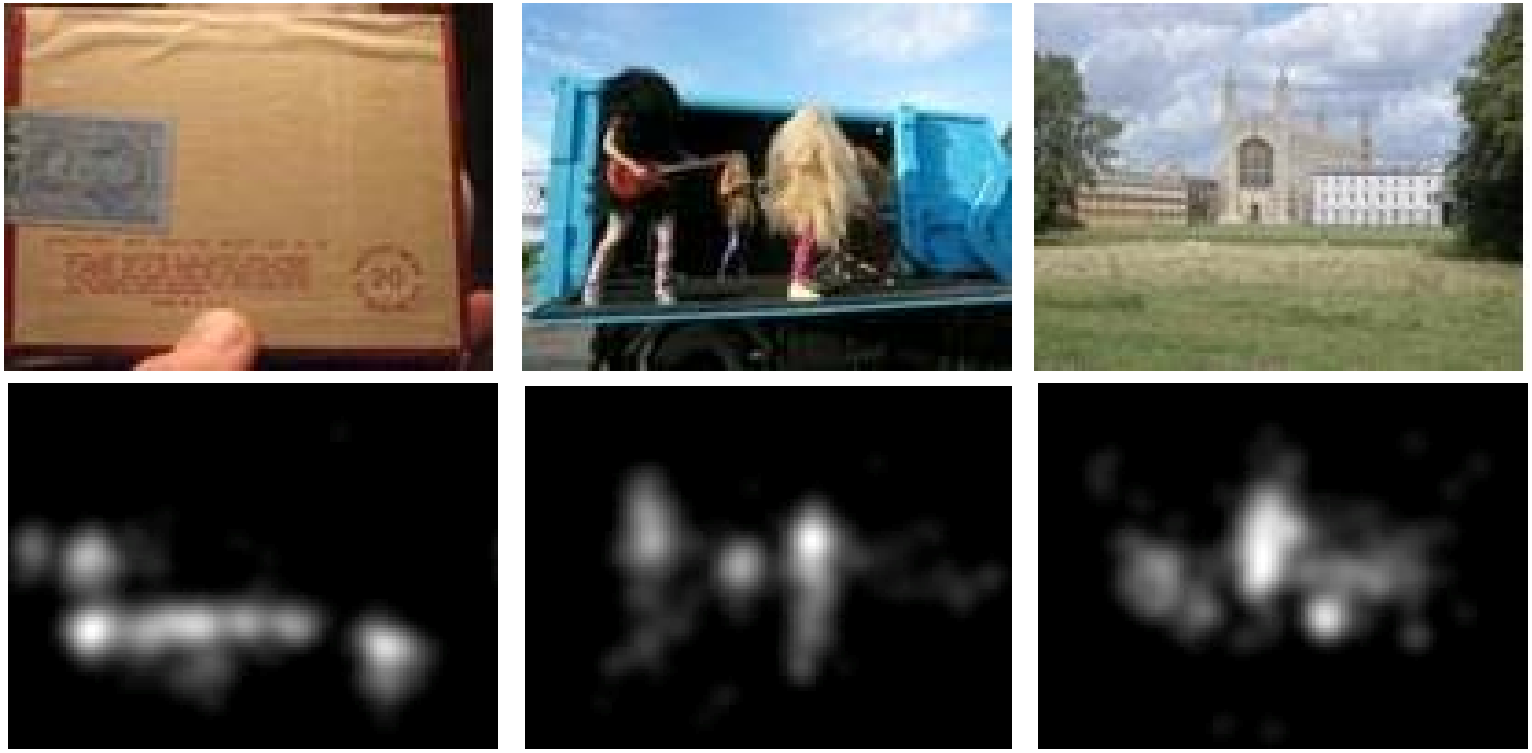
Saliency Prediction



Top: Original Images; Bottom: Saliency Maps

[1] http://saliency.mit.edu/results_mit300.html

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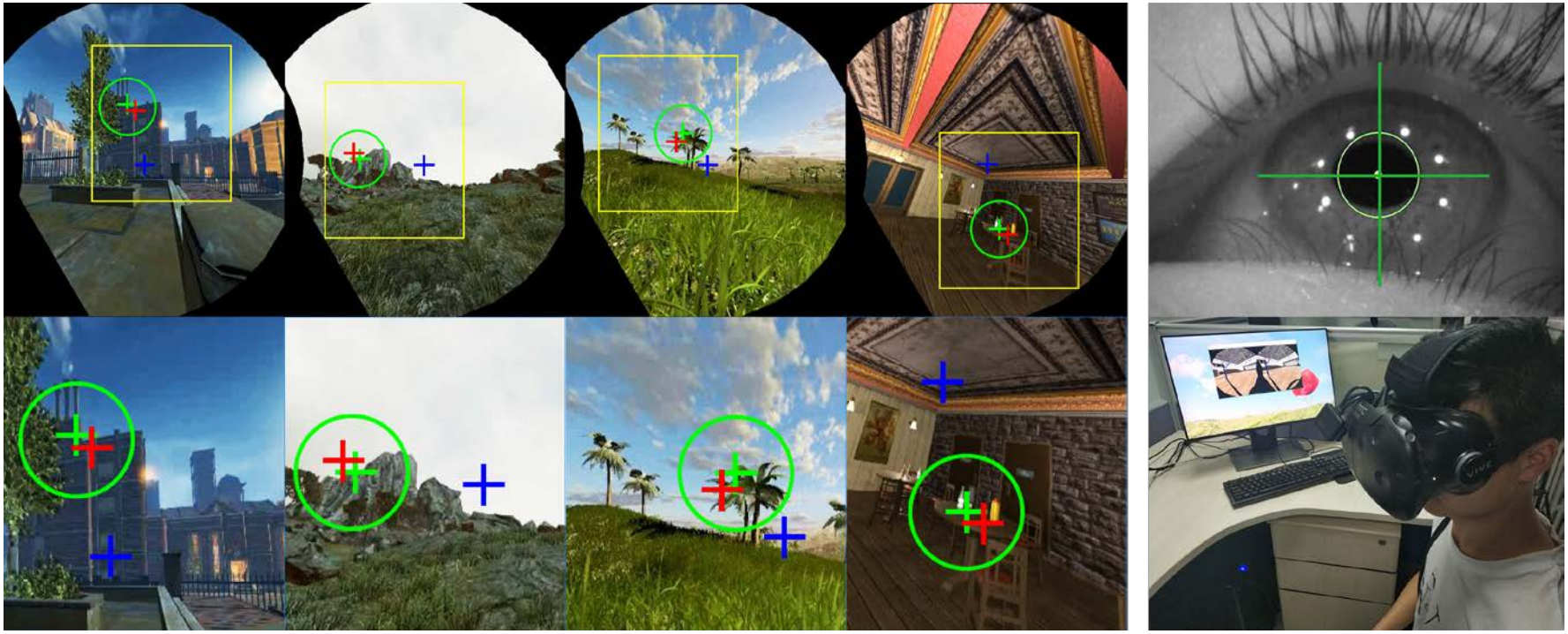
Visual Attention Prediction in VR



Gaze Prediction in Static Free-Viewing Virtual Environments
[Hu et al. 2019]

Related Work

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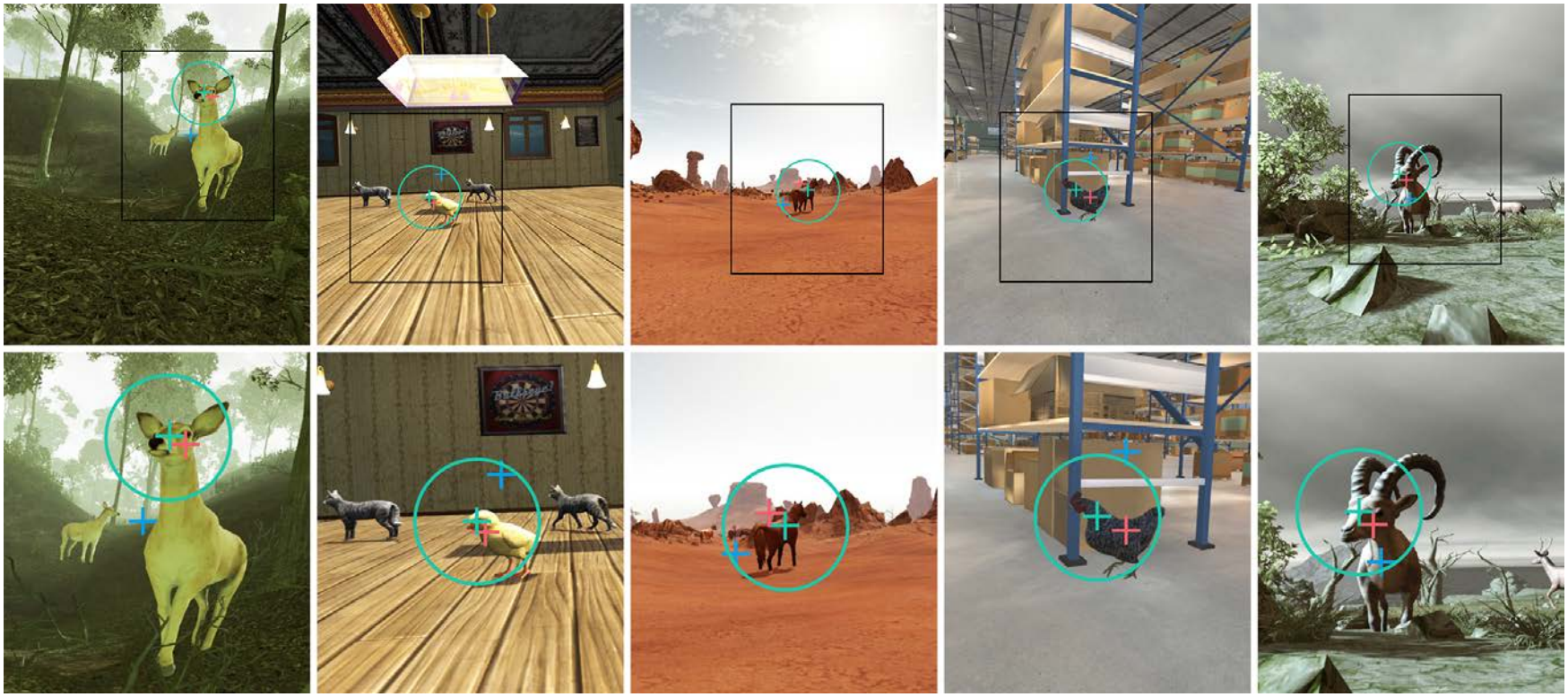
Visual Attention Prediction in VR



Gaze Prediction in Dynamic Free-Viewing Virtual Environments
[Hu et al. 2020]

Related Work

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Our Work *vs.* Previous Work

- Prediction Goal

Eye Fixations *vs.* Salient Objects, Saliency Maps

- Scene

Immersive Virtual Environments *vs.* Images, Videos

Task-Oriented Situations *vs.* Free-Viewing Conditions

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Contributions

- Propose a novel learning-based fixation prediction model (*FixationNet*)
- Analyze and reveal the characteristics of users' task-oriented visual attention in VR
- Build a task-oriented VR eye tracking dataset

Data Collection

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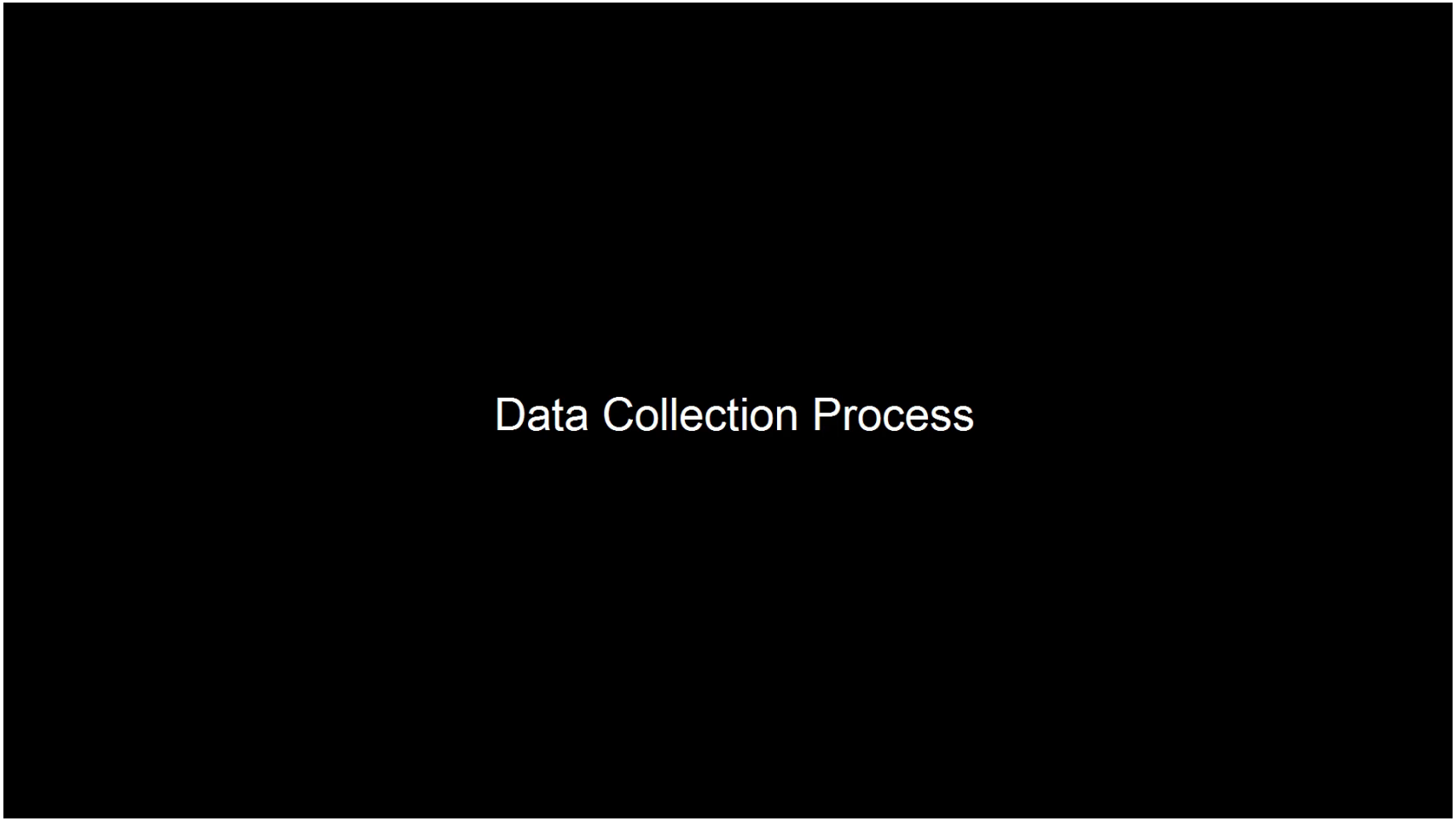
- Participants: 27 users (15 male, 12 female, ages 17-32)
- Stimuli: four immersive virtual environments
- Apparatus: HTC Vive, eye tracker
- Procedure: visual search task
- Data: VR content, task-related objects, eye fixations, head movements

Stimuli

Data Collection Process



Analysis of Eye Fixation

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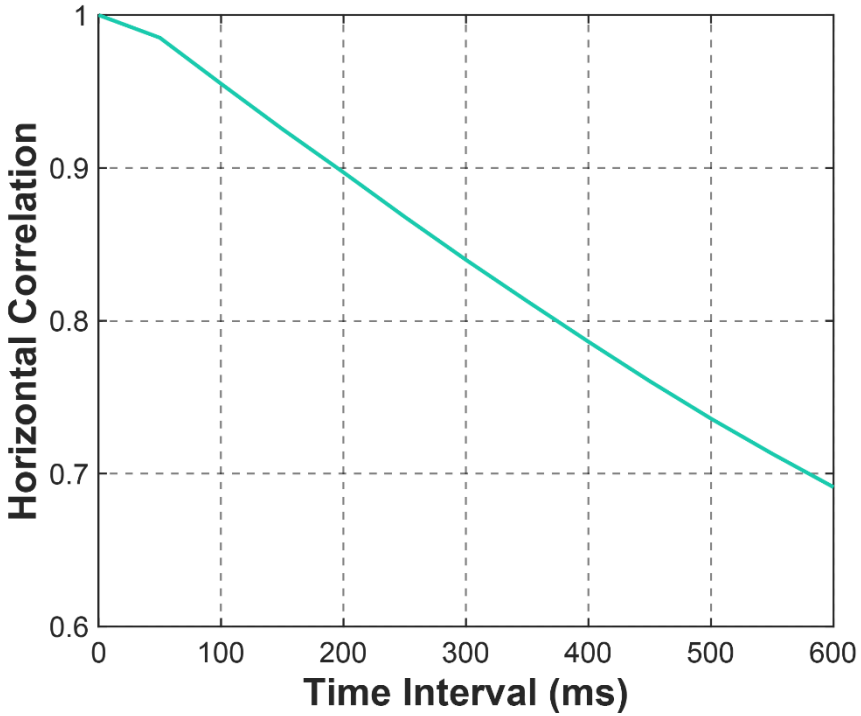
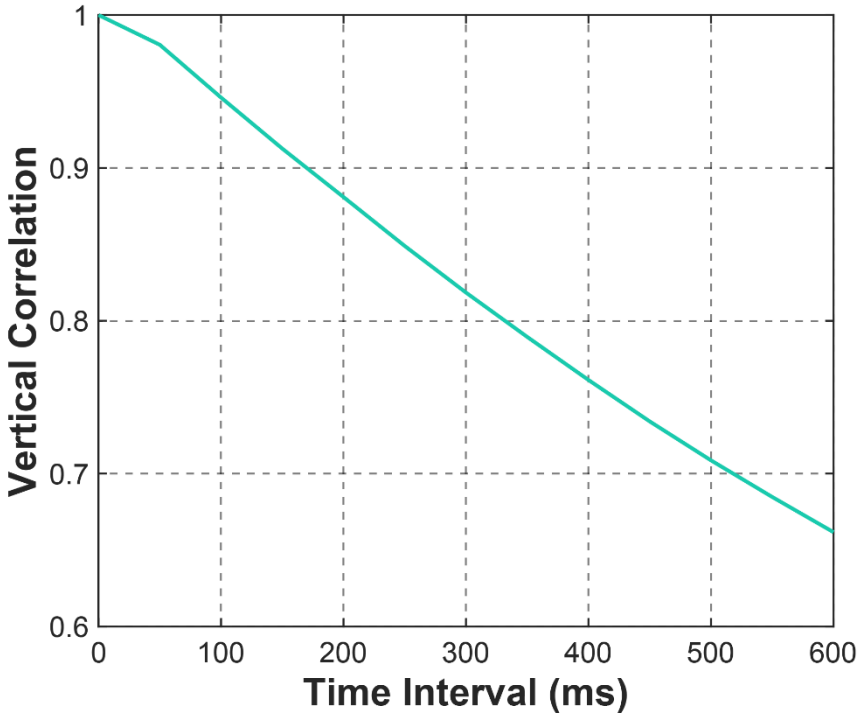
Fixation-Gaze Correlation





Fixation-gaze correlations in the horizontal (left) and vertical (right) directions

Eye fixations are highly correlated with historical gaze positions

Analysis of Eye Fixation

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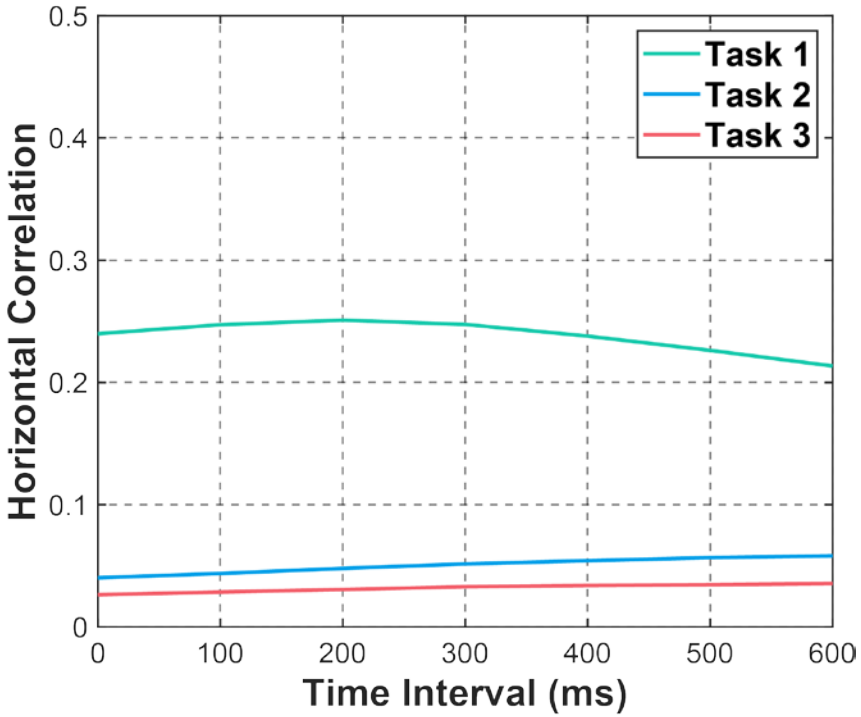
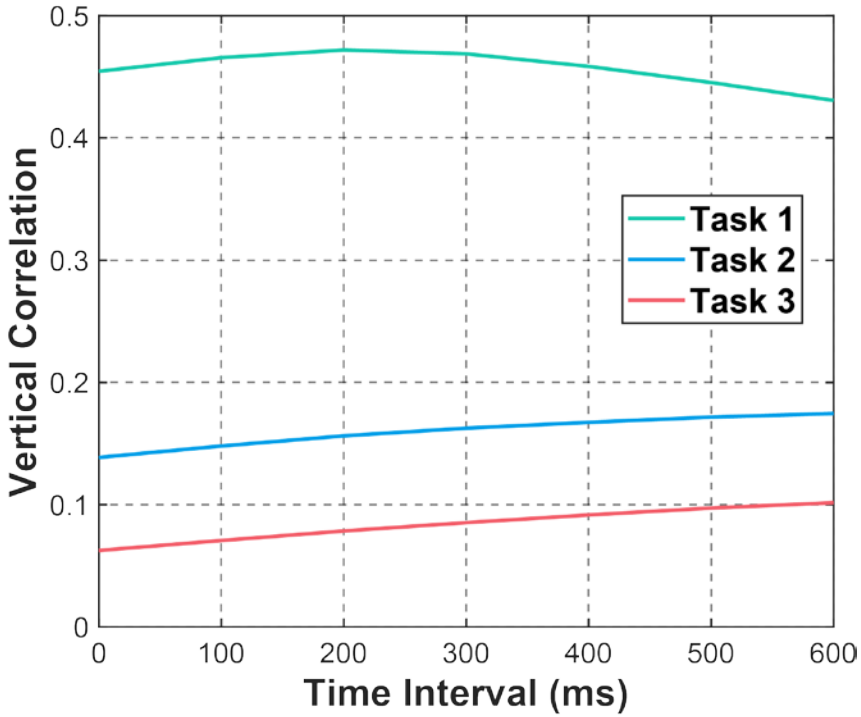
Fixation-Task Correlation





Fixation-task correlations in the horizontal (left) and vertical (right) directions

Fixations are correlated with task-related objects

Analysis of Eye Fixation

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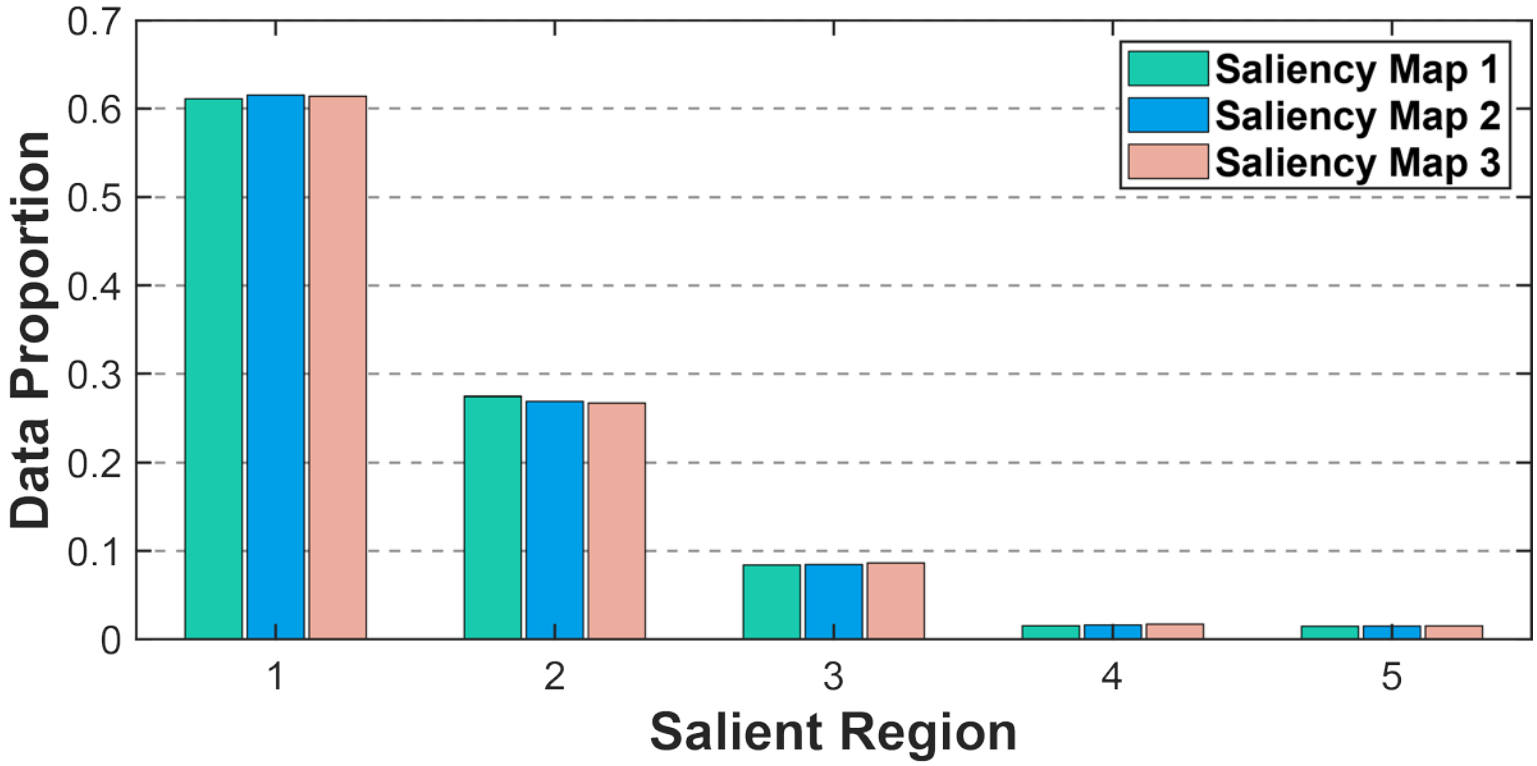
Fixation-Saliency Correlation



The distribution of users' fixation positions on the salient regions

The fixation positions are mostly located in the regions with high saliency values

Analysis of Eye Fixation

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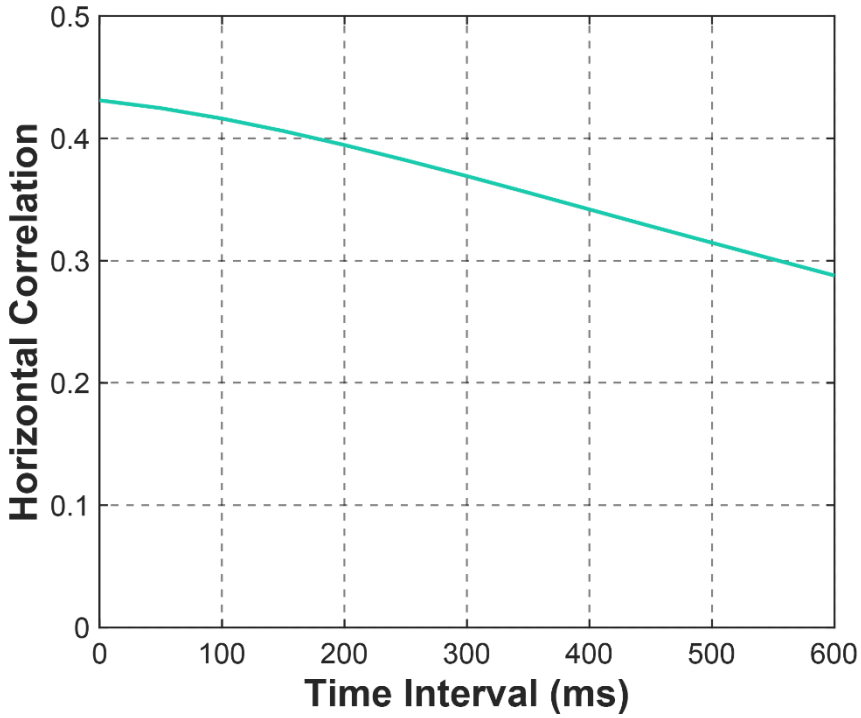
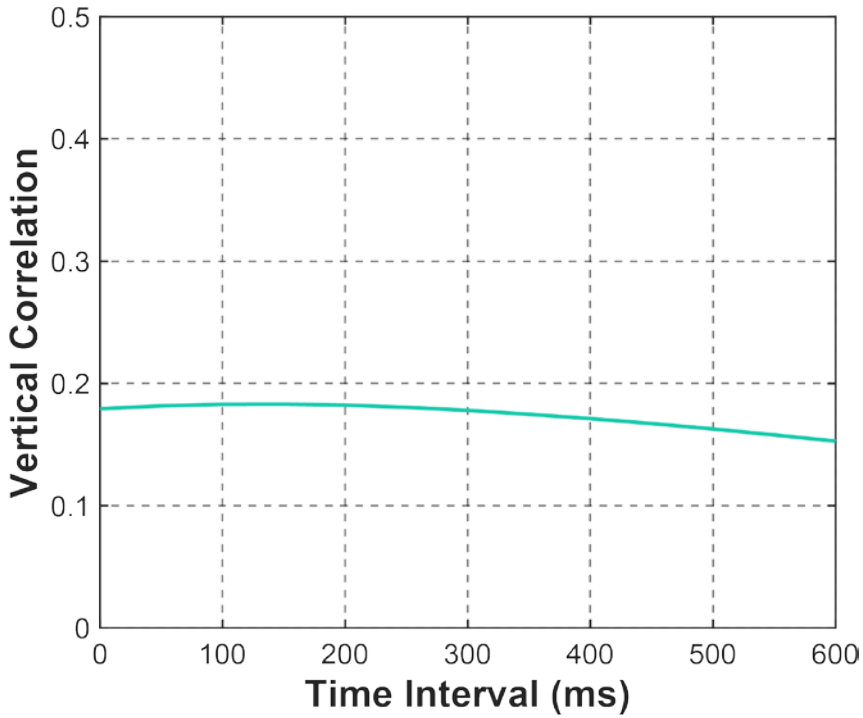
Fixation-Head Correlation

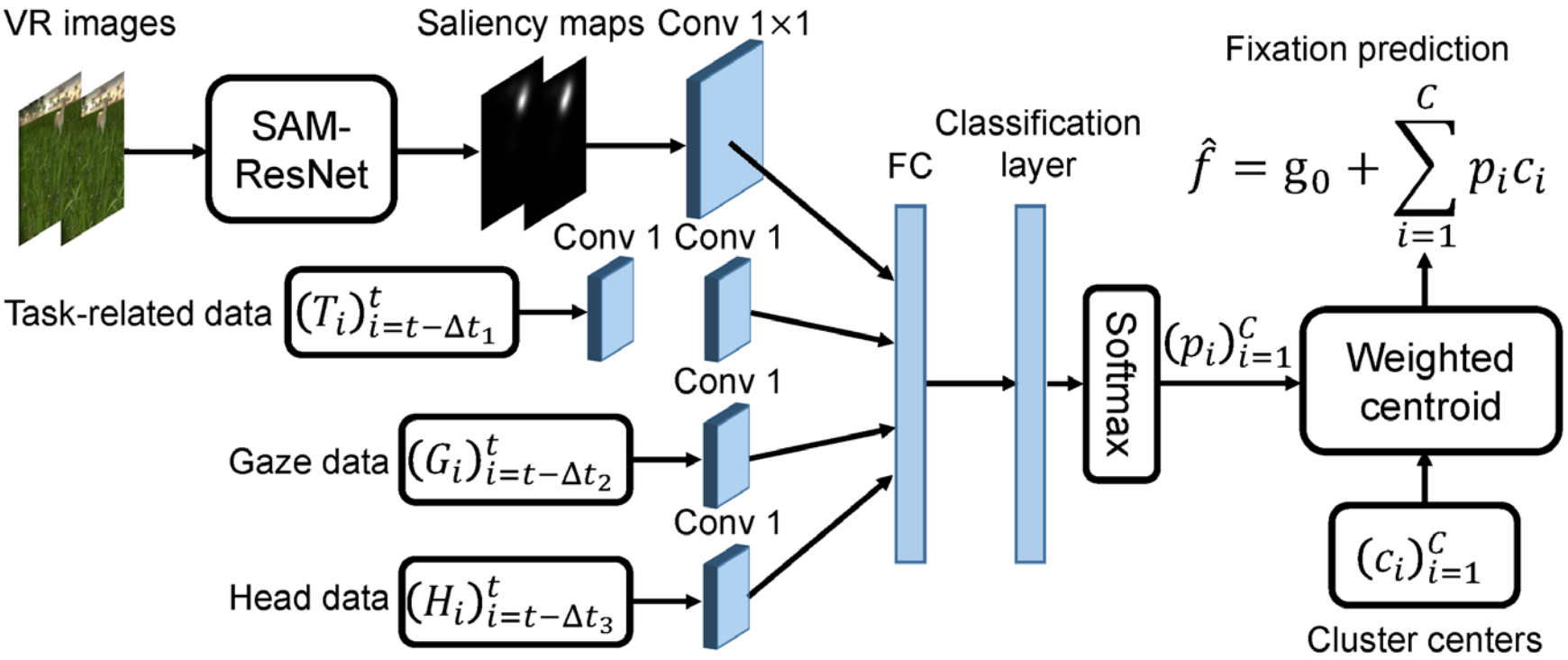




Fixation-head correlations in the horizontal (left) and vertical (right) directions

Fixations have correlations with head velocities

FixationNet Model



Architecture of FixationNet model

Experiments and Results

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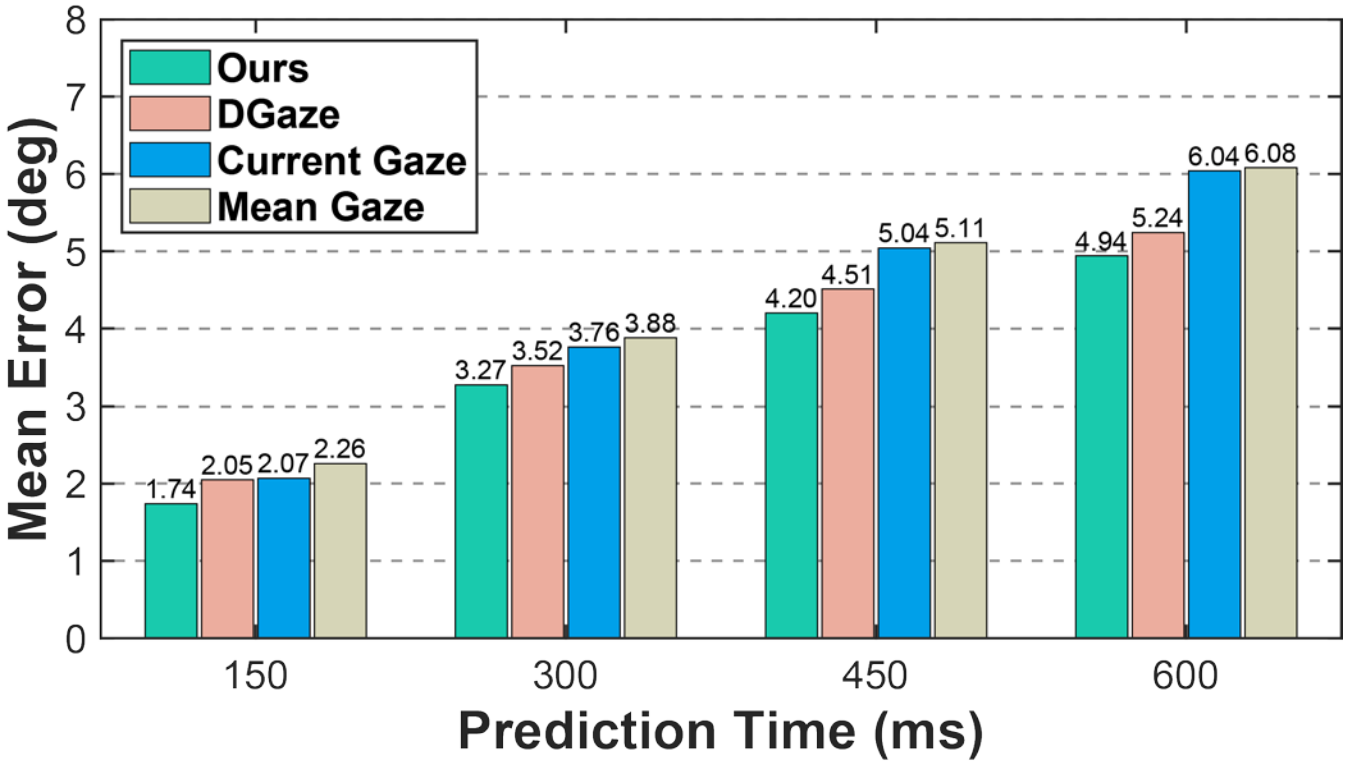
Performance in Task-Oriented Situations



Performances in task-oriented situations at different time intervals

FixationNet outperforms other methods at different prediction times

Experiments and Results

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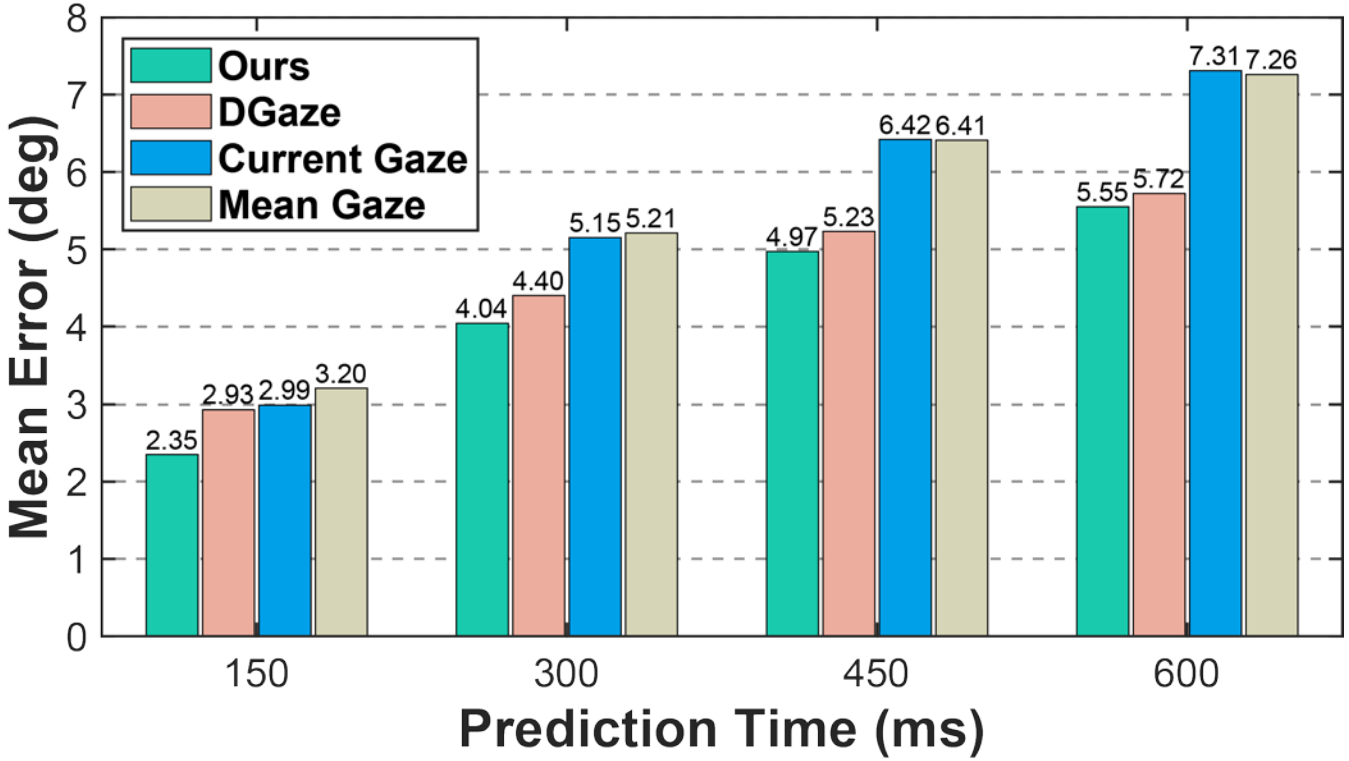
Performance in Free-Viewing Conditions



Performances in free-viewing conditions at different time intervals

FixationNet outperforms other methods at different time intervals

Discussion

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Limitations

- Our dataset is restricted to visual search task
- Our model employs pre-computed cluster centers
- The influence of sound is not considered in our model

Discussion

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Future Work

- Overcome the limitations
- Improve our model by considering other factors related to users' visual attention
- Explore the problem of forecasting users' long-term eye fixations
- Convert our model to other systems like AR and MR systems

Thank you