Research Report Summary

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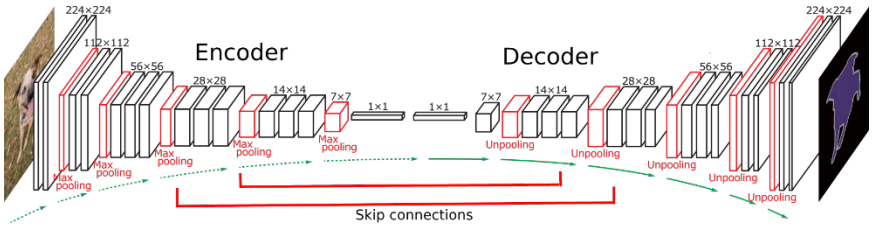
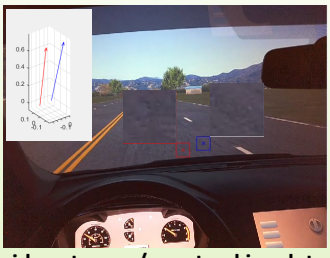
Quantifying the Impacts of Situational Visual Clutter on Driving Performance using Video Analysis and Eye Tracking

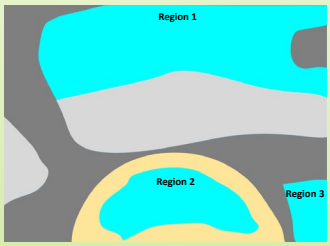
Situational visual clutter and its impact on driving performance have been widely acknowledged but under-investigated. There is a need to leverage the existing simulation data to quantify the critical interactions among drivers, vehicles, road users, and road infrastructure. In this study, a new situational visual clutter model that objectively quantifies the complex and dynamic driving scene based on video analysis and the linkage with eye-tracking data was developed. The video analysis tool was established upon the emerging deep learning framework, i.e., VGG16-FCN (Shelhamer et al., 2017), and the image color and texture analysis algorithms. The number and complexity of the blobs in the segmented image frames were defined to quantify the level of the clutter of the scene and the object that appeared in the scene, respectively. The potential usage of the developed model to support other retrospective studies and data mining was explored using the existing driving simulation data captured by Knodler et al. in 2019.



This study shows that the newly developed model for quantifying situational visual clutter can potentially reveal insight on how drivers search and acquire information from the scene and how the clutter may impact the effectiveness of the search and acquisition. More importantly, the developed methodology for video analysis provides an effective means for leveraging the existing driving simulation data and quantifying the possible factors impacting driver's behavior and performance, including situational visual clutter.

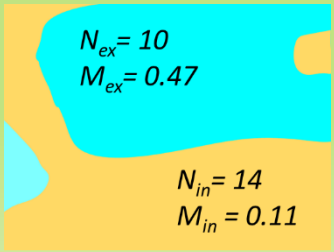


video stream / eye-tracking data



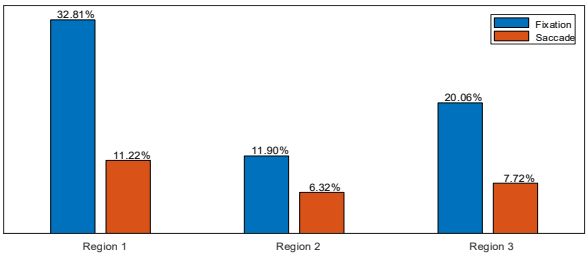
Segmentation data

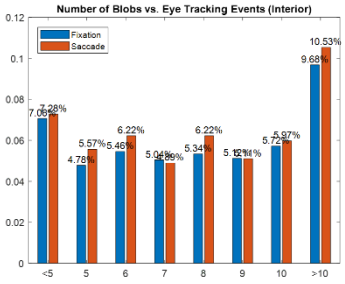
Color/object identification data

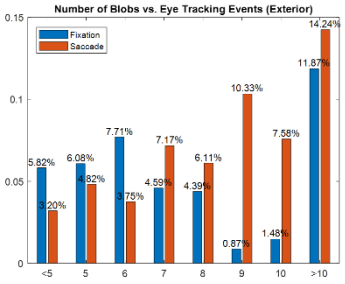


Visual clutter quantification data

Do drivers obtain information differently from different regions of the scene? Drivers attempt to search and acquire more frequently and intensively from the regions where unknown information may be present. At the same time, they spend less effort in the regions where anticipated or known information may be present.

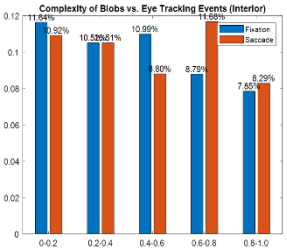


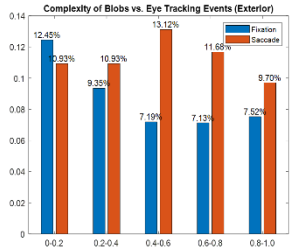




How do drivers search/acquire information when the scene is cluttered? Drivers do not search or acquire more information when the scene is more cluttered. However, drivers tend to increase the frequency and intensity in searching information if the more cluttered scene is not familiar to them or unknown information is anticipated in a familiar scene.

How do drivers search/acquire information when objects are complex in the scene? Drivers do not increase or decrease their frequency and level of intensity for search unanticipated information regardless of the complexity of the object in the scene. However, drivers tend to increase the frequency and intensity of acquiring information if the object is less complex.





Outcomes

- *This study developed a new situational visual clutter model that objectively quantify the complex and dynamic driving scene based on video analysis and the linkage with eye-tracking data*
- *This study explored the potential usage of the proposed model to support other retrospective studies and data mining using the existing driving simulation data*

Impacts

- *The developed methodology processed 5,953,786 image frames captured from previous simulation scenarios*
- *The developed methodology provides a new and effective means for leveraging the existing driving simulation data and quantifying the possible factors impacting driver's behavior and performance, including situational visual clutter*

References

1. E. Shelhamer, J. Long, and T. Darrell. (2017). "Fully Convolutional Networks for Semantic Segmentation." IEEE Transactions on Pattern Analysis and Machine Intelligence, 39(4), 640–651.
2. Knodler Jr, M., Christofa, E., Hajiseyedjavadi, F., Tainter, F., and Campbell, N. (2019). "To Trust or Not to Trust? A Simulation-based Experimental Paradigm." Harvard Dataverse.

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