PanoFlex: Adaptive Panoramic Vision to Accommodate 360° Field-of-View for Humans

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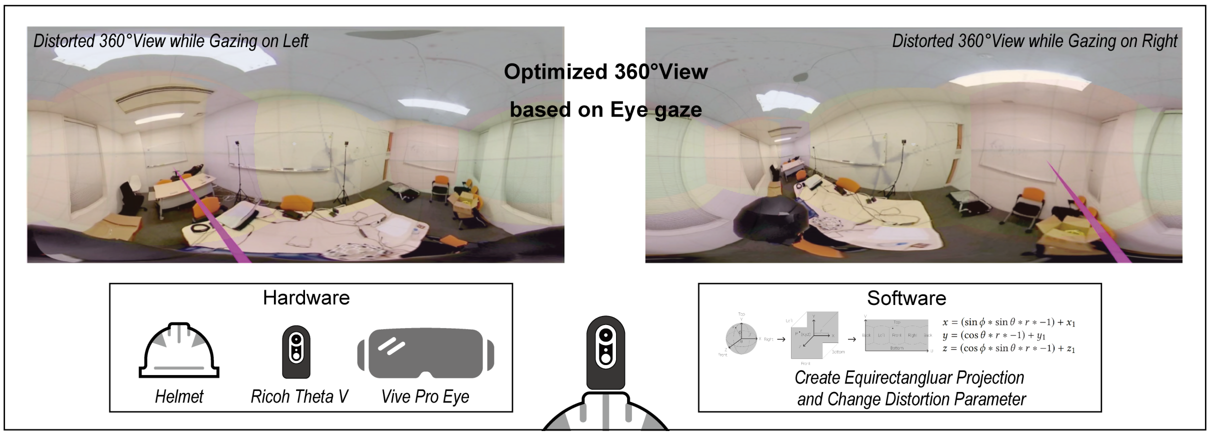

Figure 1: PanoFlex prototype showing how the image of what user gazes on remains clear with the minimal distortion, which user decided, while preserving a 360° field-of-view.

ABSTRACT

We propose PanoFlex, an adaptive method for projecting panoramic vision using a dynamic distortion method based on eye gaze. We stream real-time video from a 360° camera and project the view on a plane to the user. The user controls the distortion of this equirectangular projection using eye gaze. For our first user study, we compare our method with conventional equirectangular projection considering the impact on spatial perception. For our second study, we perform a simulator sickness evaluation when the user performs regular daily activities. We found that PanoFlex did not carry any significant negative impact towards the user's spatial perception, perceived task load, and simulator sickness compared to the more conventional equirectangular view.

VRST '19, November 12–15, 2019, Parramatta, NSW, Australia

ACM ISBN 978-1-4503-7001-1/19/11…$15.00
https://doi.org/10.1145/3359996.3364767

CCS CONCEPTS

• **Human-centered computing → Interaction techniques**; *Interactive systems and tools*; Visualization techniques.

KEYWORDS

360 degree vision, projections, visual augmentation

ACM Reference Format:
Feng Liang, Stevanus Kevin, Kai Kunze, and Yun Suen Pai. 2019. PanoFlex: Adaptive Panoramic Vision to Accommodate 360° Field-of-View for Humans. In *25th ACM Symposium on Virtual Reality Software and Technology (VRST '19), November 12–15, 2019, Parramatta, NSW, Australia.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3359996.3364767

1 INTRODUCTION

A common research direction in augmented reality is to enhance our senses, for example, how to extend our vision towards 360° [Gruenefeld et al. 2017]. In order to aware objects or people that are out of our FOV, there have been several research works focusing on showing out-of-view contents[Gruenefeld et al. 2018], increasing FOV in HMDs[Xiao and Benko 2016] and increasing the user's spatial awareness[Schoop et al. 2018], etc. Researches like FlyViz[Ardouin et al. 2012] that expend the human FOV beyond 200° is also another related direction to our study. One of the approaches on optimizing 360° vision is using different kinds of projection methods[Debarba et al. 2015]. Also, there are several works using eye gaze as an interaction technique in virtual reality and 360° video[Outram et al. 2018; Pai et al. 2017]. However, there has been very little research on optimizing the best method of viewing a panoramic vision, given that there is a myriad of panoramic projection methods available.

In this work, we propose PanoFlex, an adaptive projection method adjusted explicitly for human vision. Our approach uses eye gaze tracking to change the distortion of the equirectangular view so that it prioritizes the gaze point by making it less distorted and broader, while still maintaining the view of the other directions at the periphery.

2 IMPLEMENTATION

Figure 2: Top: Conventional equirectangular view and Bottom: PanoFlex with frontal distortion at X (left&right) =0.1, Y (top&bottom) =-0.6, Z (front&back) =0.45.

We implemented our distortion manipulation method using the rendering engine to utilize the computational workload the the graphic processing unit (GPU) and increase framerate performance. Our solution uses eye gaze to dynamically reduce distortion and increase viewing space of the gaze point using a HMD and viewed using a 360° camera. The resulting distortion for PanoFlex can be seen on Figure 2.

We use the Vive Pro Eye as the eye tracking solution in a VR HMD. The content of the projection is from a Ricoh Theta V 360° camera mounted on a helmet worn by the user. The laptop used in this study is the Alienware Area-51M running an Intel Core i7-9700K CPU and an Nvidia RTX 2080 GPU. We achieve a framerate of roughly 20fps.

We conducted a pilot study with 8 participants (4 males, mean: 26.75, SD: 1.49) to determine distortion parameter for PanoFlex. Our pilot results shows people have their own preferred view using different distortion parameters. Therefore, we let each user decide their own distortion parameter prior to using it.

3 USER STUDY

We conducted two user studies to evaluate the spatial perception and simulator sickness of participants using our system.

In the spatial perception study, we recruited a total of 12 participants (9 males, mean: 30.67, SD: 6.21). Since paticipants needed to answer the SSQ questionnaire for a pre-test, we found that participant 1 was unwell and was therefore removed. P10 was also removed because he/she did not perform in accordance with the briefed procedure, resulting in 10 participants (8 males, mean: 30.5, SD: 6.13). In this study, participants were required to place a selection cube on 360° view to indicate where they think the target cube is relative to them. As a result, we did not obtain any statistical significance between the means of equirectangular and PanoFlex, suggesting that they performed equally in terms of spatial perception.

For simulator sickness study, we recruited a total of 8 participants (6 males, mean: 26.13, SD: 6.31). The prototype displays live feed from a 360° camera that is attached on a helmet worn by the participant. The participant then uses the device for a period of 6 minutes to perform 3 simple everyday tasks: sitting, reading and walking to and fro. We identify two outliers according to their SSQ for pre-test. As a result, we did not obtain any statistically significance for the three conditionss. This means that a new approach like PanoFlex carries no indication that it would cause additional motion sickness.

4 CONCLUSION

In this work, we propose PanoFlex, an adaptive panoramic vision system that uses dynamic distortion based on eye gaze. From our results, we proved that it could potentially be used to substitute our vision system without any significant negative impact. We envision a future where people may consider the possibility of using such a device for not just security and surveillance, but also as an augmentation device to improve our overall daily routine.

ACKNOWLEDGMENTS

This project was a collaboration between Keio Graduate School of Media Design and Ignition Point, Inc.

REFERENCES

Jérôme Ardouin, Anatole Lécuyer, Maud Marchal, Clément Riant, and Eric Marchand. 2012. FlyVIZ: A Novel Display Device to Provide Humans with 360° Vision by Coupling Catadioptric Camera with Hmd. In *Proceedings of the 18th ACM Symposium on Virtual Reality Software and Technology (VRST '12)*. ACM, New York, NY, USA, 41–44. https://doi.org/10.1145/2407336.2407344

Henrique G. Debarba, Sami Perrin, Bruno Herbelin, and Ronan Boulic. 2015. Embodied Interaction Using Non-planar Projections in Immersive Virtual Reality. In *Proceedings of the 21st ACM Symposium on Virtual Reality Software and Technology (VRST '15)*. ACM, New York, NY, USA, 125–128. https://doi.org/10.1145/2821592.2821603

Uwe Gruenefeld, Abdallah El Ali, Susanne Boll, and Wilko Heuten. 2018. Beyond Halo and Wedge: Visualizing Out-of-view Objects on Head-mounted Virtual and Augmented Reality Devices. In *Proceedings of the 20th International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI '18)*. ACM, New York, NY, USA, Article 40, 11 pages. https://doi.org/10.1145/3229434.3229438

Uwe Gruenefeld, Dag Ennenga, Abdallah El Ali, Wilko Heuten, and Susanne Boll. 2017. EyeSee360: Designing a Visualization Technique for Out-of-view Objects in Head-mounted Augmented Reality. In *Proceedings of the 5th Symposium on Spatial User Interaction (SUI '17)*. ACM, New York, NY, USA, 109–118. https://doi.org/10.1145/3131277.3132175

Benjamin I Outram, Yun Suen Pai, Tanner Person, Kouta Minamizawa, and Kai Kunze. 2018. AnyOrbit: Orbital navigation in virtual environments with eye-tracking. In *Proceedings of the 2018 ACM Symposium on Eye Tracking Research & Applications*. ACM, 99.

Yun Suen Pai, Benjamin I Outram, Benjamin Tag, Megumi Isogai, Daisuke Ochi, and Kai Kunze. 2017. GazeSphere: navigating 360-degree-video environments in VR using head rotation and eye gaze. In *ACM SIGGRAPH 2017 Posters*. ACM, 23.

Eldon Schoop, James Smith, and Bjoern Hartmann. 2018. HindSight: Enhancing Spatial Awareness by Sonifying Detected Objects in Real-Time 360-Degree Video. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, Article 143, 12 pages. https://doi.org/10.1145/3173574.3173717

Robert Xiao and Hrvoje Benko. 2016. Augmenting the Field-of-View of Head-Mounted Displays with Sparse Peripheral Displays. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, USA, 1221–1232. https://doi.org/10.1145/2858036.2858212