Energy Efficient VR: A Deeper Dive Into Foveated Rendering

Fredy J Martinez, and Dr.Ziliang Zong
Department of Computer Science, Texas State University, San Marcos, TX

VR's Challenge

Visual immersion is virtual reality's current challenge. For VR to reach expected quality standards it would require data transfers of 50 ~100 Gigabits/Sec [1]

- ~10 HD movies a second
- ~12000 MP3 songs a second
- ~15000 Pictures a second

Reducing VR's energy consumption requires reducing the amount of data VR requires. This project experimented with solutions introduced in Nividia's VRWorks suite [2].

Research Questions

- Can Nvidia's VRWorks be utilized to make a virtual environments created in unity more efficient?
- Will VRWorks function the same across all HMDs or only major supported HMD?
- If VRWorks's fixed foveated rendering techniques (MRS/LMS) do increase efficiency, is it significant enough to move towards DFR?
- Which eye tracking setup will be the most efficient to use when combined with VRWorks?
- What are the benefits of efficient Virtual Reality applications?

Methodology

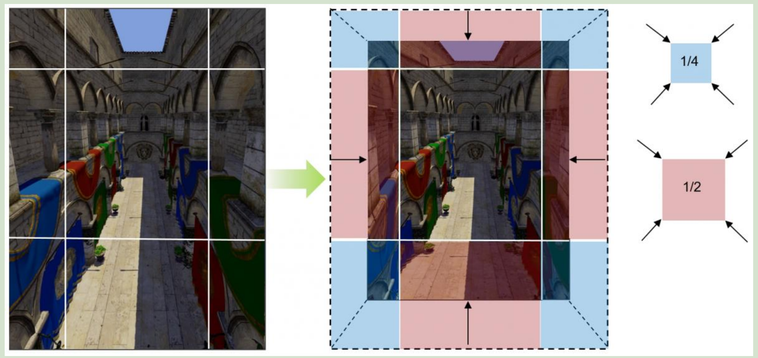
Tools used for this project : VS 2017, Unity 2018.1.1f1, Nvidia VRWorks 1.0.5, Intel Power Gadget (IPG) API, HMDs.

- Python script and IPG used to quantify data
- GPU and CPU consumption recorded
- Interpret the data

Nvidia VRWorks Solutions [3]

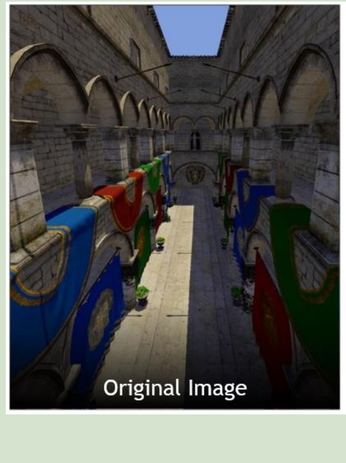
MRS

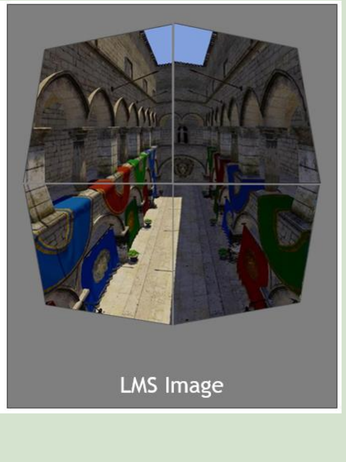
- Split the image up into multiple viewports
- Center viewport the same size, but scale edges
- Render faster so less resources are used



LMS

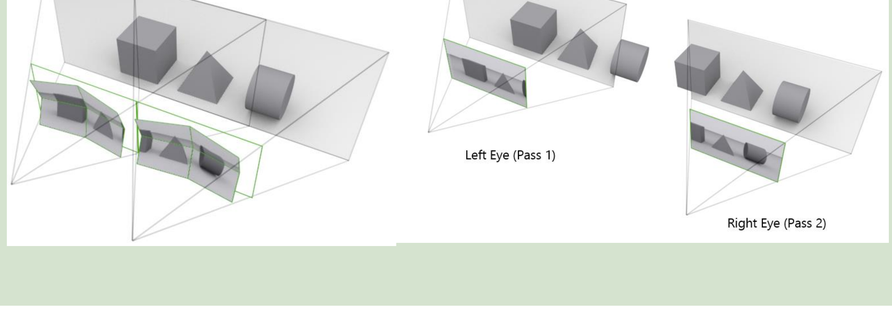
- Avoids rendering pixels that would be discarded





SPS

- SPS draws geometry only once instead of twice for both eyes



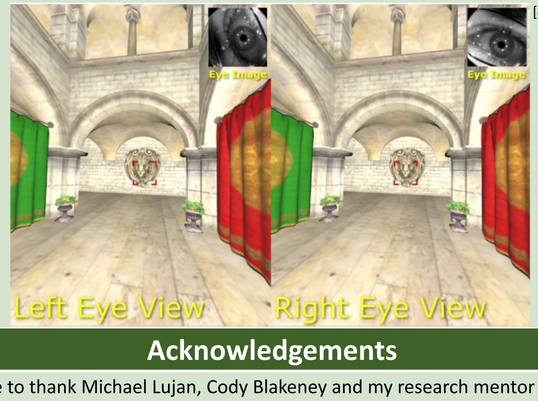
Results and Conclusion

VRWorks Solution	Fove		Vive	
	Avg Power (W)	% Savings	Avg Power (W)	% Savings
None: baseline	109.742	-	148.617	-
LMS	122.862	< 0	117.785	20.75
SPS	129.247	< 0	121.063	18.54
MRS	112.936	< 0	131.589	11.46

When the Vive HMD was used, there was a significant increase in efficiency. The preliminary results for fixed foveated rendering are significant enough to consider implementing a dynamic foveated rendering (DFR) solution. Utilizing DFR, virtual reality's challenge could be solved. The resources saved by these solutions could be used to create more immersive experiences in VR.

Future Research

- Create a prototype for Dynamic Foveated Rendering using Eye Tracking



[4]

Acknowledgements

I would like to thank Michael Lujan, Cody Blakeney and my research mentor Dr. Zong for their guidance throughout my learning experience. Lastly, We thank the National Science Foundation (NSF) for funding this research under the Research Experiences for Undergraduates Program (CNS-1358939, CNS-1659807) and the infrastructure support provided by the NSF-CRI 1305302 award.

Citations

[1] Bavor, C. (2017, May). *Enabling rich and immersive experiences in virtual and augmented reality.* Keynote session presented at SID Display Week Confrence, Los Angeles, CA.
[2] Liu E., Cebenoyan C.. *ACCELERATING YOUR VR APPLICATIONS WITH VRWORKS .; 2017.* Available at http://on-demand.gputechconf.com/gtc/2017/video/s7578-edward-liu-accelerating-your-vr-applications-with-vrworks.mp4. Accessed on August 1, 2018.
[3] NVIDIA VRWorks™. (2018, July 25). Retrieved from https://developer.nvidia.com/vrworks
[4] Anjul Patney, Joohwan Kim, Marco Salvi, Anton Kaplanyan, Chris Wyman, Nir Benty, Aaron Lefohn, and David Luebke. 2016. Perceptually-based foveated virtual reality. In ACM SIGGRAPH 2016 Emerging Technologies (SIGGRAPH '16). ACM, New York, NY, USA, Article 17, 2 pages. DOI: https://doi.org/10.1145/2929464.2929472