EE367 Project Proposal: Foveated Rendering for Virtual Reality

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Motivation:

Foveated rendering is of particular interest to virtual reality for two reasons: adding depth cues to Virtual Reality (VR) experiences and reducing the need for a high-bandwidth interconnect between Head-Mounted-Displays (HMD) and PCs.

The basic premise of foveated rendering is to first detect which part of the image the subject is observing and then only display that section in focus. Since defocus blurring is an important cue that our visual system relies on for depth estimation, adding foveated rendering creates a more comfortable and realistic VR experience.

Foveated rendering presents itself as an ideal solution for the need to reduce the bandwidth required between the PC and the HMD. This done by taking advantage of the fact that the human visual system can only perceive high resolution images in the foveal region. As such we only need to display that part of the image in high resolution, leaving the other part blurred and compressed. In contrast, many of the video compressions algorithms that exist today are not suitable for VR as they either add latency, corrupt lens calibration, or produce noticeable artifacts when viewed at such short distances. In fact, when done correctly, foveated rendering is lossless since it only loses information in the part of the screen that is not being viewed.

Unlike most foveated rendering schemes that exist today, our proposal is to have the PC render a completely blurred image. We then compress the image and transmit to the HMD taking advantage of the fact that low frequency images compress better. In the HMD we will detect the pupils and then focus on the relevant parts of the screen. Since the blurring kernel used on the PC side is known to us we can use that to focus the image using an optimization technique like ADMM. The primary motivation behind implementing the focusing step on the HMD is to reduce the latency introduced by communicating the location of the pupils back to the PC, but also to reduce the bandwidth between the PC and the HMD to a minimum.

Project Overview:

The Project will be split into two sections, one of those sections will represents the computation done on the PC side while the other will represent the computation done on the HMD side

On the PC side we will take a sharp high resolution image and do the following

1- Compute a customized prior for each image that will be later used to deblur it. We believe this step can improve the quality of our deblurring step on the HMD.
2- Then we will blur the image using a known kernel. We will investigate different kinds of blurring methods and determine the one best suited for this application.

3- Then we will compress the image to be transferred. It is believed in literature that blurred images have a higher compression ratio. Again, we will investigate various compression methods.

On the HMD side we will do the following

1- Uncompress the image to get the blurred version.
2- Determine the gaze of the user, this will simply be a predetermined pattern that we input into our script.
3- Identify the section that we need to focus. We will also compute an uncertainty term. Higher uncertainty will cause a larger part of the image to be in focus.
4- Using the prior that we transmit along with the blurred image, we bring back the identified section into focus.

To determine the effectiveness of our algorithm we will optimize two parameters.

1- The compression ratio which is the ratio of the image we transmitted to the original image.
2- PSNR of the in-focus potion of the final image compared to the original image.

Milestones

Feb 19 – Investigate and implement priors and blur kernel.

Feb 26 – Determine compression algorithm. Confirm and code blurring/de-blurring and uncompressing on HMD side.

March 5 – Implement partial de-blurring of images from "Pupil Tracking" input.

March 9 – Finalize and determine effectiveness from compression ratio/PSNR.

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