

Realtime HDR Imaging

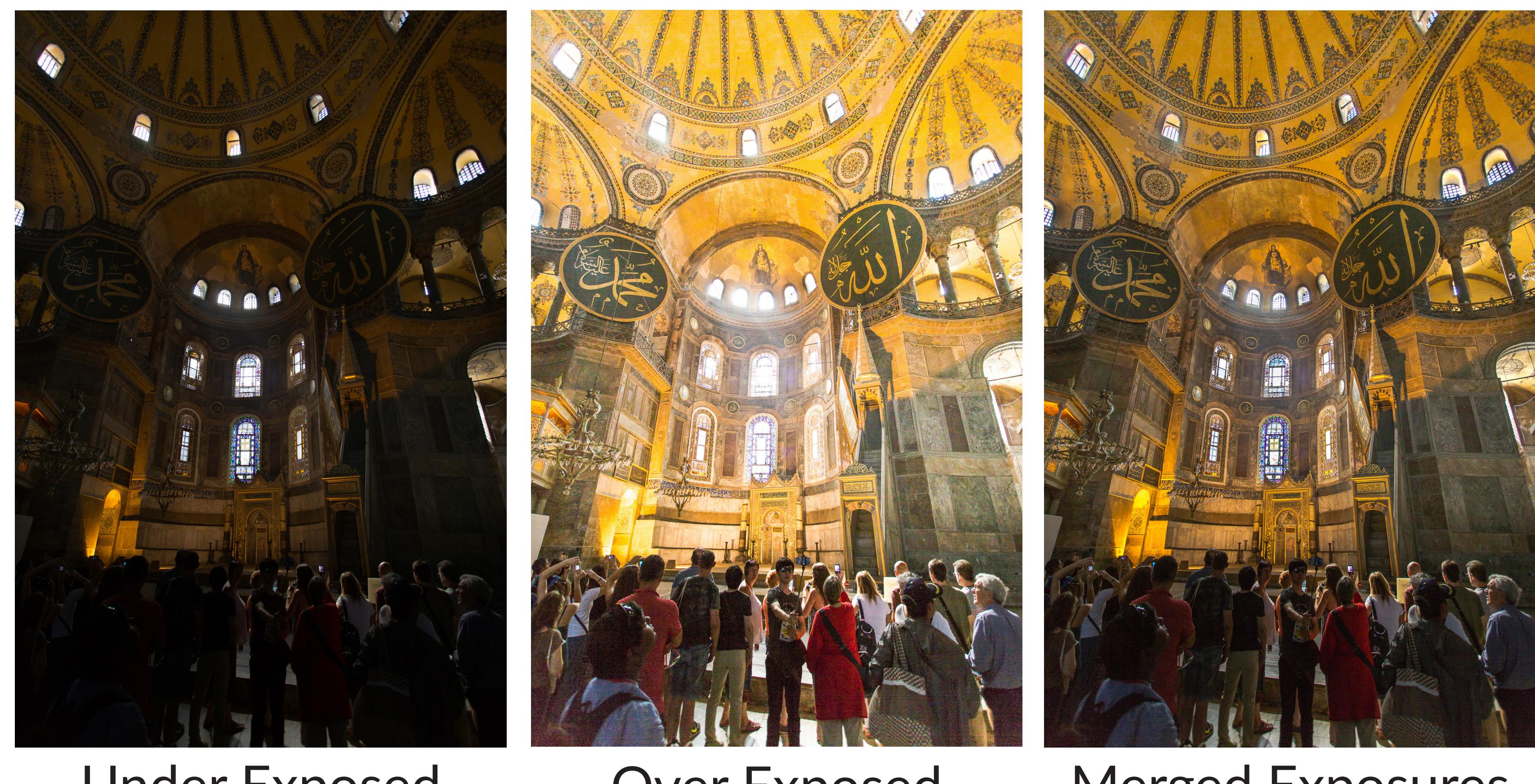
GPU-based image synthesis pipeline for realtime processing

Cameras capture a narrower range of intensities than humans can perceive for a given scene.

Scene luminances outside sensor capabilities causes oversaturation or starvation of a pixel, causes undesirable clipping.

Dynamic range is the ratio of the highest and lowest intensities in a scene (SNR)

Without wide dynamic range capabilities, the output image may not represent the environment as well as our eyes can.



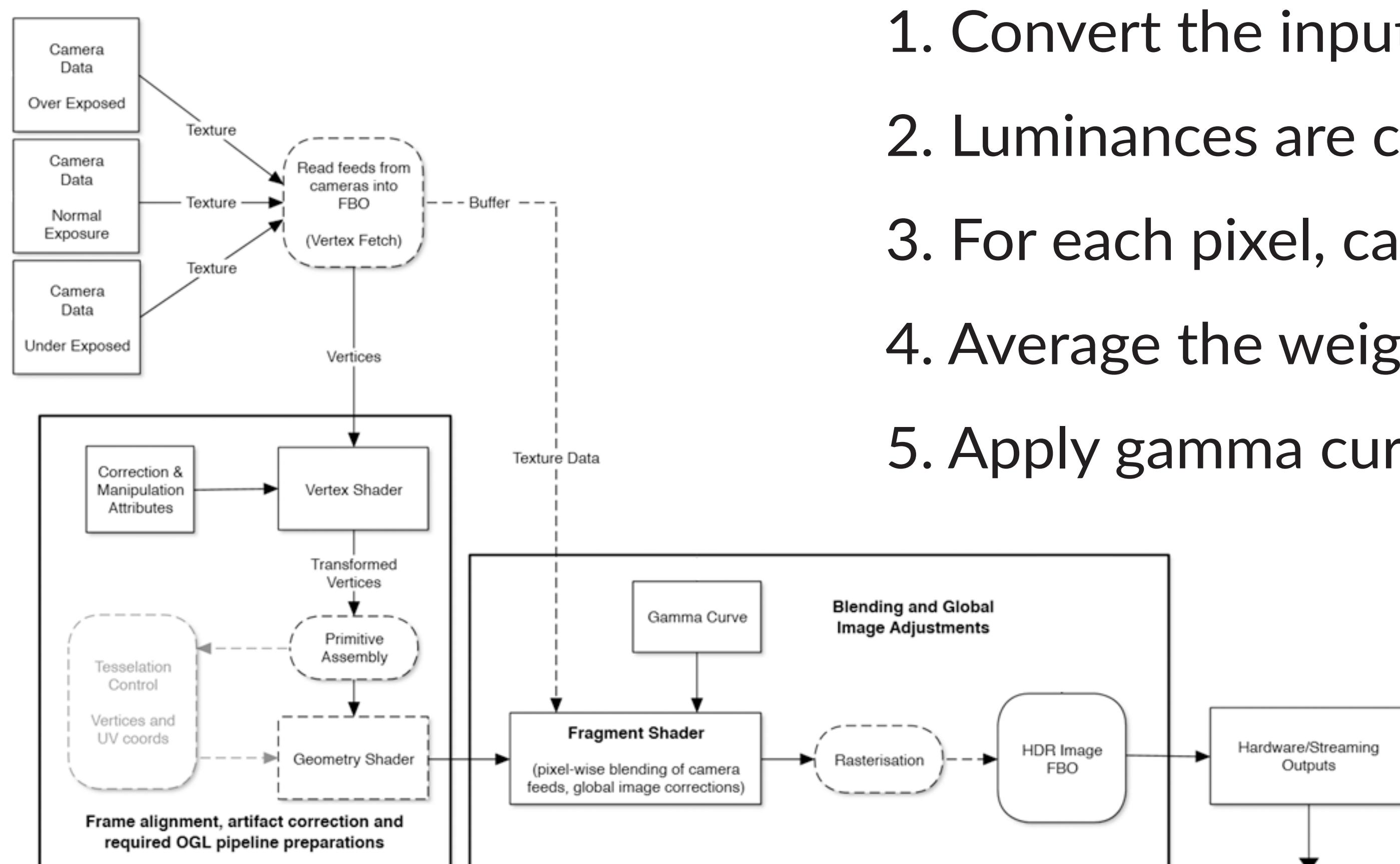
Under Exposed

Over Exposed

Merged Exposures

We coalesce data from multiple commodity webcams to improve output dynamic range, giving a High Dynamic Range Image (HDR) with no loss of temporal resolution. Cost is reduced by accepting some optical artifacts

Image Processing on the GPU with Fragment shaders



1. Convert the input image into linear colour space.
2. Luminances are calculated and weighted.
3. For each pixel, calculate its weight for each of the LDR frames
4. Average the weighted LDR pixels together.
5. Apply gamma curve on output colourspace and reduce bitdepth

$$HDR\ Pixel = \sum_{i=1}^{LDR} \frac{pixel_{rgb}}{exposureOffset} * weight(pixel_{luma})$$

Global Tone Mapping - Gamma Curves

Conventional displays do not support HDR output, so a reduction in contrast is required.

This process allows the image to be viewed with natural appearance for humans.

Global tonemapping is performed with adapted Reinhard Operator (sigmoidal curve)

The final output is quantized from 16bit for 8-bit display.

Application

On robotic platforms, HDR improves situational awareness for remote viewing operators

The additional scene detail allows for more robust computer vision tasks.

Shader code runs on any OpenGL 2 capable GPU
430fps on desktop GPU*, 45fps on ODroid XU4**
for 3 source exposures at 1280x720 resolution.

Project Outcomes

- GPU accelerated image processing approach uses fragment shaders for pixel domain processing.
- Shader code runs per-pixel, and scales well with improved GPU hardware.
- Approach allows realtime output on untethered robotic platforms with single board computers.
- Improved imaging allows for better handling of uncontrolled incident lighting in outdoor environments

*nVidia 660Ti | **Mali T628 - All tested with textures loaded in memory

