

Image Processing

CSCI 4239/5239

**Advanced Computer Graphics
Spring 2025**

Types of Image Processing

- Sample texture to generate image
 - Texture can be read from file
 - Generate texture on pass 1, process on pass 2
- Combing values from different textures
 - Differencing/merging images
- Combining surrounding values from one texture
 - Sharpen, blur, erosion, dilation,
 - Edge detection
 - Anti-aliasing

Image Processing by Shader

- Pixel value based on the pixels in the vicinity
 - Weighted average of group of pixels
 - Sum of weights should be one
 - Weights may be negative
 - Edge detection
 - Sum of weights should be zero
 - Some weights must be negative
- Fragment processing can get values from a texture by sampling
 - Need the image in a texture
 - For interactive graphics, need image -> texture

OpenGL Implementation

- Draw the scene
- Copy scene to texture
 - `glCopyTexImage2D`
 - Set pixel spacing
- Apply processing to texture
 - Identity projection
 - Draw quad size of window
 - Sample pixel from texture
- Can do multiple iterations

Framebuffer Implementation

- Procedure remains the same
 - Draw the scene to texture framebuffer
 - Apply processing to (framebuffer) texture
- Very efficient
 - No need to move buffers to and from video card
- Simple to implement
 - Allocate and size buffer
 - Switch destination with `glBindFramebuffer`

Image Filters

- Sharpen (sum of weights=1)

$$\begin{array}{ccc} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{array}$$

- Blur (sum of weights=1)

$$\begin{array}{ccc} 1 & 2 & 1 \\ 2 & 1 & 2 & / & 13 \\ 1 & 2 & 1 \end{array}$$

- Erosion (minimum)
- Dilation (maximum)

Edge Detection

- Laplacian (sum of weights=0)

$$\begin{array}{ccc} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{array}$$

- Prewitt $\sqrt{H^2+V^2}$

$$H = \begin{array}{ccc} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{array}$$

$$V = \begin{array}{ccc} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{array}$$

- Sobel $\sqrt{H^2+V^2}$

$$H = \begin{array}{ccc} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{array}$$

$$V = \begin{array}{ccc} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{array}$$

Anti-Aliasing

- Draw image at higher resolution to FBO
 - FBO dimensions integer multiple of screen
 - 1024x768 => 2048x1536 or 4068x3072
- Use shader to average FBO pixels
 - 2x2 (1/4 each) or 4x4 (1/16 each)
- Lines need to be drawn thicker, text and raster operations enlarged

Real Time Image Processing

- Same shaders as post-processing
- OpenCV
 - videoio module
 - VideoCapture class
 - Frame class
- Do the processing at camera resolution
 - Do processing at camera capture rate
 - Copy final result to screen

Inter-image processing

- Often used to detect differences
 - Image registration is critical
- Can be used to merge images
 - Monochrome images to color
 - Image enhancement

Assignment 6: Image Processing

- Use a shader to do image processing
 - Spatial transformation (sharpen, ...)
 - Color transformation
 - Resampling (e.g. anti-aliasing)
 - Multi-image operations
 - Special effects (lens flare)
- Can be on a generated scene or existing image (e.g. video feed)