Image Processing

CSCI 4239/5239
Advanced Computer Graphics
Spring 2026

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)

  ```
  -1  -1   -1
  -1   9   -1
  -1  -1   -1
  ```

- Blur (sum of weights=1)

  ```
  1   2   1
  2   1   2   /  13
  1   2   1
  ```

- Erosion (minimum)

- Dilation (maximum)

Edge Detection

- Laplacian (sum of weights=0)

```
-1  -1   -1
-1   8   -1
-1  -1   -1
```

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

```
          -1  -1  -1                    1   0  -1
H  =       0   0   0        V  =        1   0  -1
           1   1   1                    1   0  -1
```

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

```
          -1  -2  -1                    1   0  -1
H  =       0   0   0        V  =        2   0  -2
           1   2   1                    1   0  -1
```

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)