Introduction to Computer Graphics with WebGL

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Buffers

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Objectives

- Introduce additional WebGL buffers
- Reading and writing buffers
- Buffers and Images

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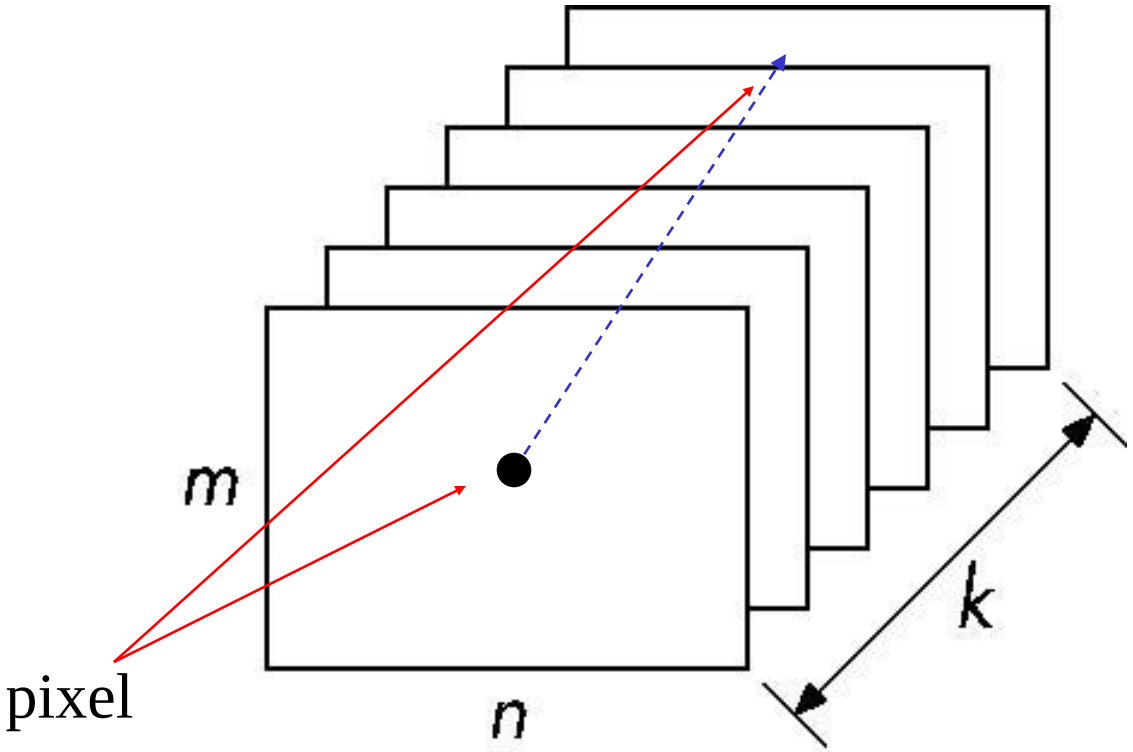
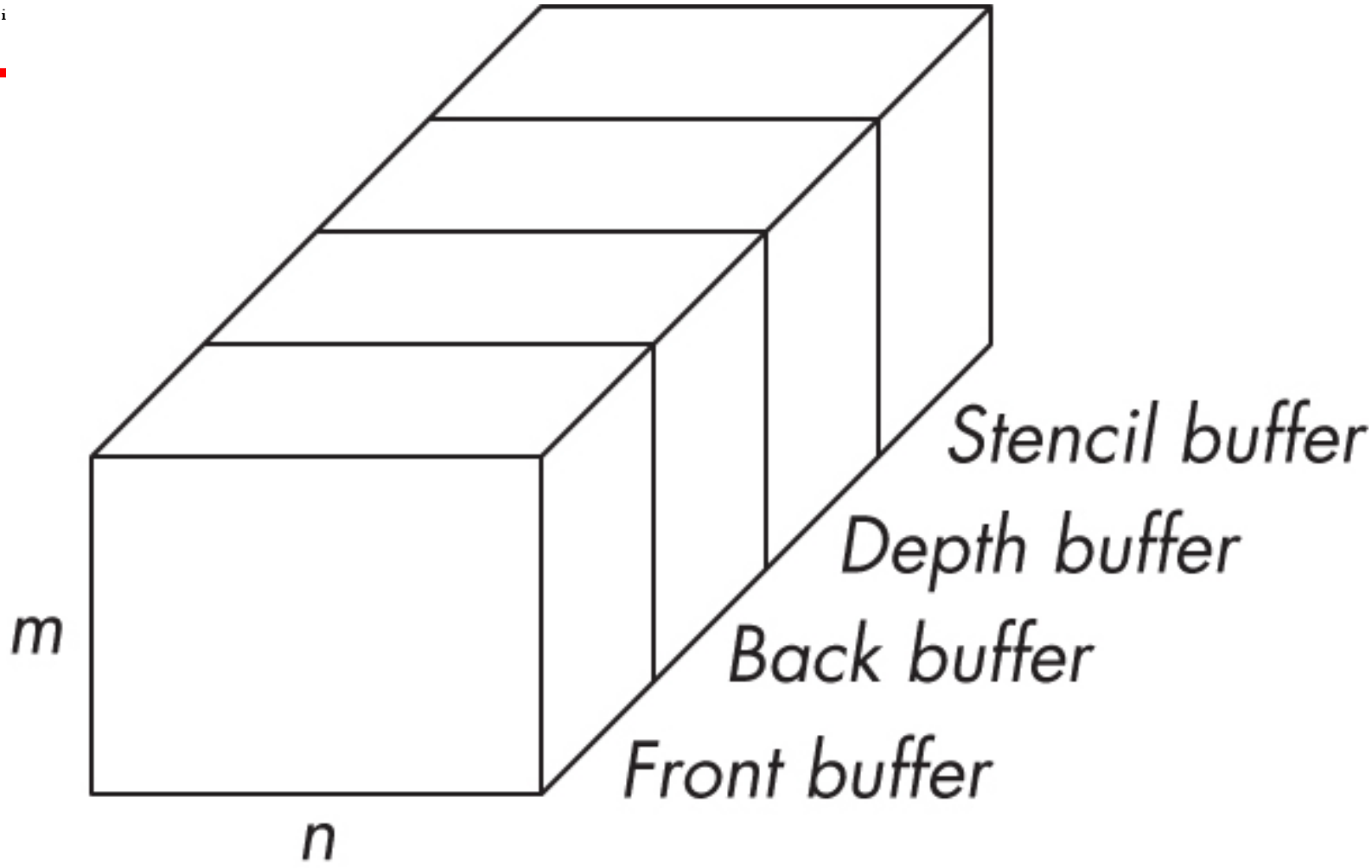
Buffer

Define a buffer by its spatial resolution (n x m) and its depth (or precision) k, the number of bits/pixel



WebGL Frame Buffer



Where are the Buffers?

- HTML5 Canvas
  - Default front and back color buffers
  - Under control of local window system
  - Physically on graphics card
- Depth buffer also on graphics card
- Stencil buffer
  - Holds masks
- Most RGBA buffers 8 bits per component
- Latest are floating point (IEEE)

Other Buffers

- desktop OpenGL supported other buffers
  - auxiliary color buffers
  - accumulation buffer
  - these were on application side
  - now deprecated
- GPUs have their own or attached memory
  - texture buffers
  - off-screen buffers
    - not under control of window system
    - may be floating point

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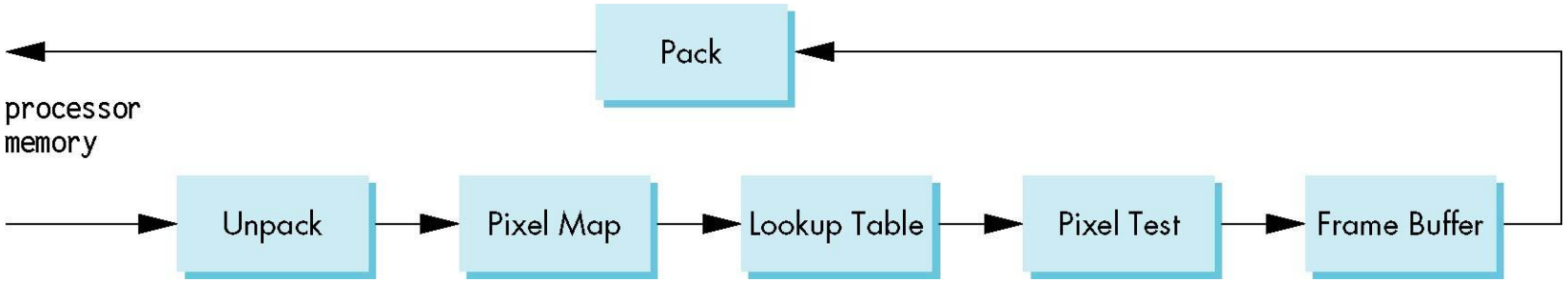
Images

- Framebuffer contents are unformatted
  - usually RGB or RGBA
  - one byte per component
  - no compression
- Standard Web Image Formats
  - jpeg, gif, png
- WebGL has no conversion functions
  - Understands standard Web formats for texture images

The (Old) Pixel Pipeline

- OpenGL has a separate pipeline for pixels
  - Writing pixels involves
    - Moving pixels from processor memory to the frame buffer
    - Format conversions
    - Mapping, Lookups, Tests
  - Reading pixels
    - Format conversion



Packing and Unpacking

- Compressed or uncompressed
- Indexed or RGB
- Bit Format
  - little or big endian
- WebGL (and shader-based OpenGL) lacks most functions for packing and unpacking
  - use texture functions instead
  - can implement desired functionality in fragment shaders

Deprecated Functionality

- glDrawPixels
- glCopyPixels
- glBitMap

Buffer Reading

- WebGL can read pixels from the framebuffer with gl.readPixels
- Returns only 8 bit RGBA values
- In general, the format of pixels in the frame buffer is different from that of processor memory and these two types of memory reside in different places
  - Need packing and unpacking
  - Reading can be slow
- Drawing through texture functions and off-screen memory (frame buffer objects)

WebGL Pixel Function

```
gl.readPixels(x,y,width,height,format,type,myimage)
```

start pixel in frame buffer

size

type of image

type of pixels

pointer to processor memory

```
var myimage[512*512*4];

gl.readPixels(0,0, 512, 512, gl.RGBA,
      gl.UNSIGNED_BYTE, myimage);
```

Render to Texture

- GPUs now include a large amount of texture memory that we can write into
- Advantage: fast (not under control of window system)
- Using frame buffer objects (FBOs) we can render into texture memory instead of the frame buffer and then read from this memory
  - Image processing
  - GPGPU

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BitBlt

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Objectives

- Introduce reading and writing of blocks of bits or bytes
- Prepare for later discussion compositing and blending

Writing into Buffers

- WebGL does not contain a function for writing bits into frame buffer
  - Use texture functions instead
- We can use the fragment shader to do bit level operations on graphics memory
- Bit Block Transfer (BitBlt) operations act on blocks of bits with a single instruction

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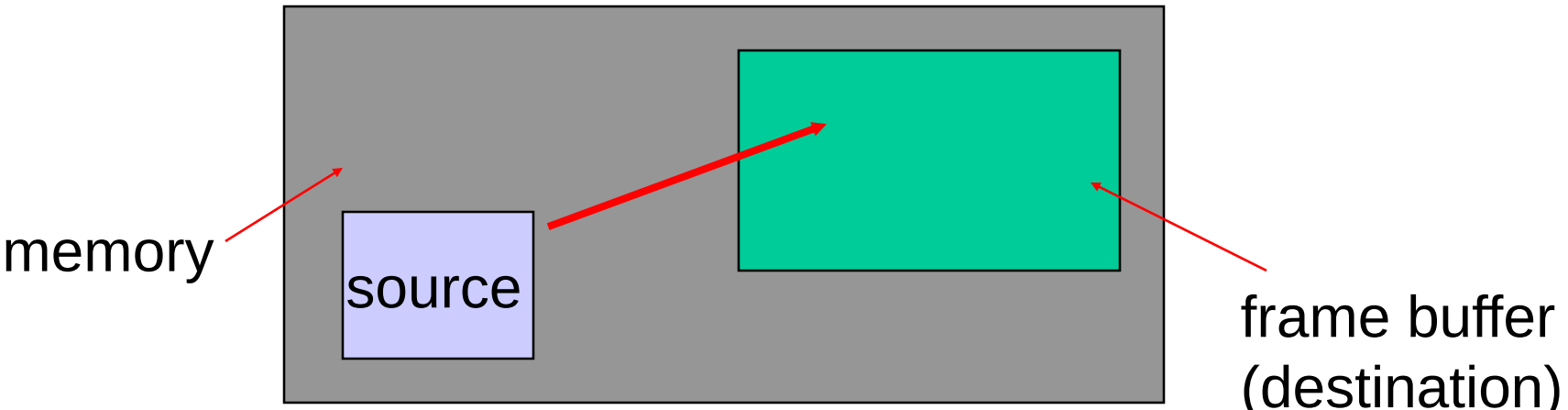
BitBlt

- Conceptually, we can consider all of memory as a large two-dimensional array of pixels
- We read and write rectangular block of pixels
- The frame buffer is part of this memory



writing into the frame buffer

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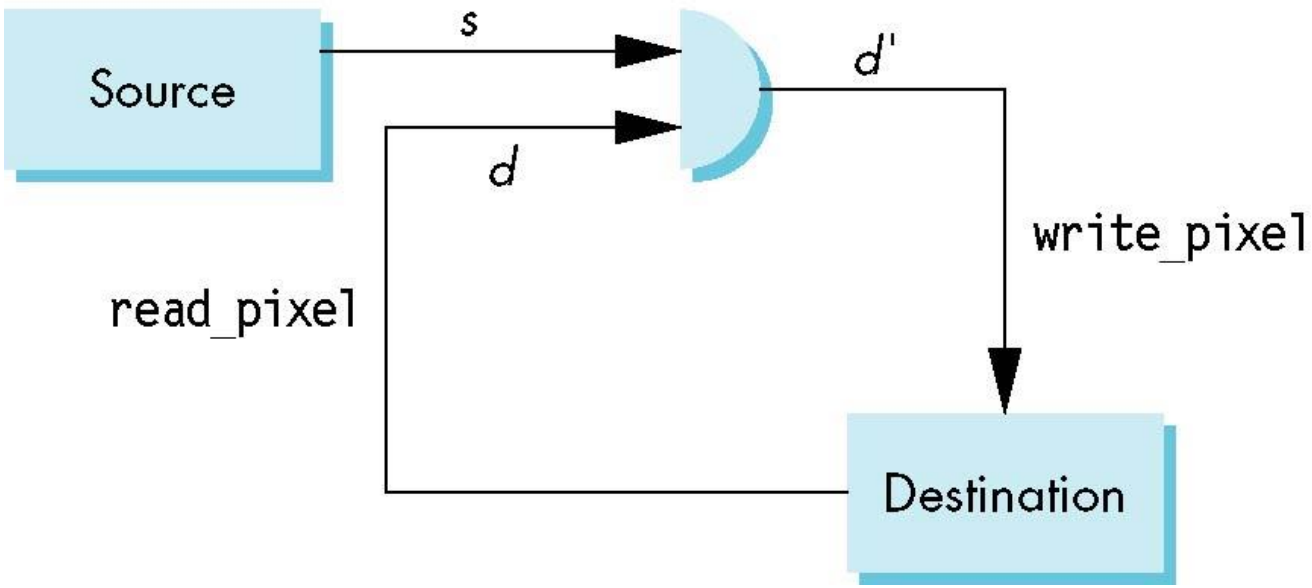
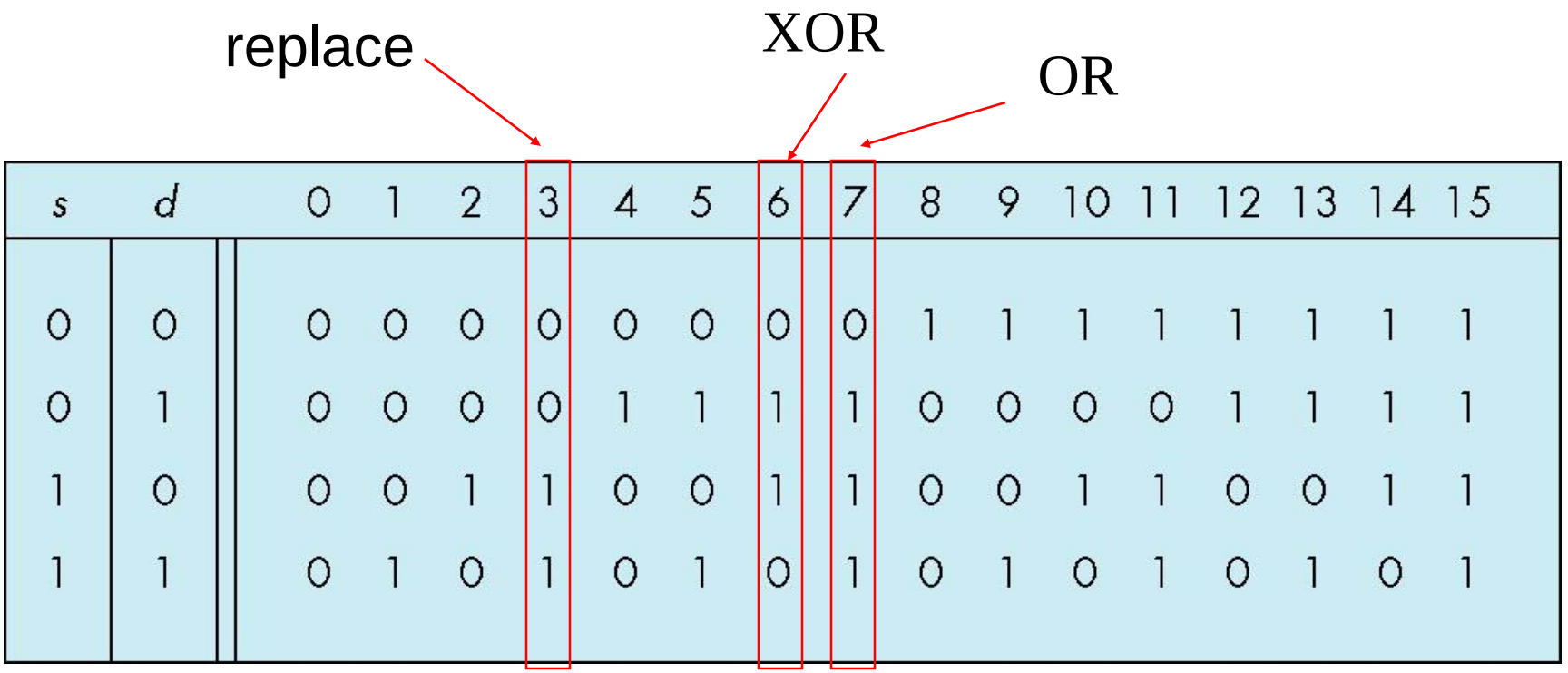
Writing Model

Read destination pixel before writing source



Bit Writing Modes

- Source and destination bits are combined bitwise
- 16 possible functions (one per column in table)



s	d	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
0	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
1	0	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1

XOR mode

- XOR is especially useful for swapping blocks of memory such as menus that are stored off screen

  If S represents screen and M represents a menu the sequence

  $$S \leftarrow S \oplus M$$
  $$M \leftarrow S \oplus M$$
  $$S \leftarrow S \oplus M$$

  swaps S and M

- Same strategy used for rubber band lines and cursors

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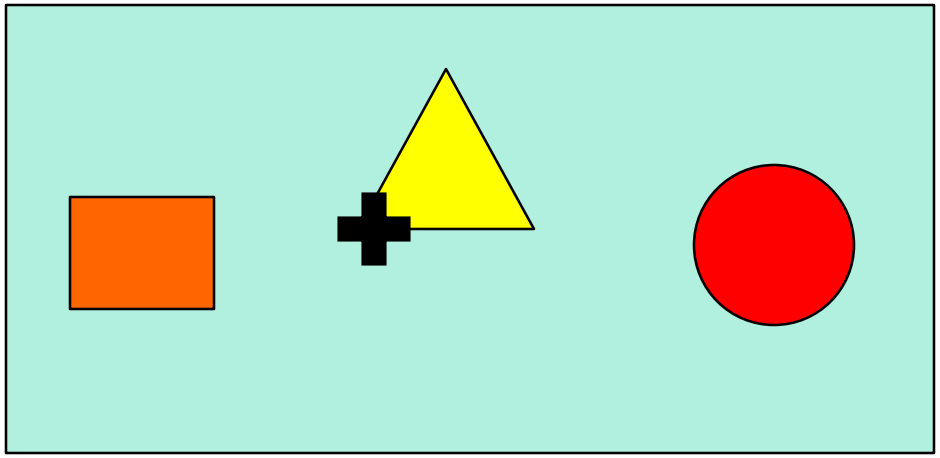
Cursor Movement

- Consider what happens as we move a cursor across the display
- We cover parts of objects
- Must return to original colors when cursor moves away



Rubber Band Line

- Fix one point
- Draw line to location of cursor
- Must return state of crossed objects when line moves