Grafică pe calculator (MLR5060)

Elemente de grafică 3_D

Programare OpenGl 3 (Part c)

- Introduction
- Rendering Primitives
- Rendering Modes
- Lighting
- Texture Mapping
- Additional Rendering Attributes
- Imaging

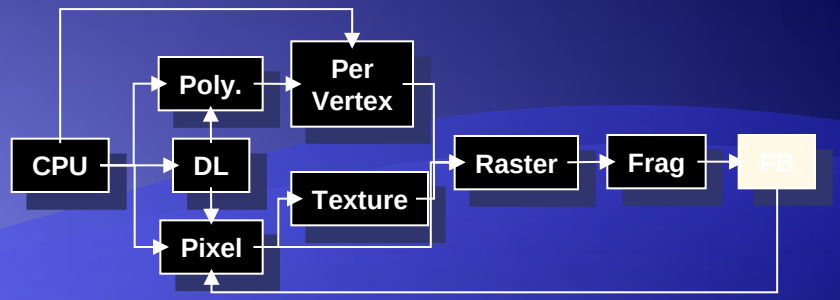
19 Dec. 2019

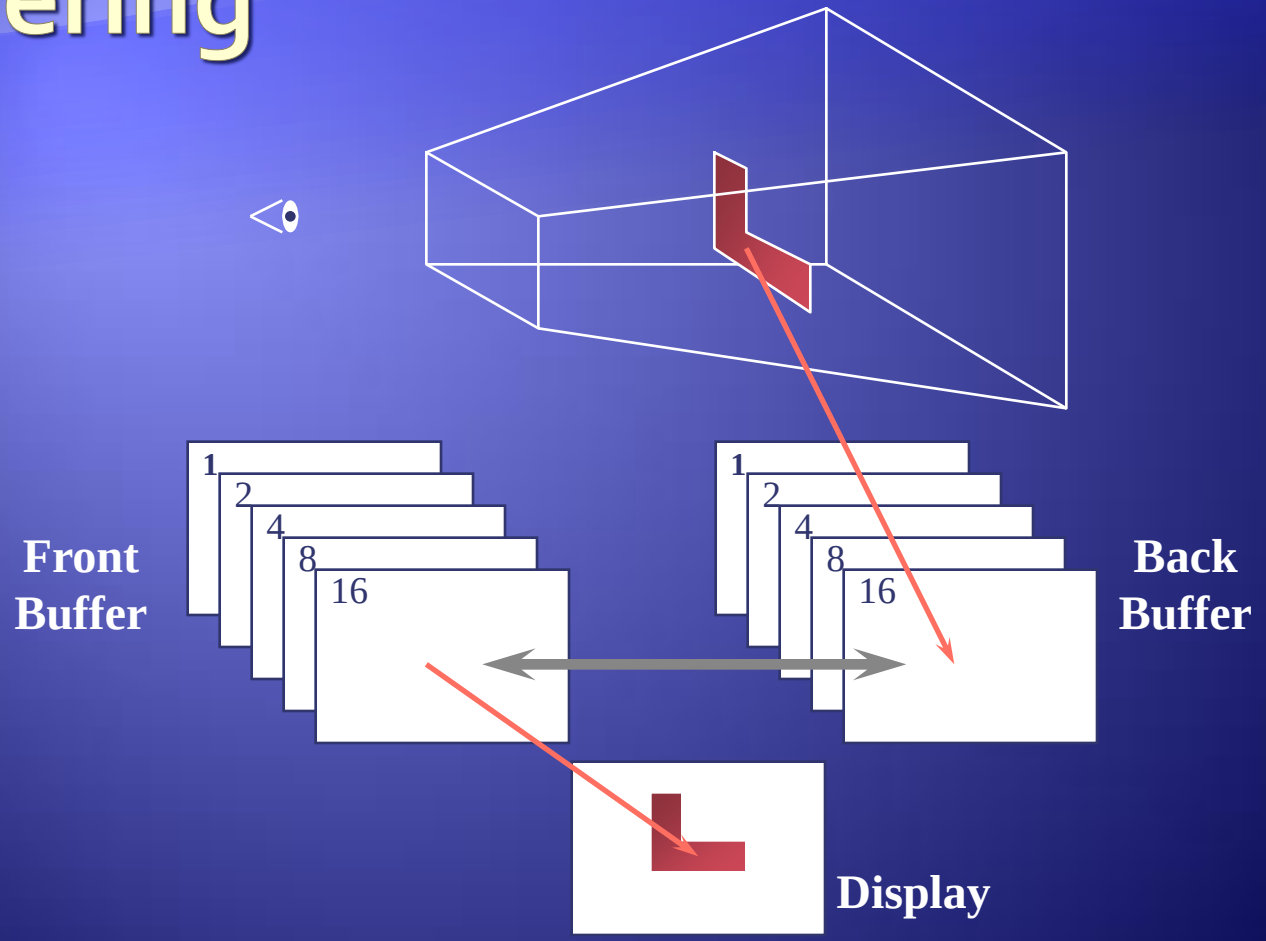
Animation and Depth Buffering

- Discuss double buffering and animation
- Discuss hidden surface removal using the depth buffer

Vicki Shreiner

Double Buffering





Animation Using Double Buffering

① Request a double buffered color buffer

```
glutInitDisplayMode(GLUT_RGB|GLUT_DOUBLE);
```

② Clear color buffer

```
glClear( GL_COLOR_BUFFER_BIT );
```

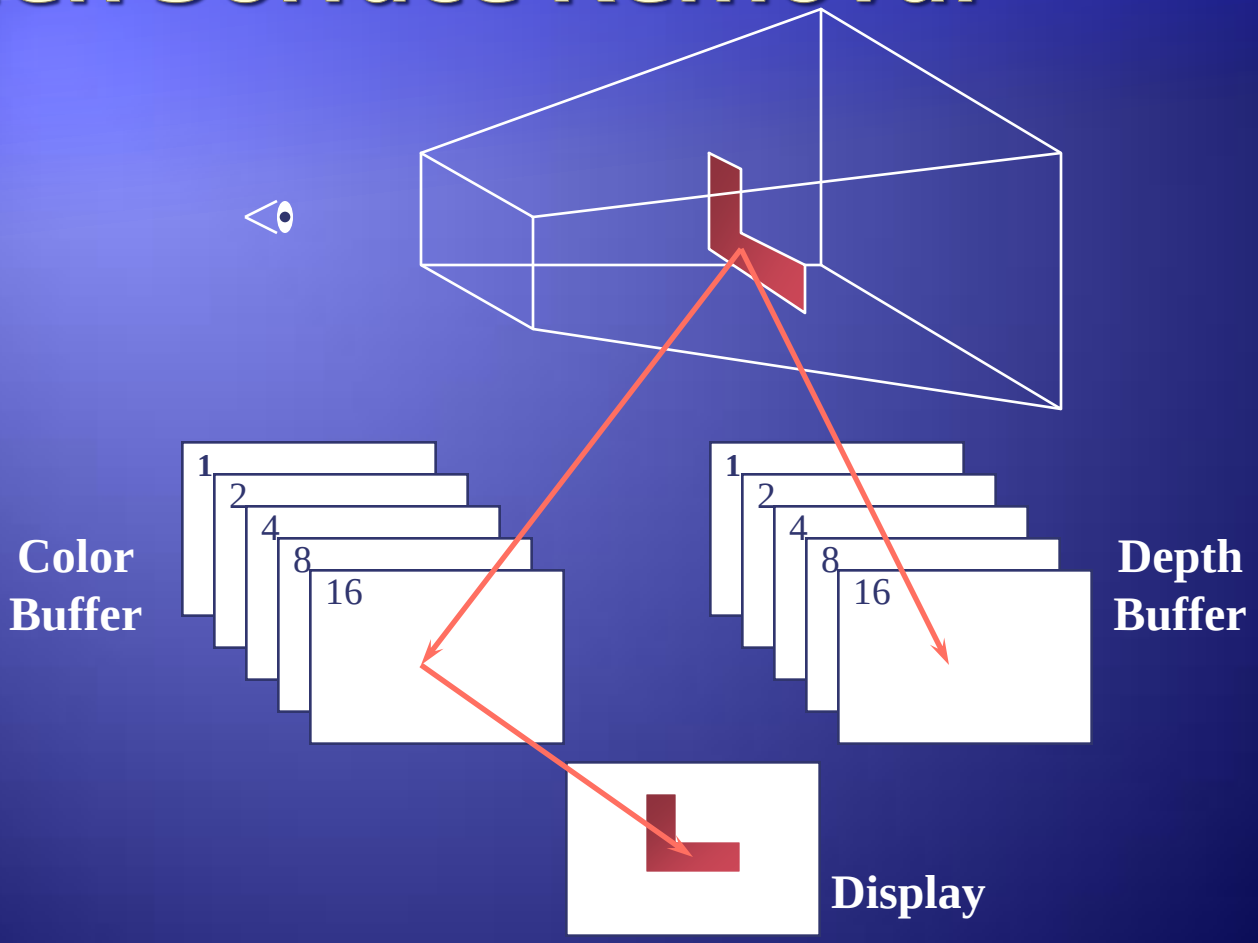
③ Render scene

④ Request swap of front and back buffers

```
glutSwapBuffers();
```

- Repeat steps 2 - 4 for animation

Depth Buffering and Hidden Surface Removal



Depth Buffering Using OpenGL

① Request a depth buffer

```
glutInitDisplayMode( GLUT_RGB |
  GLUT_DOUBLE | GLUT_DEPTH );
```

② Enable depth buffering

```
glEnable( GL_DEPTH_TEST );
```

③ Clear color and depth buffers

```
glClear( GL_COLOR_BUFFER_BIT |
  GL_DEPTH_BUFFER_BIT );
```

④ Render scene

⑤ Swap color buffers

An Updated Program Template

```
void main( int argc, char** argv )
{
    glutInit( &argc, argv );
    glutInitDisplayMode( GLUT_RGB |
       GLUT_DOUBLE | GLUT_DEPTH );
    glutCreateWindow( "Tetrahedron" );
    init();
    glutIdleFunc( idle );
    glutDisplayFunc( display );
    glutMainLoop();
}
```

… An Updated Program Template …

```
void init( void )
{
    glClearColor( 0.0, 0.0, 1.0, 1.0 );
}


void idle( void )
{
    glutPostRedisplay();
}
```

… An Updated Program Template …

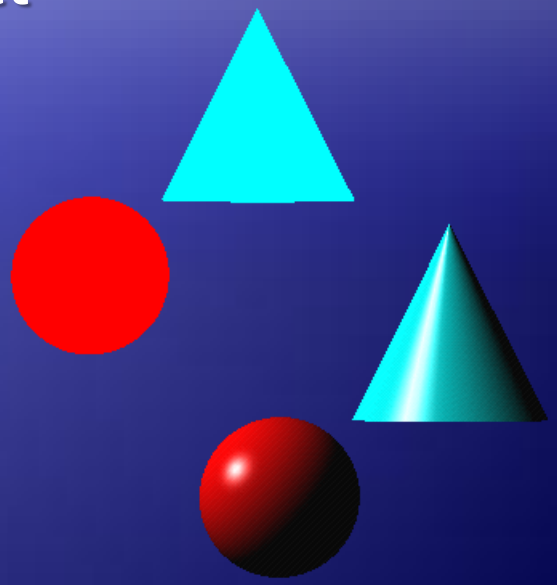
```
void drawScene( void )
{
    GLfloat vertices[] = { … };
    GLfloat colors[] = { … };
    glClear( GL_COLOR_BUFFER_BIT |
             GL_DEPTH_BUFFER_BIT );
    glBegin( GL_TRIANGLE_STRIP );
  /* calls to glColor*() and glVertex*() */
    glEnd();
    glutSwapBuffers();
}
```

LIGHTING

LIGHTING PRINCIPLES

Lighting simulates how objects reflect light

- material composition of object
- light's color and position
- global lighting parameters
  - ambient light
  - two sided lighting
- available in both color index and RGBA mode

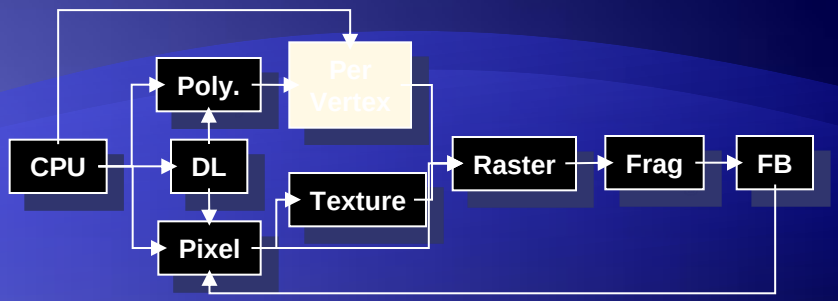


Dave Shreiner

How OpenGL Simulates Lights

- *Phong lighting model*
  - Computed at vertices
- *Lighting contributors*
  - Surface material properties
  - Light properties
  - Lighting model properties

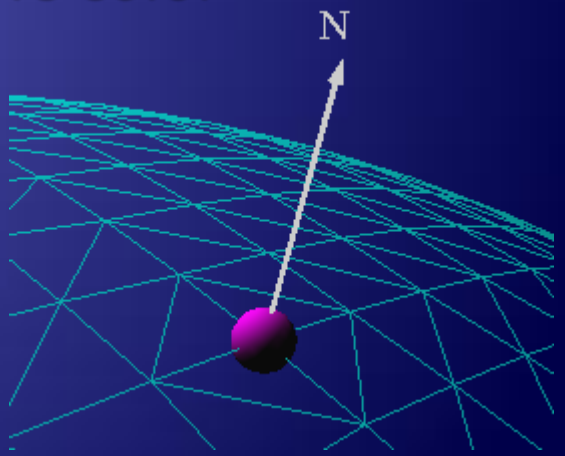
Surface Normals



- Normals define how a surface reflects light

```
glNormal3f( x, y, z )
```

  - Current normal is used to compute vertex's color
  - Use *unit* normals for proper lighting
    - scaling affects a normal's length




```
glEnable( GL_NORMALIZE )
```

or

```
glEnable( GL_RESCALE_NORMAL )
```

Material Properties

- Define the surface properties of a primitive

```
glMaterialfv( face, property, value );
```

GL_DIFFUSE	Base color
GL_SPECULAR	Highlight Color
GL_AMBIENT	Low-light Color
GL_EMISSION	Glow Color
GL_SHININESS	Surface Smoothness

  - separate materials for front and back

Light Properties

```
glLightfv( light, property, value );
```

- ***light*** specifies which light
  - multiple lights, starting with **GL_LIGHT0**

```
glGetIntegerv( GL_MAX_LIGHTS, &n );
```

- ***properties***
  - colors
  - position and type
  - attenuation

Light Sources (cont.)

- Light color properties
  - `GL_AMBIENT`
  - `GL_DIFFUSE`
  - `GL_SPECULAR`

Types of Lights

- OpenGL supports two types of Lights
  - Local (Point) light sources
  - Infinite (Directional) light sources
- Type of light controlled by w coordinate

$w = 0$ ***Infinite Light directed along*** $\begin{pmatrix} x & y & z \end{pmatrix}$

$w \neq 0$ ***Local Light positioned at*** $\begin{pmatrix} x/w & y/w & z/w \end{pmatrix}$

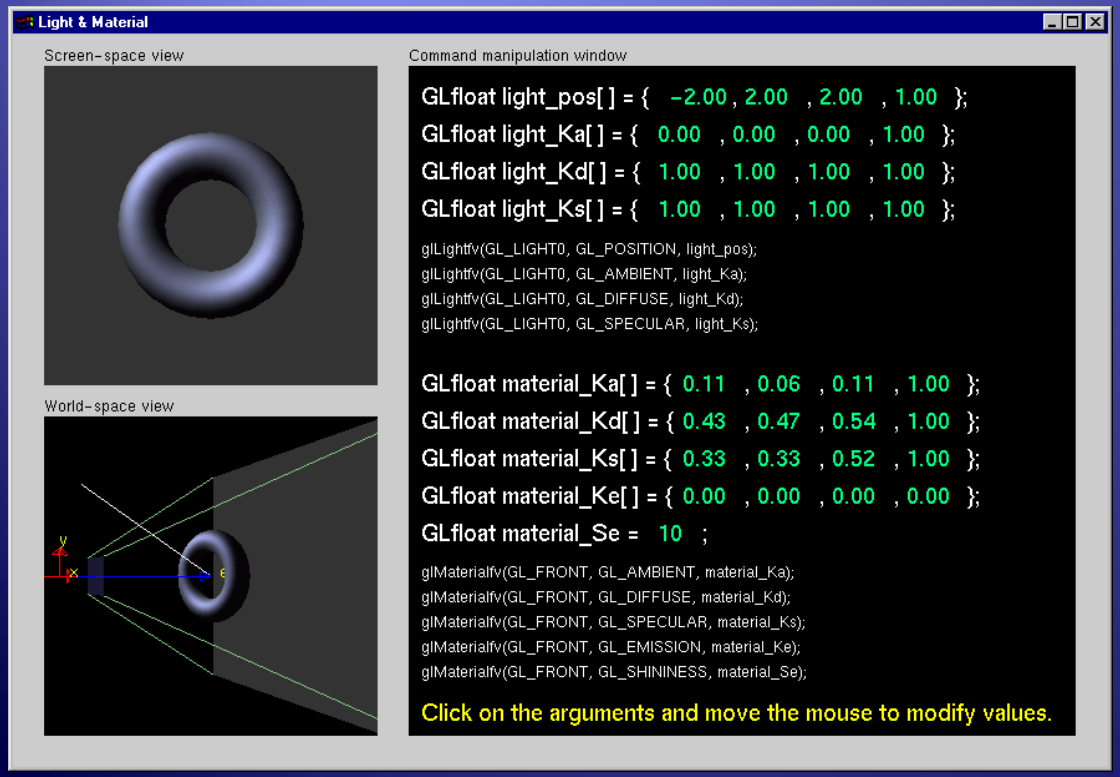
Turning on the Lights

- Flip each light's switch

  `glEnable( GL_LIGHTn );`

- Turn on the power

  `glEnable( GL_LIGHTING );`



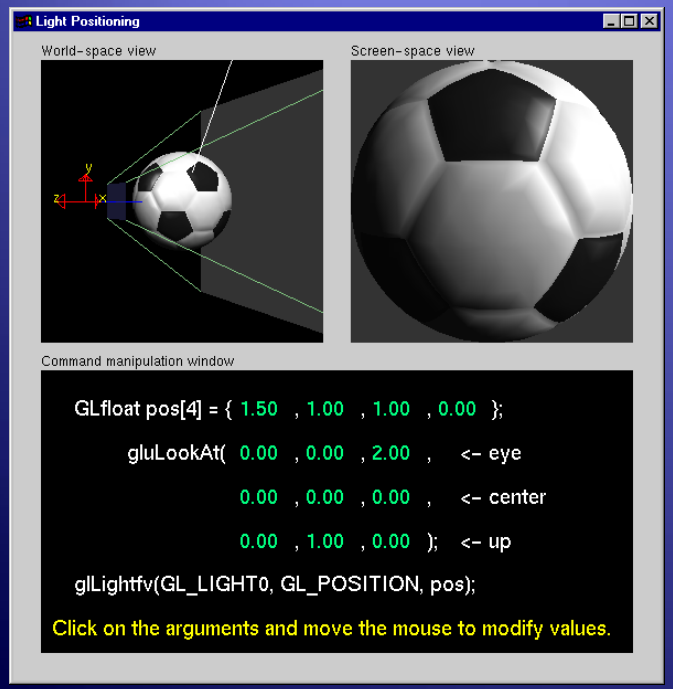
Light

Material

Tutorial

Controlling a Light's Position

- Modelview matrix affects a light's position
  - Different effects based on when position is specified
    - eye coordinates
    - world coordinates
    - model coordinates
  - Push and pop matrices to uniquely control a light's position



Light

Position

Tutorial

Advanced Lighting Features

- **Spotlights**
  - localize lighting affects
    - ***GL_SPOT_DIRECTION***
    - ***GL_SPOT_CUTOFF***
    - ***GL_SPOT_EXPONENT***
- **Light attenuation**
  - decrease light intensity with distance
    - ***GL_CONSTANT_ATTENUATION***
    - ***GL_LINEAR_ATTENUATION***
    - ***GL_QUADRATIC_ATTENUATION***

$$f_i = \frac{1}{k_c + k_l d + k_q d^2}$$

Light Model Properties

```
glLightModelfv( property, value );
```

- Enabling two sided lighting

  GL_LIGHT_MODEL_TWO_SIDE
- Global ambient color

  GL_LIGHT_MODEL_AMBIENT
- Local viewer mode

  GL_LIGHT_MODEL_LOCAL_VIEWER
- Separate specular color

  GL_LIGHT_MODEL_COLOR_CONTROL

Tips for Better Lighting

- Recall lighting computed only at vertices
  - model tessellation heavily affects lighting results
    - better results but more geometry to process
- Use a single infinite light for fastest lighting
  - minimal computation per vertex

IMAGING AND RASTER PRIMITIVES

Vicki Shreiner

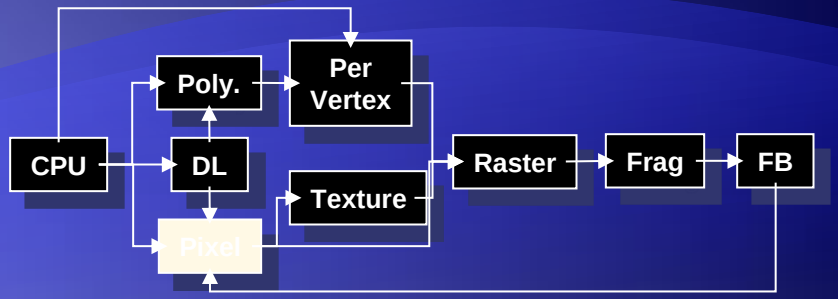
Imaging and Raster Primitives

- Describe OpenGL's raster primitives: bitmaps and image rectangles
- Demonstrate how to get OpenGL to read and render pixel rectangles

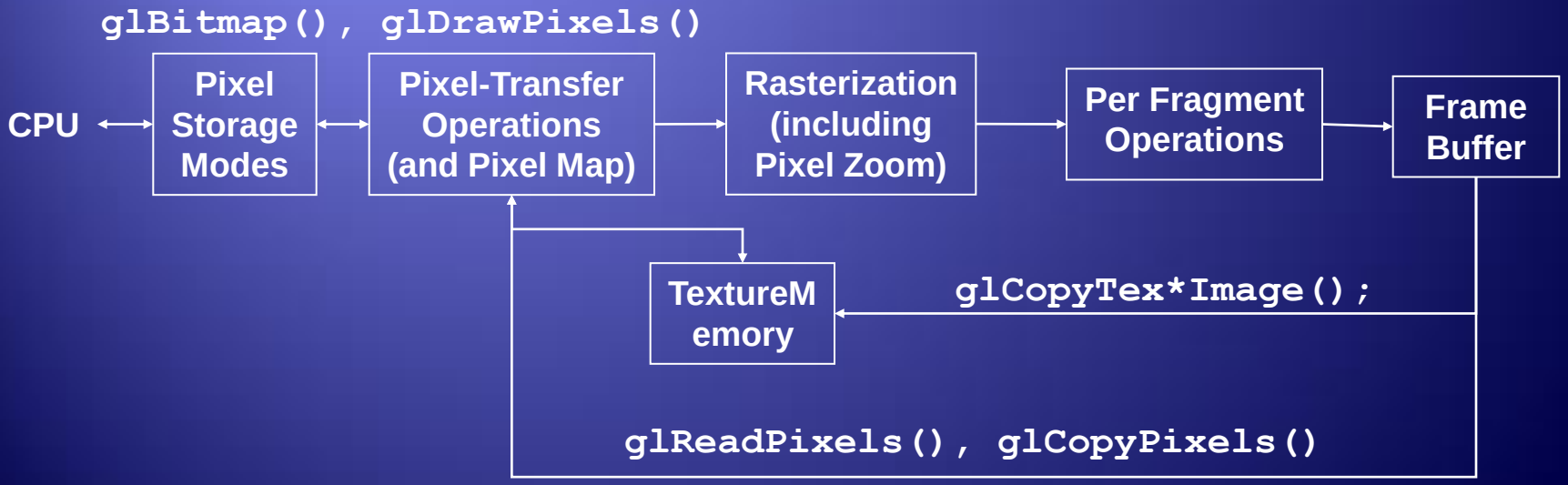
Pixel-based primitives

- Bitmaps
  - 2D array of bit masks for pixels
    - update pixel color based on current color
- Images
  - 2D array of pixel color information
    - complete color information for each pixel
- OpenGL doesn't understand image formats

Pixel Pipeline



- Programmable pixel storage and transfer operations



Positioning Image Primitives

`glRasterPos3f( x, y, z )`

- raster position transformed like geometry
- discarded if raster position is outside of viewport
  - may need to fine tune viewport for desired results

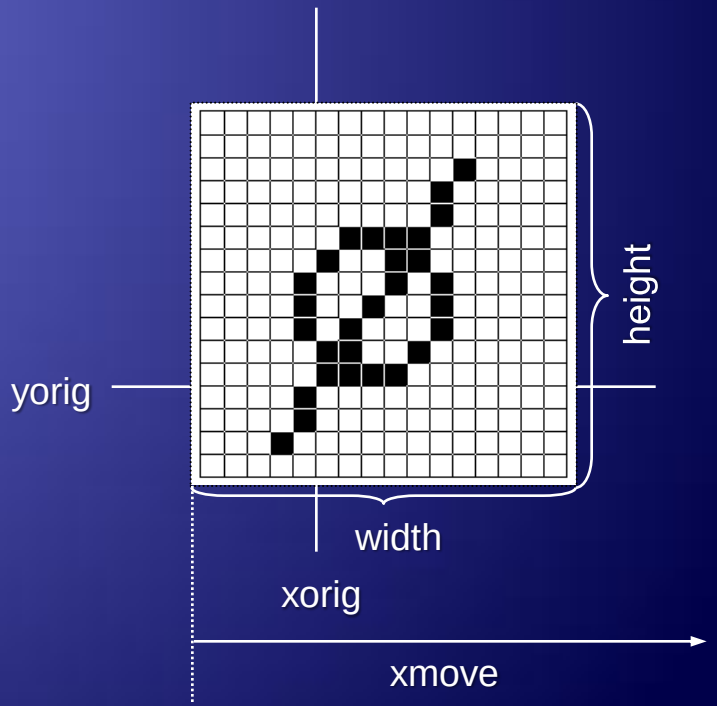
Raster Position

Rendering Bitmaps

```
glBitmap( width, height, xorig, yorig, xmove,
                                ymove, bitmap )
```

- render bitmap in current color at $(\lfloor x - xorig \rfloor \quad \lfloor y - yorig \rfloor)$
- advance raster position by after rendering

$$(xmove \quad ymove)$$



Rendering Fonts using Bitmaps

- OpenGL uses bitmaps for font rendering
  - each character is stored in a display list containing a bitmap
  - window system specific routines to access system fonts
    - `glXUseXFont()`
    - `wglUseFontBitmaps()`

Rendering Images

`glDrawPixels(`*`width,height,format,type,pixels`*`)`

- render pixels with lower left of image at current raster position
- numerous formats and data types for specifying storage in memory
  - best performance by using format and type that matches hardware

Reading Pixels

`glReadPixels(`*`x,y,width,height,format,type,pixel`*`)`

- read pixels form specified (*x,y*) position in framebuffer
- pixels automatically converted from framebuffer format into requested format and type

- Framebuffer pixel copy

```
glCopyPixels( x, y, width, height, type )
```

Pixel Zoom

`glPixelZoom( x, y )`

- expand, shrink or reflect pixels around current raster position
- fractional zoom supported

Raster Position

```
glPixelZoom(1.0, -1.0);
```

Storage and Transfer Modes

- Storage modes control accessing memory
  - byte alignment in host memory
  - extracting a subimage
- Transfer modes allow modify pixel values
  - scale and bias pixel component values
  - replace colors using pixel maps

Referințe

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   - http://www.unibuc.ro/prof/vlada_m/docs/2011/apr/11_12_12_01OpenGL_Programming_Guide.pdf
2. *Intro to 3D Graphics using Tao.OpenGL*, Erika Troll, Josh Lavinder, Alton Ng, Andrew Padilla
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4. *Learning Modern 3D Graphics Programming*, Jason L. McKesson
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Temă

Realizarea unei aplicatii simple care sa utilizeze:

1. Rendering Primitives
2. Rendering Modes
3. Lighting

Succes!