More Details of the Graphics Pipeline
(and Why the Shading Languages Give You Access to Things You’ve Never Heard Of)

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The Generic Computer Graphics System

Input Devices
Network

CPU
Display List

Bus

Vertex Processor
Rasterizer
Fragment Processor
Shader Memory

Video Driver

Z-Buffer
Cursor

Texture Memory
Double-buffered Framebuffers

Unified Memory Architecture (UMA)

MC = Model Coordinates
WC = World Coordinates
EC = Eye Coordinates
CC = Clip Coordinates
NDC = Normalized Device Coordinates
SC = Screen Coordinates
TC = Texture Coordinates

Unified Memory

Attributes

Variables

Varying variables

Uniform variables

MC Vertices

RGBAZ Pixels

Pixel Parameters

Texture

 RGBA Texels

Texture Coordinates

Homogeneous Division

Projection

Transform

gluLookAt

Viewport

Video Input

Network
Transforming a Surface Normal

Before transformation:

\[ T = (P_0 - P) \]
\[ \mathbf{N} \cdot T = 0, \text{ or expressed in matrix notation:} \]
\[ [\mathbf{N}]^T \{T\} = 0 \]

After transformation:

\[ T' = (P_0' - P') = ([M]\{P_0\} - [M]\{P\}) = [M] (\{P_0\} - \{P\}) = [M] \{T\} \]
\[ \mathbf{N}' \cdot T' = 0, \text{ or, expressed in matrix notation:} \]
\[ [\mathbf{N}']^T \{T'\} = 0 \]

If \([Q]\) is the matrix which needs to transform the normal, then:

\[ ([Q][\mathbf{N}]')^T \{T'\} = 0 \]
\[ ([Q][\mathbf{N}]') [M] \{T\} = 0 \]
\[ [\mathbf{N}]^T ([Q]^T [M]) \{T\} = 0 \]
\[ [Q]^T [M] = \mathbf{I} \]
\[ Q = ([M]^{-1})^T \]