Vulkan Sample Code

Caveats on the Sample Code

- I've written everything out in appalling longhand.
- Everything is in one .cpp file (except the geometry data). It really should be broken up, but this way you can find everything.
- At times, I could have hidden complexity, but I didn’t. At all stages, I have tried to err on the side of showing you everything, so that nothing happens in a way that’s a secret to you.
- I've setup Vulkan structs every time they are used, even though, in many cases, they could have been setup once and then re-used each time.
- At times, I've setup things that didn’t need to be setup just to show you what could go there.
- There are good uses for C++ classes and methods here to hide some complexity, but I've not done that.
- I've typedef'ed a couple things to make the Vulkan phraseology more consistent.
- Even though it is not good software style, I have put persistent information in global variables, rather than a separate data structure
- At times, I have copied lines from vulkan.h into the code as comments to show you what certain options could be.
- I've divided functionality up into the pieces that make sense to me. Many other divisions are possible. Feel free to invent your own.
void InitGraphics()
{
    HERE_I_AM(“InitGraphics”);
    VkResult result = VK_SUCCESS;
    Init01Instance();
    Init02GLFW();
    Init02CreateDebugCallbacks();
    Init03PhysicalDeviceAndGetQueueFamilyProperties();
    Init04LogicalDeviceAndQueue();
    Init05UniformBuffer( sizeof(Matrices), &MyMatrixUniformBuffer);
    Fill05DataBuffer( MyMatrixUniformBuffer, (void *) &Matrices);
    Init05UniformBuffer( sizeof(Light), &MyLightUniformBuffer);
    Fill05DataBuffer( MyLightUniformBuffer, (void *) &Light);
    Init05MyVertexDataBuffer( sizeof(VertexData), &MyVertexDataBuffer);
    Fill05DataBuffer( MyVertexDataBuffer, (void *) VertexData);
    Init06TextureSampler(&MyPuppyTexture.texSampler);
    Init06TextureBufferAndFillFromBmpFile(“puppy.bmp”, &MyPuppyTexture);
    Init07Swapchain();
    Init08DepthStencilImage();
    Init09RenderPasses();
    Init10Framebuffers();
    Init11CommandPool();
    Init11CommandBuffers();
    Init12SpirvShader(“sample-vert.spv”, &ShaderModuleVertex);
    Init12SpirvShader(“sample-frag.spv”, &ShaderModuleFragment);
    Init13DescriptorSetPool();
    Init13DescriptorSetLayouts();
    Init13DescriptorSet();
    Init14GraphicsVertexFragmentPipeline( ShaderModuleVertex, ShaderModuleFragment,
                                           VK_PRIMITIVE_TOPOLOGY_TRIANGLE_LIST, &GraphicsPipeline );
}
The Vertex Data is in a Separate File

#include “SampleVertexData.cpp”

struct vertex
{
    glm::vec3    position;
    glm::vec3    normal;
    glm::vec3    color;
    glm::vec2    texCoord;
};

struct vertex VertexData[ ] =
{
    // triangle 0-2-3:// vertex #0:
    { -1., -1., -1. },{  0.,  0., -1. },{  0.,  0.,  0. },{  1., 0. }
    // vertex #2:
    { -1.,  1., -1. },
    {  0.,  0., -1. },
    {  0.,  1.,  0. },{  1., 1. }
    // vertex #3:
    { -0.5, 0.5, -1. },{  0.,  0., -1. },{  0.,  0.,  0. },{  1., 0. }
    // vertex #4:
    { -0.5, -0.5, -1. },{  0.,  0., -1. },{  0.,  0.,  0. },{  1., 0. }
    // vertex #5:
    { -0.5, 0.5, -1. },{  0.,  0., -1. },
    {  0.,  0., -1. },
    {  0.,  0.,  0. },{  1., 0. }
    // vertex #6:
    {  0., -1., -1. },{  0.,  0., -1. },
    { -1.,  0., -1. },
    {  0.,  0.,  0. },{  1., 0. }
    // vertex #7:
    {  0.,  1., -1. },{  0.,  0., -1. },
    { -1.,  0., -1. },
    {  0.,  0.,  0. },{  1., 0. }
    // vertex #8:
    {  1., -1., -1. },{  0.,  0., -1. },
    { -1.,  0., -1. },
    {  0.,  0.,  0. },{  1., 0. }
    // vertex #9:
    {  1.,  1., -1. },{  0.,  0., -1. },
    { -1.,  0., -1. },
    {  0.,  0.,  0. },{  1., 0. }
    // vertex #10:
    {  1., -1., -1. },{  0.,  0., -1. },
    { -1.,  0., -1. },
    {  0.,  0.,  0. },{  1., 0. }
    // vertex #11:
    {  0.,  1., -1. },{  0.,  0., -1. },
    { -1.,  0., -1. },
    {  0.,  0.,  0. },{  1., 0. }
    // vertex #12:
    {  0., -1., -1. },{  0.,  0., -1. },
    { -1.,  0., -1. },
    {  0.,  0.,  0. },{  1., 0. }
    // vertex #13:
    {  0.,  0., -1. },{  0.,  0., -1. },
    { -1.,  0., -1. },
    {  0.,  0.,  0. },{  1., 0. }
    // vertex #14:
    {  0.,  0.,  1. },{  0.,  0., -1. },
    { -1.,  0., -1. },
    {  0.,  0.,  0. },{  1., 0. }
    // vertex #15:
    {  0.,  0.,  1. },{  0.,  0., -1. },
    { -1.,  0., -1. },
    {  0.,  0.,  0. },{  1., 0. }
};

What if you don’t need all of this information?

For example, what if you are not doing texturing in this application? Should you re-do this struct and leave the texCoord element out?

As best as I can tell, the only penalty for leaving in vertex attributes you aren’t going to use is memory space, but not performance. So, I recommend keeping this struct intact, and, if you don’t need texturing, simply don’t use the texCoord values in your vertex shader.

Vulkan Software Philosophy

1. There are lots of typedefs that define C/C++ structs and enums
2. Vulkan takes a non-C++ object-oriented approach in that those typedefed structs pass all the necessary information into a function. For example, where we might normally say in C++:

   result = LogicalDevice->vkGetDeviceQueue ( queueFamilyIndex, queueIndex, OUT &Queue );

   we would actually say in C:

   result = vkGetDeviceQueue ( LogicalDevice, queueFamilyIndex, queueIndex, OUT &Queue );

Vulkan Conventions

vkXxx is a typedef, probably a struct
vkXxx( ) is a function call
VK_XXX is a constant

My Conventions

“Init” in a function call name means that something is being setup that only needs to be setup once

The number after “Init” gives you the ordering

In the source code, after main( ) comes InitGraphics( ), then all of the InitXXX( ) functions in numerical order. After that comes the helper functions

“Find” in a function call name means that something is being looked for

“Fill” in a function call name means that some data is being supplied to Vulkan

“IN” and “OUT” ahead of function call arguments are just there to let you know how an argument is going to be used by the function. Otherwise, they have no significance.
Querying the Number of Something and Allocating Structures to Hold Them All

```c
uint32_t count;
result = vkEnumeratePhysicalDevices( Instance, OUT &count, OUT (VkPhysicalDevice *) nullptr );
result = vkEnumeratePhysicalDevices( Instance, OUT &count, OUT physicalDevices );
```

This way of querying information is a recurring OpenCL and Vulkan pattern (get used to it):

```
result = vkEnumeratePhysicalDevices( Instance, &count, nullptr );
result = vkEnumeratePhysicalDevices( Instance, &count, physicalDevices );
```

### Reporting Error Results, I

```c
struct errorcode
{
    VkResult resultCode;
    std::string meaning;
} ErrorCodes[] =
{
    { VK_NOT_READY, "Not Ready" },
    { VK_TIMEOUT, "Timeout" },
    { VK_EVENT_SET, "Event Set" },
    { VK_EVENT_RESET, "Event Reset" },
    { VK_INCOMPLETE, "Incomplete" },
    { VK_ERROR_OUT_OF_HOST_MEMORY, "Out of Host Memory" },
    { VK_ERROR_OUT_OF_DEVICE_MEMORY, "Out of Device Memory" },
    { VK_ERROR_INITIALIZATION_FAILED, "Initialization Failed" },
    { VK_ERROR_DEVICE_LOST, "Device Lost" },
    { VK_ERROR_MEMORY_MAP_FAILED, "Memory Map Failed" },
    { VK_ERROR_LAYER_NOT_PRESENT, "Layer Not Present" },
    { VK_ERROR_EXTENSION_NOT_PRESENT, "Extension Not Present" },
    { VK_ERROR_FEATURE_NOT_PRESENT, "Feature Not Present" },
    { VK_ERROR_INCOMPATIBLE_DRIVER, "Incompatible Driver" },
    { VK_ERROR_TOO_MANY_OBJECTS, "Too Many Objects" },
    { VK_ERROR_FORMAT_NOT_SUPPORTED, "Format Not Supported" },
    { VK_ERROR_FRAGMENTED_POOL, "Fragmented Pool" },
    { VK_ERROR_SURFACE_LOST_KHR, "Surface Lost" },
    { VK_ERROR_NATIVE_WINDOW_IN_USE_KHR, "Native Window In Use" },
    { VK_SUBOPTIMAL_KHR, "Suboptimal" },
    { VK_ERROR_OUT_OF_DATE_KHR, "Out of Date" },
    { VK_ERROR_INCOMPATIBLE_DISPLAY_KHR, "Incompatible Display" },
    { VK_ERROR_VALIDATION_FAILED_EXT, "Validation Failed" },
    { VK_ERROR_INVALID_SHADER_NV, "Invalid Shader" },
    { VK_ERROR_OUT_OF_POOL_MEMORY_KHR, "Out of Pool Memory" },
    { VK_ERROR_INVALID_EXTERNAL_HANDLE_KHR, "Invalid External Handle" },
};
```

### Reporting Error Results, II

```c
void PrintVkError( VkResult result, std::string prefix )
{
    if (Verbose & result == VK_SUCCESS){
        fprintf(FpDebug, "%s: %s\n", prefix.c_str(), "Successful");
        fflush(FpDebug);
        return;
    }
    const int numErrorCodes = sizeof( ErrorCodes ) / sizeof( struct errorcode );
    std::string meaning = "";
    for( int i = 0; i < numErrorCodes; i++ )
    {
        if( result == ErrorCodes[i].resultCode )
        {
            meaning = ErrorCodes[i].meaning;
            break;
        }
    }
    fprintf(FpDebug, "%s: %s\n", prefix.c_str(), meaning.c_str());
    fflush(FpDebug);
}
```
#define REPORT(s)               PrintVkError( result, s );  fflush(FpDebug);

#define HERE_I_AM(s)          if( Verbose )  { fprintf( FpDebug, "***** %s *****\n", s );  fflush(FpDebug); }

bool   Pased;

bool   Verbose;

#define DEBUGFILE               "VulkanDebug.txt"
errno_t err = fopen_s( &FpDebug, DEBUGFILE, "w" );

Extras in the Code