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Vulkan Sample Code

Oregon State University
Mike Bailey
mjb@cs.oregonstate.edu

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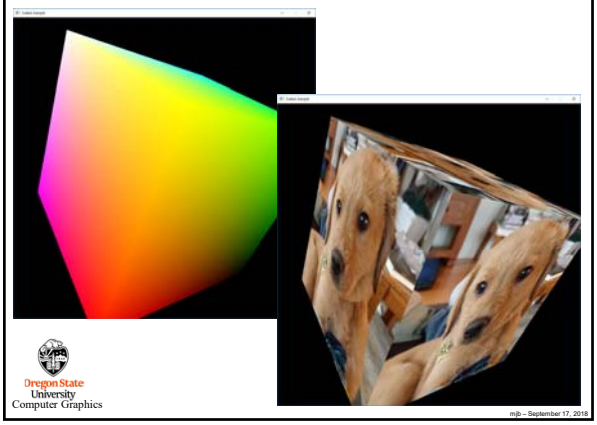
Sample Program Output



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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.

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Main Program

```
int
main( int argc, char * argv[ ] )
{
	Width = 800;
	Height = 600;

	errno_t err = fopen_s( &FpDebug, DEBUGFILE, "w" );
	if( err != 0 )
	{
		fprintf( stderr, "Cannot open debug print file '%s'\n", DEBUGFILE );
		FpDebug = stderr;
	}
	fprintf(FpDebug, "FpDebug: Width = %d ; Height = %d\n", Width, Height);

	Reset( );
	InitGraphics( );

	// loop until the user closes the window:

	while( glfwWindowShouldClose( MainWindow ) == 0 )
	{
		glfwPollEvents( );
		Time = glfwGetTime( );		// elapsed time, in double-precision seconds
		UpdateScene( );
		RenderScene( );
	}

	fprintf(FpDebug, "Closing the GLFW window\n");

	vkQueueWaitIdle( Queue );
	vkDeviceWaitIdle( LogicalDevice );
	DestroyAllVulkan( );
	glfwDestroyWindow( MainWindow );
	glfwTerminate( );
	return 0;
}
```

Loop

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InitGraphics( ), I

```
void
InitGraphics( )
{
	HERE_I_AM( "InitGraphics" );

	VkResult result = VK_SUCCESS;

	Init01Instance( );

	InitGLFW( );

	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 );

	Init06CommandPool( );
	Init06CommandBuffers( );
```

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InitGraphics( ), II

```
	Init07TextureSampler( &MyPuppyTexture.texSampler );
	Init07TextureBufferAndFillFromBmpFile("puppy.bmp", &MyPuppyTexture);

	Init08Swapchain( );

	Init09DepthStencilImage( );

	Init10RenderPasses( );

	Init11Framebuffers( );

	Init12SpirvShader( "sample-vert.spv", &ShaderModuleVertex );
	Init12SpirvShader( "sample-frag.spv", &ShaderModuleFragment );

	Init13DescriptorSetPool( );
	Init13DescriptorSetLayouts();
	Init13DescriptorSets( );

	Init14GraphicsVertexFragmentPipeline( ShaderModuleVertex, ShaderModuleFragment,
					VK_PRIMITIVE_TOPOLOGY_TRIANGLE_LIST, &GraphicsPipeline );
}
```

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A Colored Cube

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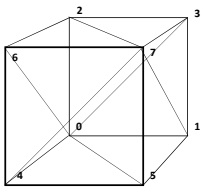

```
static GLfloat CubeColors[ ][3] =
{
        { 0., 0., 0. },
        { 1., 0., 0. },
        { 0., 1., 0. },
        { 1., 1., 0. },
        { 0., 0., 1. },
        { 1., 0., 1. },
        { 0., 1., 1. },
        { 1., 1., 1. },
};
```

```
static GLfloat CubeVertices[ ][3] =
{
        { -1., -1., -1. },
        {  1., -1., -1. },
        { -1.,  1., -1. },
        {  1.,  1., -1. },
        { -1., -1.,  1. },
        {  1., -1.,  1. },
        { -1.,  1.,  1. },
        {  1.,  1.,  1. }
};
```

```
static GLuint CubeTriangleIndices[ ][3] =
{
        { 0, 2, 3 },
        { 0, 3, 1 },
        { 4, 5, 7 },
        { 4, 7, 6 },
        { 1, 3, 7 },
        { 1, 7, 5 },
        { 0, 4, 6 },
        { 0, 6, 2 },
        { 2, 6, 7 },
        { 2, 7, 3 },
        { 0, 1, 5 },
        { 0, 5, 4 }
};
```

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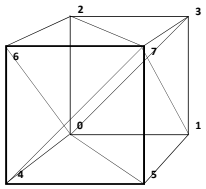
```
struct vertex
{
        glm::vec3       position;
        glm::vec3       normal;
        glm::vec3       color;
        glm::vec2       texCoord;
};

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:
        {
                {  1.,  1., -1. },
                {  0.,  0., -1. },
                {  1.,  1.,  0. },
                {  0.,  1. }
        },
```



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The Vertex Data is in a Separate File

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#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. }
        },
. . .
```

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

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

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.

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Vulkan Software Philosophy

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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 typedef'ed 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);

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Vulkan Conventions

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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 InitxxYYY( ) 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 pointer (address) arguments are just there to let you know how a pointer is used by the function. Otherwise, they have no significance.

```
#define    IN
#define    OUT
```

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Querying the Number of Something and Allocating Structures to Hold Them All

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

VkPhysicalDevice * physicalDevices = new VkPhysicalDevice[ count ];
result = vkEnumeratePhysicalDevices( Instance, OUT &count, OUT physicalDevices );
```

2 calls

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

How many total there are — Where to put them

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

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


Your Sample2017.zip File Contains This

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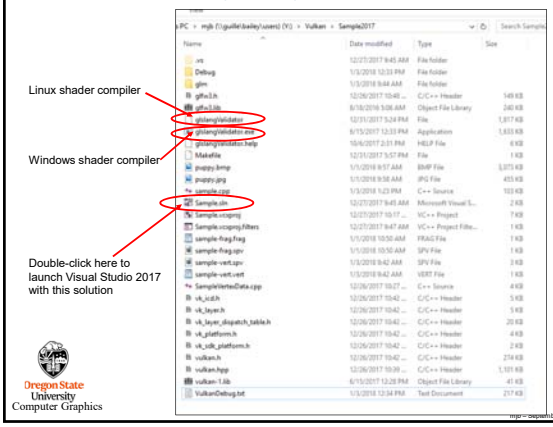

Reporting Error Results, I

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```
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,		"Error Out of Date"		},
	{ VK_ERROR_INCOMPATIBLE_DISPLAY_KHR,	"Incompatible Display"		},
	{ VK_ERROR_VALIDATION_FAILED_EXT,	"Valuidation Failed"		},
	{ VK_ERROR_INVALID_SHADER_NV,		"Invalid Shader"		},
	{ VK_ERROR_OUT_OF_POOL_MEMORY_KHR,	"Out of Pool Memory"		},
	{ VK_ERROR_INVALID_EXTERNAL_HANDLE_KHX,	"Invalid External Handle"	},
};
```


Reporting Error Results, II

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```
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, "\n%s: %s\n", prefix.c_str(), meaning.c_str() );
	fflush(FpDebug);
}
```


Extras in the Code

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```
#define REPORT(s)		PrintVkError( result, s );  fflush(FpDebug);


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

bool		Paused;

bool		Verbose;



#define DEBUGFILE		"VulkanDebug.txt"

errno_t err = fopen_s( &FpDebug, DEBUGFILE, "w" );
```