VkRunner

A simple shader script tester for Vulkan ®

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Overview

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- History
- Examples
- Current status
- Future
- Questions

Introduction

What is VkRunner?

- Tool to test shaders on your Vulkan driver
- Inspired by Piglit’s shader_runner
- Minimal overhead to execute a script
- Just write the scripts and some simple commands to execute them
- Standalone tool, runs the script and reports status

Example

```
[vertex shader passthrough]

[fragment shader]
#version 450

layout(location = 0) out vec4 color_out;

void
main()
{
        color_out = vec4(0.0, 1.0, 0.0, 1.0);
}

[test]
# Fill the framebuffer with the output from the shader
draw rect -1 -1 2 2
# Check that we got the colour we wanted
probe all rgba 1.0 0.0 0.0 1.0
```

Example

```
$ vkrunner ./simple-example.shader_test
Command failed at line 18
Probe color at (0,0)
  Expected: 1.000000 0.000000 0.000000 1.000000
  Observed: 0.000000 1.000000 0.000000 1.000000
PIGLIT: {"result": "fail" }
```

Behind the scenes

- Compiles the shader to SPIR-V by invoking glslang as an external process.
- Creates pipelines for the state for each draw command.
- Creates an offscreen framebuffer (no window system support).
- Puts test commands into a command buffer and executes it.
- Probes result.

History

ARB_gl_spirv

- VkRunner was created during Igalia’s work to add support for ARB_gl_spirv to the i965 driver in Mesa.
- ARB_gl_spirv uses the same compiler as Intel’s Vulkan driver.
- We were testing this with an adaptation of Piglit’s shader_runner.

- shader_runner is the same principle as VkRunner.
- Tested ARB_gl_spirv by automatically converting existing shader_runner tests to SPIR-V.
- Piglit has many many tests.
- This ended up testing more of the Intel SPIR-V compiler than was tested with existing Vulkan tests.
- We wanted a quick way to verify whether test failures were specific to SPIR-V on OpenGL or also happen with Vulkan.

- shader_runner tests can be converted to VkRunner with minimal changes.
- However there are differences because of how Vulkan works.
- For GL, shader_runner can use the API to query properties of the shader such as the uniform names.
- This isn’t available in Vulkan.
- Instead we use explicit offsets to set uniforms and SSBOs.

shader_runner example

```
[require]
GL >= 4.3
GLSL >= 4.30

[vertex shader passthrough]

[fragment shader]
#version 430

uniform vec4 color;
uniform float multiplier;
layout(location = 0) out vec4 color_out;

void
main()
{
        color_out = color * multiplier;
}

[test]
uniform vec4 color 0.5 0.25 0.5 1.0
uniform float multiplier 0.5
draw rect -1 -1 2 2
probe all rgb 0.25 0.125 0.25
```

shader_runner example

```
[require]
GL >= 4.3
GLSL >= 4.30

[vertex shader passthrough]

[fragment shader]
#version 430

uniform vec4 color;
uniform float multiplier;
layout(location = 0) out vec4 color_out;

void
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{
        color_out = color * multiplier;
}

[test]
uniform vec4 color 0.5 0.25 0.5 1.0
uniform float multiplier 0.5
draw rect -1 -1 2 2
probe all rgb 0.25 0.125 0.25
```

global named uniform

shader_runner example

```
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GLSL >= 4.30

[vertex shader passthrough]

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#version 430

uniform vec4 color;
uniform float multiplier;
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main()
{
        color_out = color * multiplier;
}

[test]
uniform vec4 color 0.5 0.25 0.5 1.0
uniform float multiplier 0.5
draw rect -1 -1 2 2
probe all rgb 0.25 0.125 0.25
```

set uniform by name

VkRunner equivalent

```
[vertex shader passthrough]

[fragment shader]
#version 430

layout(push_constant) uniform block {
        vec4 color;
        float multiplier;
};
layout(location = 0) out vec4 color_out;

void
main()
{
        color_out = color * multiplier;
}

[test]
# Set color
uniform vec4 0    0.5 0.25 0.5 1.0
# Set multiplier
uniform float 16    0.5
draw rect -1 -1 2 2
probe all rgb 0.25 0.125 0.25
```

VkRunner equivalent

```
[vertex shader passthrough]

[fragment shader]
#version 430

layout(push_constant) uniform block {
        vec4 color;
        float multiplier;
};
layout(location = 0) out vec4 color_out;

void
main()
{
        color_out = color * multiplier;
}

[test]
# Set color
uniform vec4 0    0.5 0.25 0.5 1.0
# Set multiplier
uniform float 16    0.5
draw rect -1 -1 2 2
probe all rgb 0.25 0.125 0.25
```

no global uniforms
need to use something else
eg, push constants

VkRunner equivalent

```
[vertex shader passthrough]

[fragment shader]
#version 430

layout(push_constant) uniform block {
        vec4 color;
        float multiplier;
};
layout(location = 0) out vec4 color_out;

void
main()
{
        color_out = color * multiplier;
}

[test]
# Set color
uniform vec4 0    0.5 0.25 0.5 1.0
# Set multiplier
uniform float 16    0.5
draw rect -1 -1 2 2
probe all rgb 0.25 0.125 0.25
```

set uniform by byte offset

Some improvements over shader_runner

- shader_runner code grown organically over time. Lives in a single large C file.
- VkRunner code written from scratch with the benefit of hindsight.
- Tries to partially automatically generate commands.
  - Systematic method for setting pipeline properties.
  - Try to support all formats for vertex data and framebuffer.

Examples

Vertex data

```
[vertex data]
# Position      Colour
0/R32G32_SFLOAT 1/A8B8G8R8_UNORM_PACK32

0.4   -0.4      0xff00a0ff
0.7   -0.7      0xff00a0ff
0.4   0.4       0xff00a0ff
0.7   0.7       0xff00a0ff

0.4    0.4      0xff0000ff
0.7    0.7      0xff0000ff
-0.4   0.4      0xff0000ff
-0.7   0.7      0xff0000ff

-0.4   0.4      0xff00ff00
-0.7   0.7      0xff00ff00
-0.4   -0.4     0xff00ff00
-0.7   -0.7     0xff00ff00

0.4    -0.4     0xffff0000
0.7    -0.7     0xffff0000
-0.4   -0.4     0xffff0000
-0.7   -0.7     0xffff0000
```

Vertex data

location

```
[vertex data]
# Position      Colour
0/R32G32_SFLOAT 1/A8B8G8R8_UNORM_PACK32

0.4   -0.4      0xff00a0ff
0.7   -0.7      0xff00a0ff
0.4   0.4       0xff00a0ff
0.7   0.7       0xff00a0ff

0.4    0.4      0xff0000ff
0.7    0.7      0xff0000ff
-0.4   0.4      0xff0000ff
-0.7   0.7      0xff0000ff

-0.4   0.4      0xff00ff00
-0.7   0.7      0xff00ff00
-0.4   -0.4     0xff00ff00
-0.7   -0.7     0xff00ff00

0.4    -0.4     0xffff0000
0.7    -0.7     0xffff0000
-0.4   -0.4     0xffff0000
-0.7   -0.7     0xffff0000
```

Vertex data

```
[vertex data]
# Position      Colour
0/R32G32_SFLOAT 1/A8B8G8R8_UNORM_PACK32

0.4   -0.4      0xff00a0ff
0.7   -0.7      0xff00a0ff
0.4   0.4       0xff00a0ff
0.7   0.7       0xff00a0ff

0.4    0.4      0xff0000ff
0.7    0.7      0xff0000ff
-0.4   0.4      0xff0000ff
-0.7   0.7      0xff0000ff

-0.4   0.4      0xff00ff00
-0.7   0.7      0xff00ff00
-0.4   -0.4     0xff00ff00
-0.7   -0.7     0xff00ff00

0.4    -0.4     0xffff0000
0.7    -0.7     0xffff0000
-0.4   -0.4     0xffff0000
-0.7   -0.7     0xffff0000
```

format names from Vulkan enums

Vertex data

```
[vertex shader]
#version 450

layout(location = 0) in vec2 position;
layout(location = 1) in vec3 color_in;

layout(location = 0) out vec3 color_out;

void
main()
{
	gl_Position = vec4(position, 0.0, 1.0);
	color_out = color_in;
}
```

[vertex data] specifes inputs for these

Indices

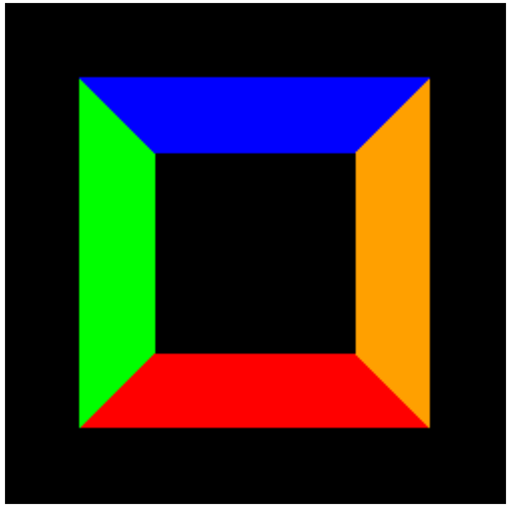
```
[indices]
0 1 2 3     65535
4 5 6 7     65535
8 9 10 11   65535
12 13 14 15 65535
```

Draw command

```
primitiveRestartEnable true

draw arrays indexed TRIANGLE_STRIP 0 20
```

Vertex data

```
[vertex shader]
#version 450

layout(location = 0) in vec2 position;
layout(location = 1) in vec3 color_in;
layout(location = 0) out vec3 color_out;

void
main()
{
        gl_Position = vec4(position, 0.0, 1.0);
        color_out = color_in;
}

[fragment shader]
#version 450

layout(location = 0) in vec3 color_in;
layout(location = 0) out vec4 color_out;

void
main()
{
        color_out = vec4(color_in, 1.0);
}

[vertex data]
# Position      Colour
0/R32G32_SFLOAT 1/A8B8G8R8_UNORM_PACK32

0.4   -0.4      0xff00a0ff
0.7   -0.7      0xff00a0ff
0.4   0.4       0xff00a0ff
0.7   0.7       0xff00a0ff

0.4    0.4      0xff0000ff
0.7    0.7      0xff0000ff
-0.4   0.4      0xff0000ff
-0.7   0.7      0xff0000ff

-0.4   0.4      0xff00ff00
-0.7   0.7      0xff00ff00
-0.4   -0.4     0xff00ff00
-0.7   -0.7     0xff00ff00

0.4    -0.4     0xffff0000
0.7    -0.7     0xffff0000
-0.4   -0.4     0xffff0000
-0.7   -0.7     0xffff0000

[indices]
0 1 2 3     65535
4 5 6 7     65535
8 9 10 11   65535
12 13 14 15 65535

[test]
clear

primitiveRestartEnable true

draw arrays indexed TRIANGLE_STRIP 0 20
```



Requires section

```
[require]
# Require an extension for the test to pass
VK_KHR_8bit_storage

# Change the framebuffer format
framebuffer R32_SFLOAT
fbsize 1024 768

# Require an optional Vulkan feature
shaderInt16
```

Compute shader

```
[compute shader]
#version 450

layout(binding = 0) buffer block {
        float values[];
};

void
main()
{
        // Calculate some square roots
        values[gl_WorkGroupID.x] = sqrt(gl_WorkGroupID.x);
}

[test]
ssbo 0 4096

# Run the compute shader
compute 1024 1 1

# Probe a few points in the buffer
probe ssbo float 0 0 ~= 0    1.0 1.4142 1.7320 2.0
probe ssbo float 0 2304 ~=   24.0
```

SPIR-V source

```
[fragment shader spirv]
               OpCapability Shader
          %1 = OpExtInstImport "GLSL.std.450"
               OpMemoryModel Logical GLSL450
               OpEntryPoint Fragment %main "main" %color
               OpExecutionMode %main OriginUpperLeft
               OpSource GLSL 450
               OpDecorate %color Location 0
       %void = OpTypeVoid
          %3 = OpTypeFunction %void
      %float = OpTypeFloat 32
%_ptr_Output_float = OpTypePointer Output %float
      %color = OpVariable %_ptr_Output_float Output
    %float_1 = OpConstant %float 1
       %main = OpFunction %void None %3
          %5 = OpLabel
               OpStore %color %float_1
               OpReturn
               OpFunctionEnd
```

Binary source

- Script available to precompile scripts to binary format

```
./precompile-script.py -o precompiled *.shader_test
vkrunner precompiled/*.shader_test
```

- Useful for running on devices where running the compiler isn’t practical.

Binary source

```
[require]
framebuffer R32_SFLOAT

[vertex shader passthrough]

[fragment shader binary]
7230203 10000 70000 a 0 20011 1 6000b 1 4c534c47 6474732e
3035342e 0 3000e 0 1 6000f 4 2 6e69616d 0 3 30010 2 7 30003
2 1c2 40047 3 1e 0 20013 4 30021 5 4 30016 6 20 40020 7 3 6
4003b 7 3 3 4002b 6 8 3f800000 50036 4 2 0 5 200f8 9 3003e 3
8 100fd 10038

[test]
clear

draw rect -1 -1 2 2

probe all rgb 1 0 0
```

Current status

Features

- All shader stages
- UBOs/SSBOs
- Vertex data, simple drawing
- Probing the framebuffer or SSBOs

Library version

```c
#include <stdio.h>

#include <vkrunner/vkrunner.h>

int
main(int argc, char **argv)
{
    struct vr_source *source =
        vr_source_from_file("simple-example.shader_test");

    struct vr_config *config = vr_config_new();
    struct vr_executor *executor = vr_executor_new(config);

    enum vr_result result = vr_executor_execute(executor, source);

    vr_executor_free(executor);
    vr_config_free(config);

    vr_source_free(source);

    return result == VR_RESULT_FAIL ? EXIT_FAILURE : EXIT_SUCCESS;
}
```

Integration

- Integrated into Khronos Vulkan CTS
  - Currently only experimental tests
  - Uses VkRunner’s API

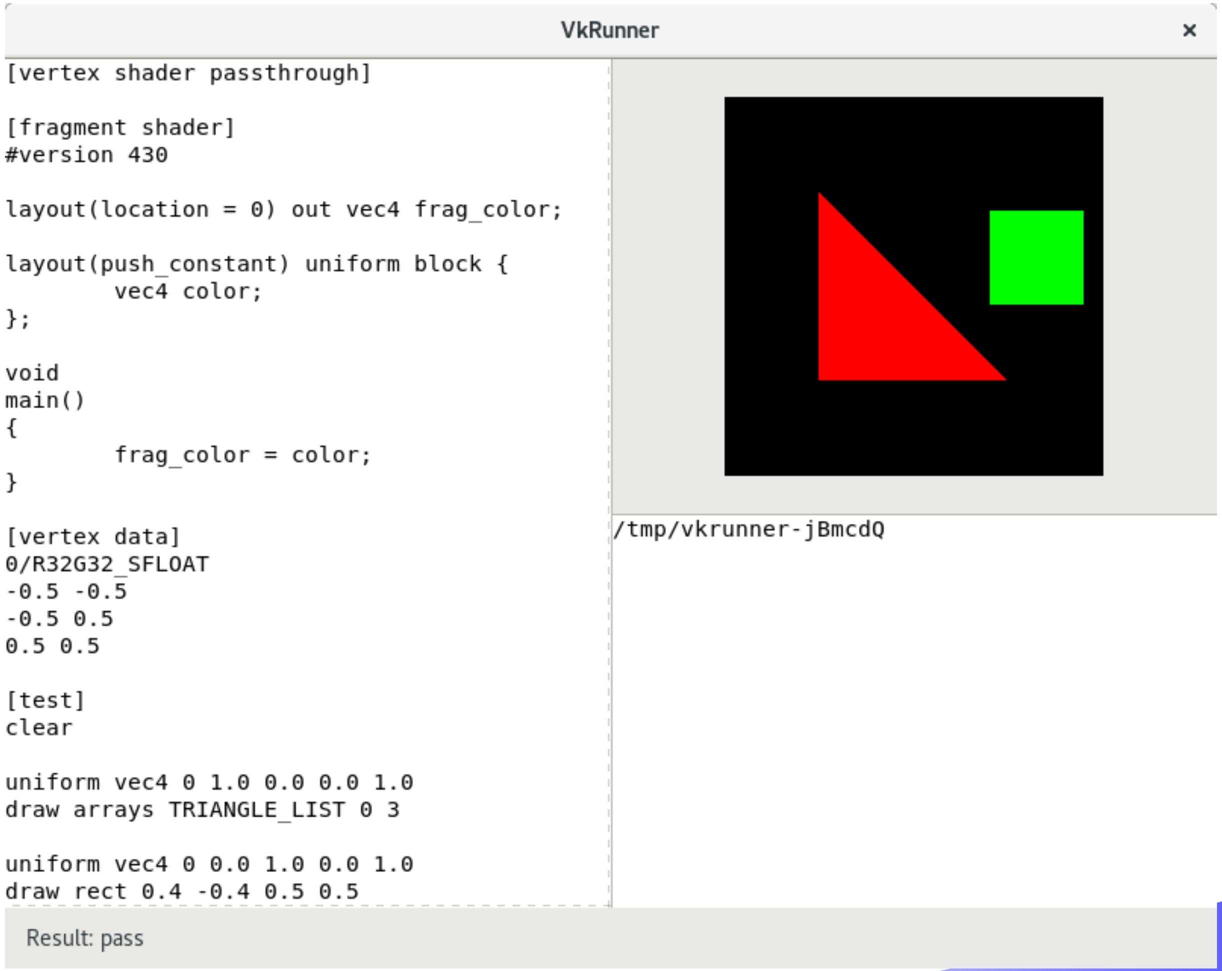
- Integrated into Piglit
  - Has real tests
  - Runs on Intel’s CI

Future

Missing features

- Image / texture support
    - Although there is a pull request for this
- Arrays of buffer bindings
- Probably a lot of other things

User Interface


VkRunner

```
[vertex shader passthrough]

[fragment shader]
#version 430

layout(location = 0) out vec4 frag_color;

layout(push_constant) uniform block {
        vec4 color;
};

void
main()
{
        frag_color = color;
}

[vertex data]
0/R32G32_SFLOAT
-0.5 -0.5
-0.5 0.5
0.5 0.5

[test]
clear

uniform vec4 0 1.0 0.0 0.0 1.0
draw arrays TRIANGLE_LIST 0 3

uniform vec4 0 0.0 1.0 0.0 1.0
draw rect 0.4 -0.4 0.5 0.5
```

```
/tmp/vkrunner-jBmcdQ
```

Result: pass

Video?

- There’s a branch for making animations.
- Adds a magic uniform to specify the frame number.
- Can be used like an offline version of shadertoy

Amber

- Google are working on a similar tool.
- Can use the same scripting format as VkRunner.
- Yet to see which where it will lead.

github.com/Igalia/vkrunner

Questions?