## Staging buffer;Transform queue

finish

## Staging buffer;mangae memory buffer

You can either implement such an allocator yourself, or use the [VulkanMemoryAllocator](https://github.com/GPUOpen-LibrariesAndSDKs/VulkanMemoryAllocator) library provided by the GPUOpen initiative. However, for this tutorial it's okay to use a separate allocation for every resource, because we won't come close to hitting any of these limits for now.

## Index buffer；go further in managing memory buffer

**Buffer Packing 目前将indexbuffer和vertexbuffer合并使用**

**Memory Aliasing**

The previous chapter already mentioned that you should allocate multiple resources like buffers from a single memory allocation, but in fact you should go a step further. [Driver developers recommend](https://developer.nvidia.com/vulkan-memory-management) that you also store multiple buffers, like the vertex and index buffer, into a single [VkBuffer](https://www.khronos.org/registry/vulkan/specs/1.0/man/html/VkBuffer.html) and use offsets in commands like [vkCmdBindVertexBuffers](https://www.khronos.org/registry/vulkan/specs/1.0/man/html/vkCmdBindVertexBuffers.html). The advantage is that your data is more cache friendly in that case, because it's closer together. It is even possible to reuse the same chunk of memory for multiple resources if they are not used during the same render operations, provided that their data is refreshed, of course. This is known as *aliasing* and some Vulkan functions have explicit flags to specify that you want to do this.

在前一个章节的基础上修改为四个顶点（注意背面剔除）

利用inputAssembly.topology = VK\_PRIMITIVE\_TOPOLOGY\_TRIANGLE\_STRIP;的效果



## [Descriptor pool and sets](https://docs.vulkan.org/tutorial/latest/05_Uniform_buffers/01_Descriptor_pool_and_sets.html)

**Alignment requirements**

## [Images](https://docs.vulkan.org/tutorial/latest/06_Texture_mapping/00_Images.html)

这里在 createTextureImage 函数内，将 graphicsQueue 和 transferQueue 分开使用，因为前面提前单独检测是否有transfer函数

**See**[**the documentation**](https://www.khronos.org/registry/vulkan/specs/1.3-extensions/html/chap7.html#VkPipelineStageFlagBits)**for more information and other examples of pseudo-stages.**

**setupCommandBuffer**

All of the helper functions that submit commands so far have been set up to execute synchronously by waiting for the queue to become idle. For practical applications it is recommended to combine these operations in a single command buffer and execute them asynchronously for higher throughput, especially the transitions and copy in the createTextureImage function. Try to experiment with this by creating a setupCommandBuffer that the helper functions record commands into, and add a flushSetupCommands to execute the commands that have been recorded so far. It’s best to do this after the texture mapping works to check if the texture resources are still set up correctly.

**textureImage 与 textureImageMemory 的关系：**

* **textureImage (VkImage)**:
* 这只是一个**逻辑上的图像对象句柄**。它定义了图像的格式、尺寸、用途（例如，用作纹理），但它**本身不包含任何像素数据**。
* 你可以把它想象成一个“纹理的规格说明书”。
* **textureImageMemory (VkDeviceMemory)**:
* 这是真正**分配在 GPU 上的物理内存块**。这块内存就是用来存储 textureImage 的**实际像素数据**的地方。
* 你可以把它想象成一个“存储像素数据的箱子”。
* **关系：** 你通过 vkCreateImage 创建 textureImage 这个“规格说明书”，然后通过 vkAllocateMemory 分配 textureImageMemory 这个“箱子”，最后通过 vkBindImageMemory 把这个“规格说明书”和“箱子”**连接起来**。应用程序完全掌控 VkImage 和 VkDeviceMemory 的生命周期和数据传输。

**swapChain 链式组件的关系：**

* **swapChain (VkSwapchainKHR)**:
* 这是 Vulkan 提供的一个**高级抽象对象**，它负责与底层的**窗口系统**（如 Windows、Linux X11/Wayland）进行交互，管理用于**屏幕呈现**的一组图像。
* 它不是直接存储像素数据，而是**管理着一系列可以显示在屏幕上的图像**。
* **swapChainImages (std::vector<VkImage>)**:
* 当 swapChain 创建时，Vulkan 驱动和窗口系统会**自动在内部创建和管理**若干个 VkImage 对象（通常是双缓冲或三缓冲）。
* swapChainImages 向量里存储的，就是这些由 swapChain **拥有并管理的 VkImage 的句柄**。你只是获取这些句柄来引用它们，但你**不负责这些 VkImage 底层内存的分配和绑定**。这些都是由 swapChain 内部处理的，因为它们是用于呈现的特殊图像。
* 这些 VkImage 才是真正用于承载渲染结果的像素数据。
* **swapChainImageViews (std::vector<VkImageView>)**:
* VkImage 是原始的内存块，GPU 管线不能直接使用它。你需要一个 **VkImageView 来定义如何“看待”和访问**这个 VkImage。
* 每个 swapChainImageViews[i] 都是为 swapChainImages[i] 创建的**一个“视图”**。这个视图定义了图像的类型（2D 纹理）、格式、哪些层和 Mipmap 级别是可见的等等。
* GPU 在渲染时，是通过 ImageView 来访问 Image 中的像素数据的。
* **swapChainFramebuffers (std::vector<VkFramebuffer>)**:
* VkFramebuffer 是一个**渲染目标的集合**，它将一个或多个 VkImageView（例如，一个颜色附件 ImageView，一个深度附件 ImageView）组合在一起，作为 Render Pass 的实际渲染目标。
* 每个 swapChainFramebuffers[i] 都是将对应的 swapChainImageViews[i] 绑定到你的 Render Pass 上。当你在命令缓冲区中开始一个 Render Pass 时，你指定要渲染到哪个 Framebuffer，从而间接指定了渲染结果应该写入哪个 swapChainImage。

**为什么不一样？ (核心原因)**

关键在于**所有权和职责分工**：

1. **普通纹理 (e.g., textureImage)：**

* 所有权在你应用程序手里。你需要完全控制内存的分配、绑定、数据上传和生命周期管理。
* 所以你需要显式地 vkCreateImage (逻辑对象) 和 vkAllocateMemory/vkBindImageMemory (物理存储)。

1. **交换链图像 (e.g., swapChainImages)：**

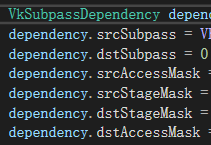
* 所有权在 Vulkan 驱动和底层窗口系统手里。这些图像是专门用于“呈现”的，它们的内存管理和同步机制非常特殊，需要与操作系统显示服务器紧密配合。
* 作为应用程序开发者，你**不需要关心这些图像的底层内存是如何分配和绑定的**，VkSwapchainKHR 会为你处理。你只获取到这些图像的句柄 (VkImage)，然后为它们创建**视图** (VkImageView)，再将视图组织成**帧缓冲** (VkFramebuffer)，供渲染管线使用。

## Combined image sampler

It is possible to **use texture sampling in the vertex shader**, for example to dynamically deform a grid of vertices by a [heightmap](https://en.wikipedia.org/wiki/Heightmap).

## Depth buffering

对于不透明的物体，深度测试是最佳选择。只有在处理透明物体时，才需要考虑使用从后到前的排序方法

这个的作用是什么

## Generating Mipmaps

Beware if you are using a **dedicated transfer queue** (as suggested in [Vertex buffers](https://vulkan-tutorial.com/Vertex_buffers/Staging_buffer)): [vkCmdBlitImage](https://www.khronos.org/registry/vulkan/specs/1.0/man/html/vkCmdBlitImage.html) must be submitted to a **queue with graphics capability.完成**

There are two alternatives in this case. You could implement a function that searches common texture image formats for one that *does* support linear blitting, or you could implement the mipmap generation in software with a library like [stb\_image\_resize](https://github.com/nothings/stb/blob/master/stb_image_resize.h). Each mip level can then be loaded into the image in the same way that you loaded the original image.

It should be noted that it is uncommon in practice to generate the mipmap levels at runtime anyway. Usually they are pregenerated and stored in the texture file alongside the base level to improve loading speed. **Implementing resizing in software and loading multiple levels from a file is left as an exercise to the reader.**