CS 5330 Week 7 Homework

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Questions

1. **What makes the bi-illuminant dichromatic reflection model different from the standard dichromatic reflection model.**

Answer:

In simple terms, the standard dichromatic reflection model assumes that there is only one light source in the scene, and all lighting effects - whether it is the inherent diffuse reflection of the object or the specular reflection (highlight part) - come from this single light source. The bi-illuminant dichromatic reflection model is not so simple. It assumes that there are two different light sources in the scene, each with its own unique spectral characteristics.

For example, in real life, you may encounter a situation where one area is illuminated by indoor lights and the other part is affected by natural light outside the window. The standard model can only be described by one light source, while the bi-illuminant model can consider the contribution of these two light sources separately, thereby more accurately explaining the color changes of objects.

In short, the bi-illuminant model is based on the standard model and adds the concept of "dual light sources", so that we can better restore the true color and reflection characteristics of objects when dealing with complex lighting conditions (such as mixed light source environments).

2. **Why is it challenging to make use of the idea of log space chromaticity?**

Answer:

In short, log space chromaticity can theoretically help us eliminate the impact of lighting changes and make color analysis more stable, but in practice, it encounters many troubles:

Numerical instability: When the pixel value is particularly low, taking the logarithm will amplify the noise, resulting in unreliable results.

Zero value problem: When the pixel value is zero or close to zero, the log function will have problems because log(0) is not defined at all.

Reduced intuitiveness: After converting to log space, the original intuitive color relationship may become complicated and not easy to directly explain and process.

So, although log space chromaticity has advantages in theory, in practical applications, how to safely deal with noise, low values and zero values makes the use of this method quite challenging.

3. **Why do we use projective coordinates when modeling the relationship between the 3-D world and a 2-D image of it?**

***Answer*:**

In layman's terms, the main reason for using projection coordinates is that it allows us to convert complex perspective projection processes into simple linear operations. The traditional three-dimensional to two-dimensional mapping is actually nonlinear, but using projection (that is, homogeneous coordinates) can use a matrix to represent this mapping, which is easier to handle mathematically. In addition, it can also conveniently represent some special cases, such as infinite points in the distance, which is very helpful for understanding and calculating camera models. So, in general, projection coordinates make it simple and unified for us to simulate the changes in perspective when a camera shoots a scene in reality.

4. **What do the extrinsic parameters of a camera specify?**

***Answer*:**

Simply put, the camera's external parameters describe the "position" and "direction" of the camera in the three-dimensional world. In other words, it tells us where the camera is and how it looks at the scene. It's like you're standing in a place taking a photo, and the external parameters are like recording where you're standing and the direction you're facing, which is very important for correctly mapping the three-dimensional scene to the two-dimensional image.

5. **What do the intrinsic parameters of a camera specify?**

Answer:

Intrinsic parameters describe the camera’s internal characteristics—basically, they’re like the camera’s “settings” that determine how it turns the 3-D world into a 2-D image. This includes things like the focal length (which affects the zoom and field of view), the principal point (the center of the image sensor), and any factors related to the shape and size of the pixels. These parameters are all about how the camera itself captures and processes light, independent of its position or orientation in the world.

6. **What are the four coordinate systems we use for developing the camera calibration matrix? Give a few sentences on each that show your own understanding of them.**

Answer:

There are four main coordinate systems used here to connect the 3D world to the 2D image, and each coordinate system plays a different role:

World Coordinate System

This coordinate system describes the scene in reality, and the positions of all objects are defined here. Think of it as a "big map" that you use to mark the objects in the scene. The origin can be chosen arbitrarily, usually at a convenient reference point.

Camera Coordinate System

When we look at the world from the perspective of a camera, we enter the camera coordinate system. The camera is located at the origin of this coordinate system, and the z-axis usually points in front of the camera. This allows points in the world to be converted into points in the camera's eyes, which is convenient for subsequent processing.

Image Coordinate System

Next, the 3D points are projected onto a two-dimensional plane through perspective projection, which is the image plane. The image coordinate system describes the points on this plane, usually expressed in continuous units (such as millimeters), which is an idealized projection model.

Pixel Coordinate System

Finally, digital cameras actually capture discrete pixels, not continuous images. So we transform the image coordinate system into the pixel coordinate system, taking into account the size of each pixel and the offset on the sensor, to accurately describe the location of each pixel in the image.

Together, these four coordinate systems form the basis of the camera calibration matrix, helping us systematically transform the 3D information of the real world into the 2D image captured by the camera.