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HW 2 **Due Date: August 11th, 2023**

Each question is 3 points, be brief in your answers.

1) Identify three different types/classes of information or objects that can be used as markers in marker-based augmented reality?
Ans:

Three different types/classes of markers commonly used in marker-based AR:

1. **Image Markers:** These markers are pre-defined 2D images with distinct patterns or features that the AR system can identify. When the AR system's camera detects and recognizes the image marker, it triggers a corresponding virtual object or content to appear in the AR experience. These markers are commonly used in printed materials, like magazines, posters, and packaging.

2.**QR Codes:** QR (Quick Response) codes are a type of 2D barcode that can be quickly scanned by a smartphone or AR device's camera. In AR applications, when a QR code is scanned, it can lead to the display of relevant augmented content, such as product information, videos, or interactive experiences.

3.**Object Markers:** Object markers involve using physical 3D objects as triggers for AR content. These objects can be recognized by the AR system based on their shape, texture, or unique features. When the system detects the object marker through its camera, it overlays digital content onto or around the physical object.

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2) Consider a person with high eyesight power who loses ability to distinguish stripes at 40 cycles per degree. Suppose this person wears a VR headset, in which the VR lens is at 5 cm distance from the screen. Let the lens focal distance be 5 cm. What is the minimum PPI (Pixel Per Inch) for this person so that this person does not perceive individual pixels?
Ans:

Given:
40 cycles per degrees = 80 pixels per degree

Distance between the VR lens and screen = 5 cm = 1.9685 inches
Focal distance of lens = 5 cm = 1.9685 inches

Therefore, Height of the object (s) = $d\ tan\theta$
Where d = Distance between the VR lens and screen or Focal distance of lens
θ = 1 radian (the smallest degree)
s = 1. 9685 (tan 1) = 0. 03431

PPI = $no\ of\ pixels\ per\ degree$ ÷ 0. 03431
PPI = 80/0. 03431 = 2331. 681 $pixels\ per\ inch$
Thus, minimum PPI is 2331.681 PPI

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3) Consider a user in VR world who is fixating on a virtual object while rotating (e.g., yawing) his head. Consider a VR display with 60 FPS (frame per second) and let the display keep the image fixed until a new frame is scanned out on the display. What happens to the user's perception of the virtual object? If there are any problems, propose methods to improve the user experience.

Ans:

The virtual object slides under the retina and is fixed for 16.67 milliseconds when the user rotates their head while using a VR display at 60 frames per second. The image display can be fixed for 2ms, then turned off, to resolve this issue. Low persistence is the result of the eye's photoreceptors being able to capture the image and the brain perceives the image. Flickering begins at a low persistence of 60 FPS, but this problem can also be solved by raising the frame rate to 90 FPS. By implementing these improvements, the user can have a good experience.

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4) Where is the virtual world generator (VWG) typically located in a VR system? How does using simpler object models (e.g., using objects with less triangles) help the virtual world generator?

Ans:

The maintenance of the virtual world simulation is the primary responsibility of VWG. In addition to accelerating rendering, a simplified model will place less of a computational load on the Virtual World Generator. For dynamic worlds, the VWG maintains a virtual world simulation that moves all geometric bodies while following physical laws that accurately reflect the real world. It needs to be capable of handling the movements of avatars, falling objects, moving objects, swaying trees, and other motions. By using simpler models, VWG would be able to update the objects much more quickly and contribute to enhancing the user experience.

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5) Describe the "post rendering image warp" method. Under what conditions black pixels appear on screen? Suggest a method to combat black pixels.

<u>Ans:</u>

Post rendering image warp is the transformation adjustment that is performed in an image as needed before display, caused due to both latency and prediction error. It is done by rendering an image larger than the targeted display and when there is an error in prediction, the correct image is displayed by shifting the image relevant to the user viewpoint. Although this method overcomes prediction errors but when there are too many errors and a large rendered image is not enough to compensate for those errors, we see black pixels on screen as there is no rasterized data to use. These black pixels generally appear on the sides of the screen, and we can combat black pixels by repeating the pixels from the rendered image edge.
