Questions

1. Suppose that for some particular stimulus, Panum’s fusional area in dioptors is ±0.1, namely 0.1 diopters in front of and behind the Vieth-Mueller circle. What is the range of depths within the fusional area if the eyes are converged on distance \( Z \) of (a) 10 m, (b) 2 m (c) 0.5 m.

2. In the lecture I briefly discussed Panum’s fusional area which refers to a maximum disparity value for the human visual system to fuse the left and right images i.e. to avoid diplopia. It turns out there several factors that determine this maximum, not just the disparity values themselves. For example, for an object of image width \( w \), the disparity must be less than \( w \) for the visual system to fuse that object.

    Give a sketch in \((x_l, x_r)\) space of two objects of the same visual angle such that one and only one of them is too wide (relative to disparity) to be fused.

3. (a) In the lecture, I showed an example of a square in front of a background and drew the scene in “disparity space” \((x_l, x_r)\).

    Consider a sphere in front of a background, shown on the left below. Some points in the scene are visible to both left and right eye. Some points visible to just one eye. Some are visible to neither eye.

    Draw the sphere and background points in \((x_{left}, x_{right})\) space, and label which points are visible to left and right eye.

    (b) If we shrink the sphere, then there will be points “directly behind” the sphere which are now visible to both eyes. (See below right.) For example, I have marked a point \( b \) on the background surface, which is visible to both eyes.

    Note the point \( s \) on the sphere which is visible to both eyes, and note that \( b \) and \( s \) are in the opposite order in the two eyes, \( x_l(s) > x_l(b) \), but \( x_r(s) < x_r(b) \). The human visual system is not able to solve the correspondence problem for such points. Such points generate “double vision” or diplopia.

    Draw a disparity space image of this situation and mark the two points \( b \) and \( s \).
4. Neurons with small receptive fields tend to encode small disparities and neurons with large receptive fields tend to encode large disparities. Moreover, as we have seen earlier in the course, there are more neurons with small receptive fields devoted to encoding intensity structure near the fovea, and fewer neurons with large receptive fields for encoding intensity structure in the periphery.

Using circles to illustrate the size of receptive fields, make a sketch of disparity space \((x_l, x_r)\) that illustrates the above statements about how cell receptive field size (circle size) varies with disparity and eccentricity. Be sure to label the fovea in your sketch.
Solutions

1. The point of this question is for you to appreciate how the absolute range of depths are quite different in the various cases.

   (a) 10 m is 0.1 diopters. So the range of fused inverse depths is \([0.1 + 0.1, 0.1 - 0.1]\), i.e. the range of fused depths is \(Z \in [5m, \infty]\).

   (b) 2 m is 0.5 diopters. So, \(\frac{1}{Z} \in [.5 + .1, .5 - .1] = [.6, .4]\), and so \(Z \in [1.67, 2.5]\) m.

   (c) \(\frac{1}{Z} \in [2.1, 1.9]\) and so \(Z \in [.476, .526]\).

2. 

3. (a) Below left: Segments \(bc, ij, ef\) are binocular. Segments \(ab, hi\) are seen by left eye only. Segments \(cd, fg\) are seen by right eye only. Segments \(gh, ad\) are seen by neither eye.

   (b) Below right.
4. The size of receptive fields increases as you move away from the $d = 0$ line and as you move away from the origin.