Questions

1. (a) Panum's fusional area refers to the range of depths over which the brain can fuse the left and right eye images of a scene point or surface. In fact, *Panum's fusional area increases with eccentricity.*

   Sketch Panum's fusional area for 2D "from above" view of a binocular observer, given the statement in italics above.

   (b) Draw the corresponding disparity space (x_l, x_r) representation.

   (c) How would you account for this non-uniformity of Panum's fusional area, in terms of what you know about how disparities are coded in the brain? Hint: recall Exercises 6.

2. 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 focal plane. 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

3. It turns out that there is more to fusion that Panum's fusional area. For example, for an object that has an image width w (visual angle), the disparity also must be less than w for the visual system to fuse the object.

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

   Hint: in this question, you cannot think of Panum's fusional area as having a fixed size. So don't attempt to draw it. Instead, just draw the two objects in disparity space such they satisfy the above constraint.

4. (a) We saw an example of random dot stereogram in which a square was in front of a background. I drew the scene in disparity space (x_l, x_r).

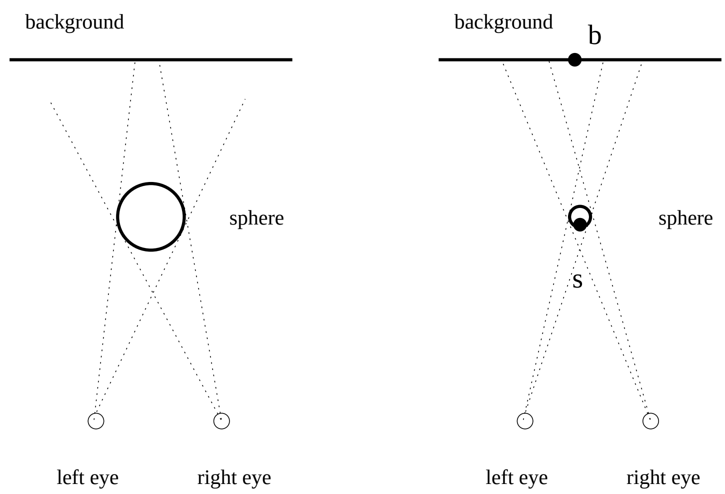
   Consider a sphere in front of a background, shown on the left below. Some points in the scene are visible to both left and right eye. Some points visible to just one eye. Some are visible to neither eye.

   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 above right.) For example, I have marked a point $\mathbf{b}$ on the background surface, which is visible to both eyes.

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

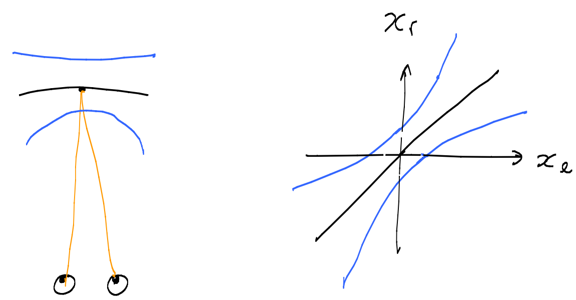
   Draw a disparity space image of this situation and mark the two points $\mathbf{b}$ *and* $\mathbf{s}$.



5. The angle θ_l and θ_r were defined to be the angles of each eye's Z axis rotated away from the forward direction, namely perpendicular to the line passing through the two eyes. If one is looking at a point directly in front, then $\theta_l > 0$ and $\theta_r < 0$. Do these variables need to obey these sign constraints for all vergence situation? If not, what are the constraints on the θ values that must be obeyed?

Solutions

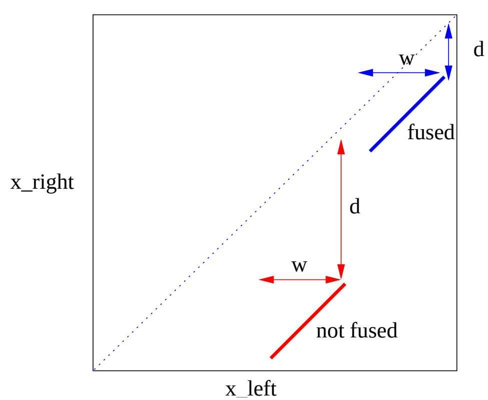
1. (a) see left. (b) see right. (c) At small eccentricities, V1 cells tend to have smaller receptive fields and tend to encode small disparities i.e. the range of disparities coded is similar to the range of receptive field sizes. At large eccentricities, we find larger cells and similarly larger disparities can be coded. See Exercises 6 Q3.



2. (a) 10 m is 0.1 diopters. So the range of fused depths in diopters is $[.2, 0] = [0.1{+}0.1, 0.1{-}0.1]$, i.e. $Z \in [5m, \infty]$.
   (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 $Z \in [.476, .526]$.

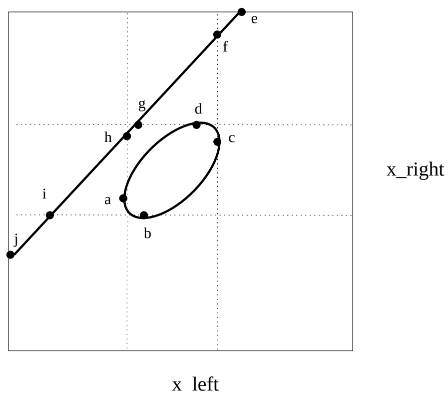
   Note that the absolute range of depths are quite different in the various cases.

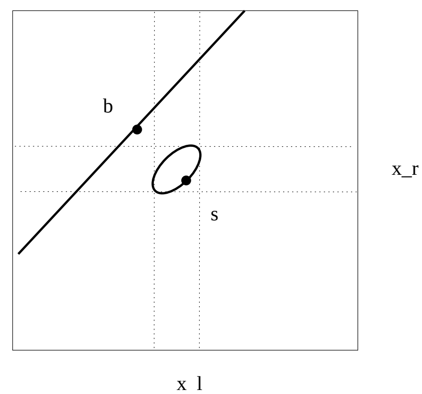
3.



4. (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.





5. If both eyes look to the right (relative to the direction that the head is facing), then both $\theta_l > 0$ and $\theta_r > 0$. If both look to the left, then both $\theta_l < 0$ and $\theta_r < 0$. The only constraint is that $\theta_l - \theta_r > 0$ since otherwise one cannot verge on a point. People with "lazy eye" have this problem.