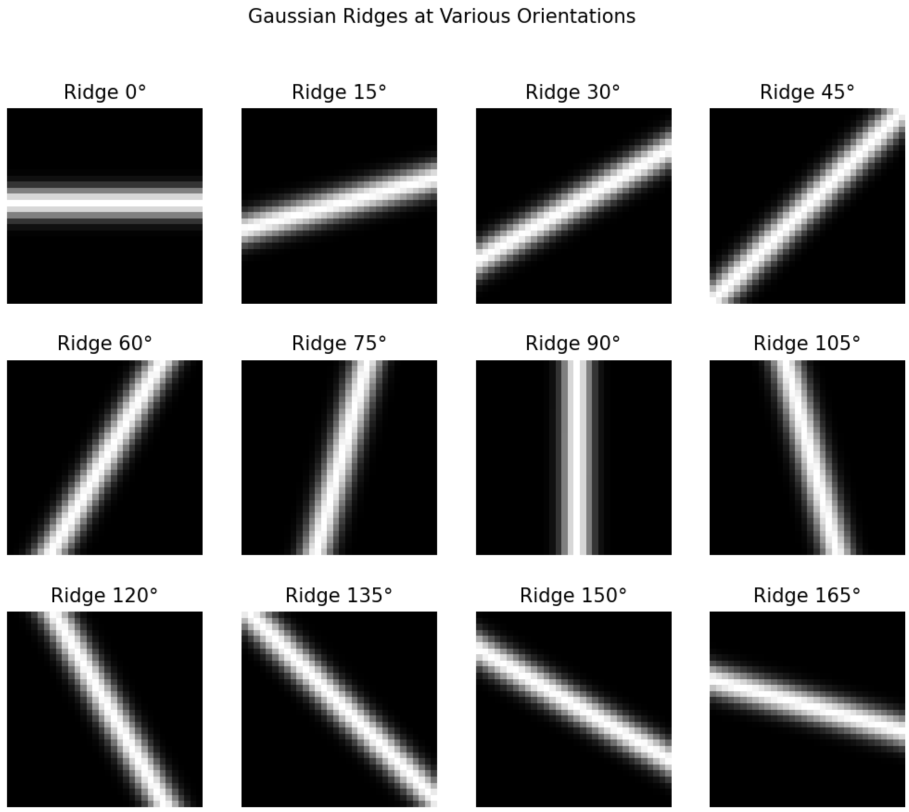
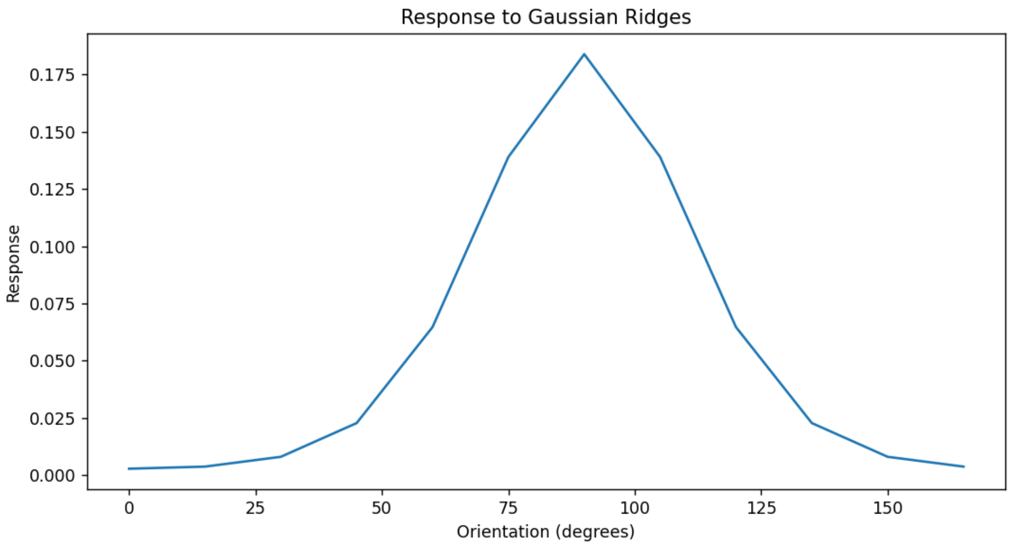
Computational Perception – A2

Filippo Grosso

Problem 1:

part (a)

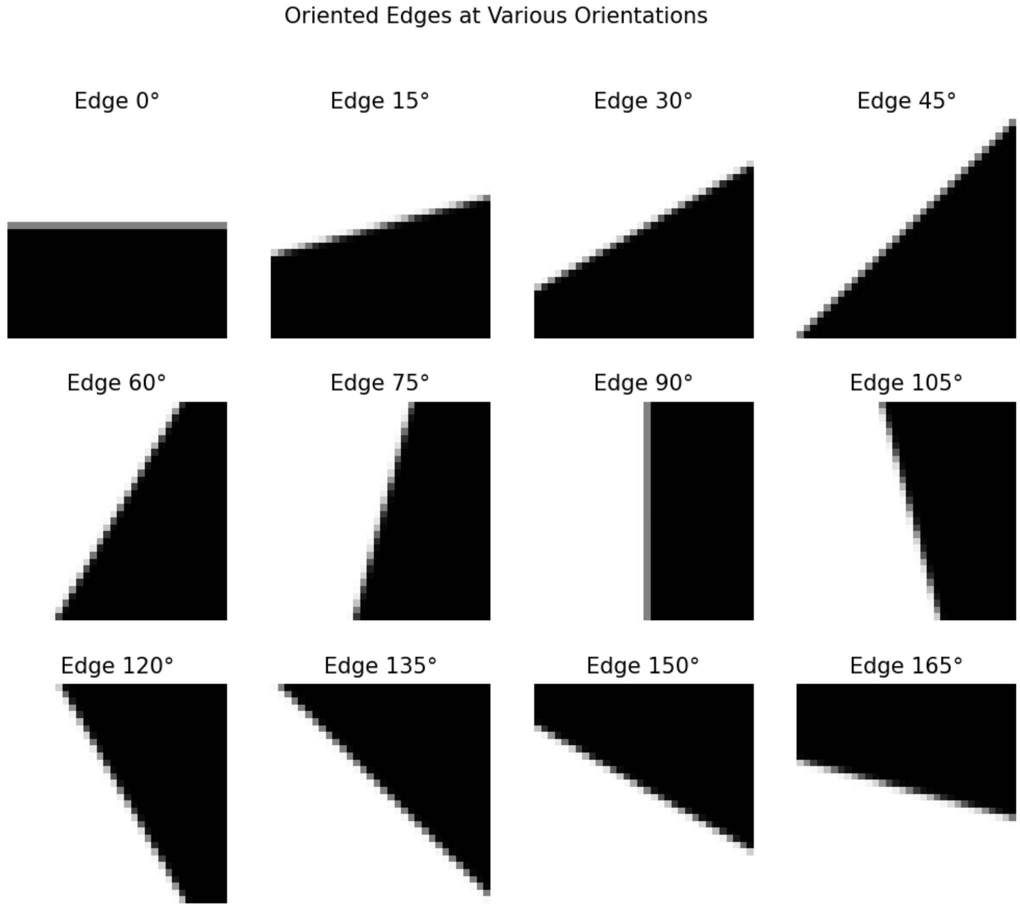


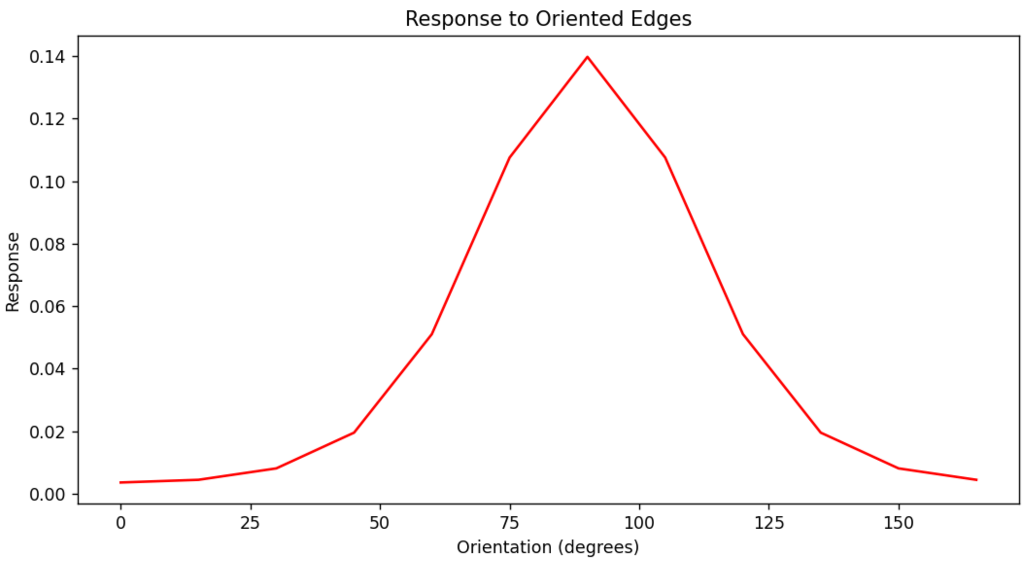


This is the plot of the response of the complex cell (with kx = 4, ky = 0) to the gaussian ridges at various orientations. As we can see the response increases the closer the orientation of the ridge to the one of the complex cell, vertical. This is why the maximum of the curve is achieved when the ridge is at 90°, at the same orientation of the curve, with a response value of 0.184The minimum is achieved when the ridge is oriented perpendicular to the complex cell at orientation 0 with a value close to 0. . The reason for this is that a complex cell is sensitive to a structure at that particular orientation, the more the ridge strays from the direction of the complex cell the less the cell picks up on its effect. The behaviour is similar to the response of a complex cell to a line.

Note: as we increase the ridge width the values of the response of the complex cell decrease

part (b)

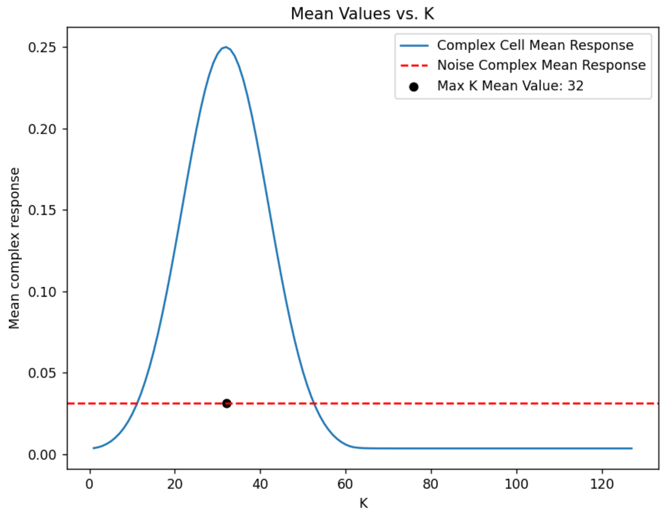




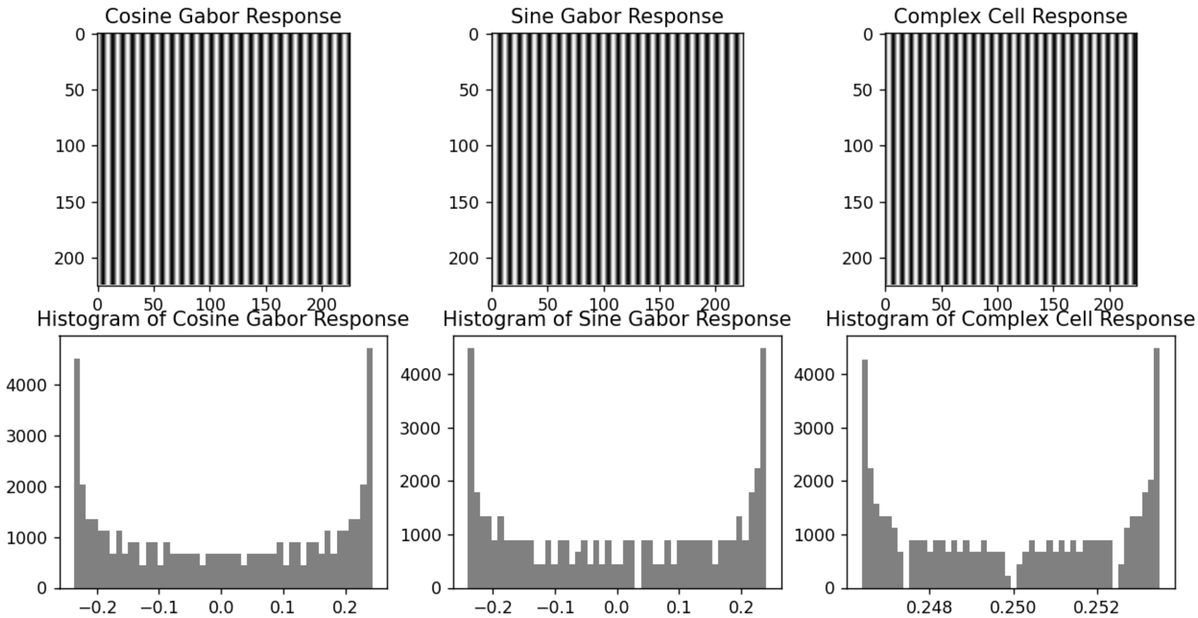
This is the plot of the response of the same complex cell to the edges at various orientations. As we can see the plot follows a similar behaviour as the ridge one. It assumes the maximum value of 0.140 at edge orientation 90°. The minimum value, close to 0, is achieved at 0°, when the edge is perpendicular to the complex cell. The reason is again similar to the one for the ridge, again the edge is a structure that leads to maximum response when it coincides with the alignment of the complex cell and to an almost null response when its perpendicular.

Problem 2:

Part(a)



We can see the optimal frequency k in this case is 32 this means that the sinusoidal image best represents the complex cell response zone, effectively acting as a ridge of just the right width for optimal complex cell response. Any lower k would have led to the cells perceiving the image as more uniform and higher k to the gabor filter seeing the image as noise.

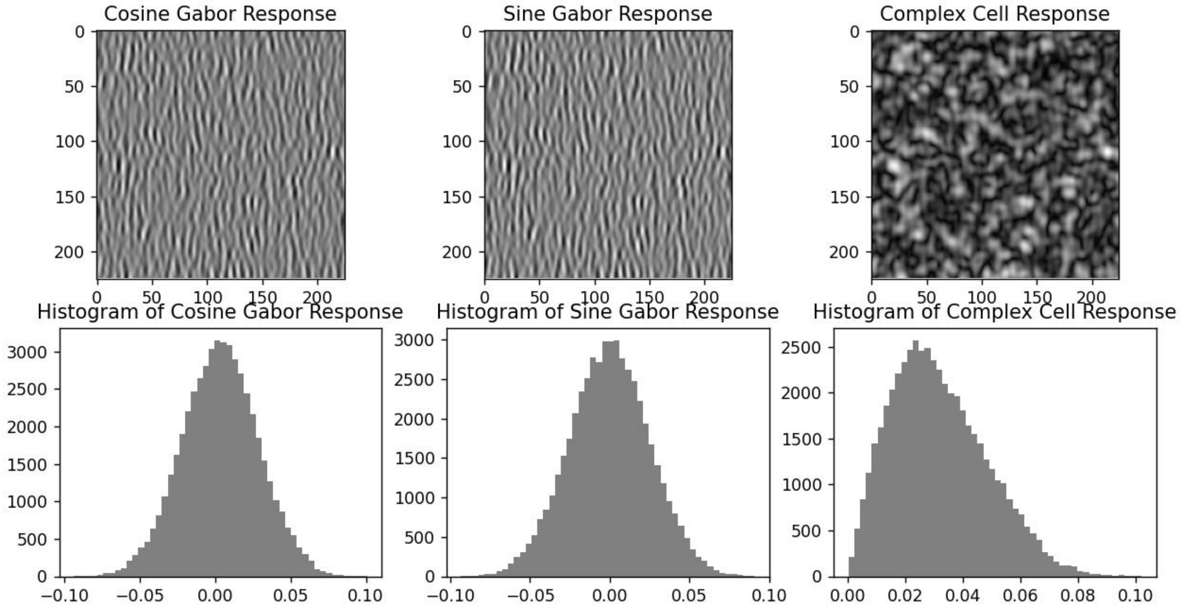


Plots to sinusoidal images with optimal k (29,29,32) respectively

We can see that the optimal frequency for the sinusoidal frequency are the ones that better match the size of the gabor filter cells excitatory zones. This way the cell is able to fully respond to the lines in the cos gaborcase, edges in sin case and general oriented structure in the case of the complex cell.

For the cosine and sine gabors the response values concentrate in two peaks around -0.2/-0.25 and 0.2/0.25 with some values in between, presumably the transition points. For the complex cell the histogram reports the same two peak structure but in this case the variance is much lower. The lower peak is concentrated around 0.246 while the higher one around 0.254. Both values are of course positive, this is probably due to the squaring effect of the complex cell

Part (b)



We can see that both the cosine and sine gabor responses highlight vertical lines and edges that were formed in the noisy image, the complex cell highlights the points where there is vertical structure.

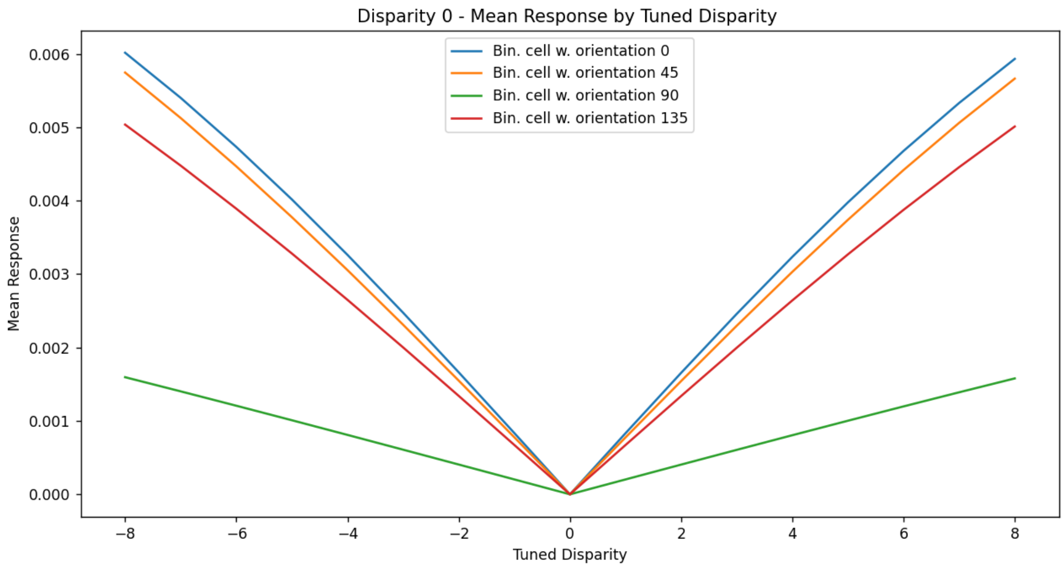
The values this time are normally distributed. For the sine and sine gabor they are distributed around 0 with the lowest values being -0.10 to the highest of 0.10, the majority is around 0 meaning they are not responding to anything in particular. The complex cell is normally distributed with an imbalance to the right, clearly the minimum value is 0 while the highest is around 0.10.

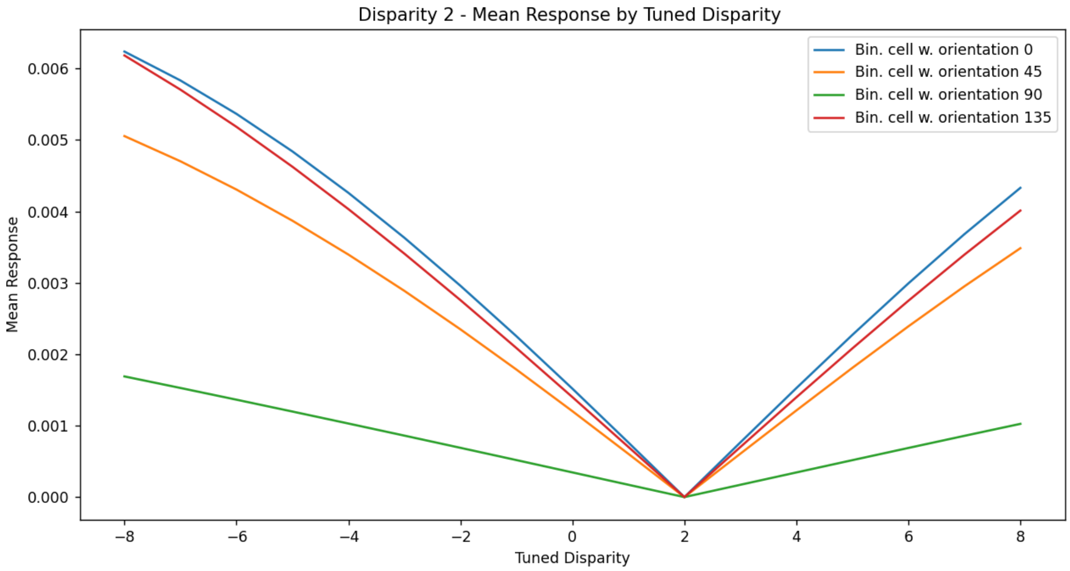
In all cases the magnitude of these extreme values are lower than the ones reported by the structured sinusoidal image. This was to be expected since the cells are only picking up on random patterns instead of actual edges.

For which frequency(s) in part (a) is/are the mean complex cell responses are approximately the same as the mean complex cell responses to the random noise image?

As we can see from the initial plot the mean complex cell responses are approximately the same for values of around 10 and around 55-60

Problem 3:





Here are the results of the mean response for the binocular complex cells. The first plot corresponds to the response of the cells to a pair of stereo images with distance 0. The second plot represents the response to a pair of stereo images with distance 2.

Starting from the first plot we can see that each one of the 4 curves, representing the 4 possible orientations of the cells, reports a minimum value of 0 when tuned at binocular disparity 0. When moving away from the tuning at distance 0 the values increase.

From the theory we know that the correct estimate for the distance by the cells is the one that minimizes the binocular cell response, in this case d=0 which is the actual shift distance between the two stereo images.

Regarding the 4 curves we can see that that the one that gives the lowest response is the one where the complex cells are oriented at 90°, followed by 135°, 45° and then finally 0°. It seems that a binocular complex cell oriented at the direction of the shift reports the shift better than one that is oriented perpendicular to it, this might be due to the weights the cell applies on the image and how they concentrate on a certain direction, similar to how normal complex cells perceive lines in their direction better.

For the second plot we can see that each one of the 4 curves, reports a minimum value of 0 when tuned at binocular disparity 2. When moving away from the tuning at distance 2 the values increase. We know that the correct estimate for the distance by the cells is the one that minimizes the binocular cell response, in this case d=2 which again is the actual shift distance between the two stereo images. Again the same pattern applies with 0° being the orientation reporting the highest response when cells are tuned at an incorrect distance.