Report TP2 MI210 : Analysis and modeling of artificial visual systems

Yufei HU,
Bo LI,
Victor TUIZAT

20/04/2020

Table des matières

1 Q1

The autonomous system we have chosen is Autonomous vehicle. The model we built can achieve outdoor navigation according to path planning. Meantime, the visual system of the autonomous vehicle can also complete road detection and vehicle detection. We think that the automatic driving system we choose can achieve the optimal path from the set departure point to the destination to complete transportation or other tasks. However, its capacity to identify road information and other vehicles still needs to be improved.

As for the hardware, we choose the GPS and IMU sensor to complete the positioning of autonomous vehicles. We also choose frame rate, static cameras and lightning device to realize road and vehicles detection. Lightning equipment is used to obtain higher quality images. The vision system can convert the images obtained by the camera into digital signal, which are later analysed by on-board image acquisition unit. In addition, we should also implement road and vehicle recognition systems through, for example, image segmentation.

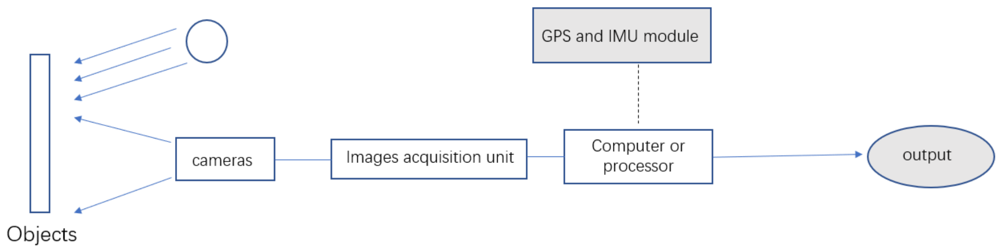


Figure 1 – Vision System

When the in-vehicle processor can identify vehicles and the road and cooperate with the appropriate navigation strategy, it can achieve the basic common capabilities.

2 Q2

The average power spectrum is shown in Figure 2. We can see that energy is higher in low frequency area and lower in high frequency area. This is a typical power spectrum of a natural image. The power spectrum is close to monkey/human visual system.

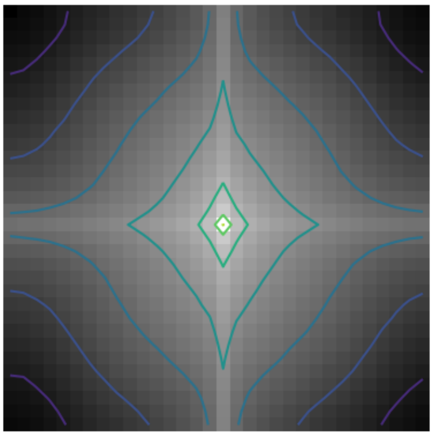


FIGURE 2 – Average Power Spectrum

3 Q3

The radical average power spectrum is shown in Figure 3. We can see clearly that energy decreases exponentially while frequency increases, which is correspondent to Figure 3.

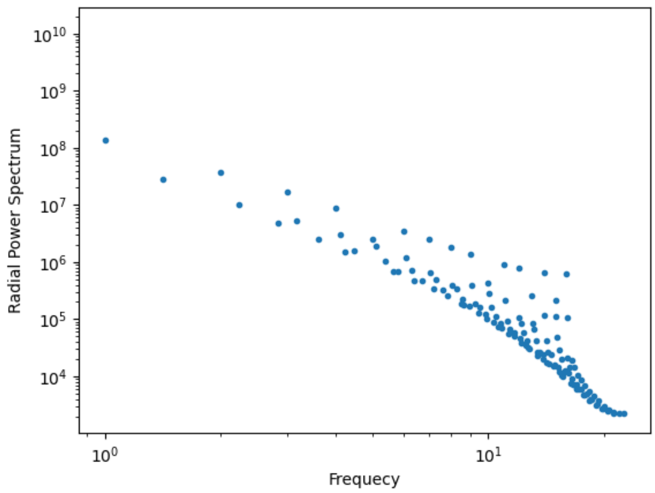


FIGURE 3 – The RADIAL average 2D power spectrum

4 Q4

The nine local power spectrums are shown in Figure 4. We can see that they are not exactly the same. Some power spectrums have the main axe inclined in different direction. Actually this direction is perpendicular to the polar angle of this local image.

The radial average is no longer the correct step for the analysis, since there is clearly an orientation preference in these power spectrums.

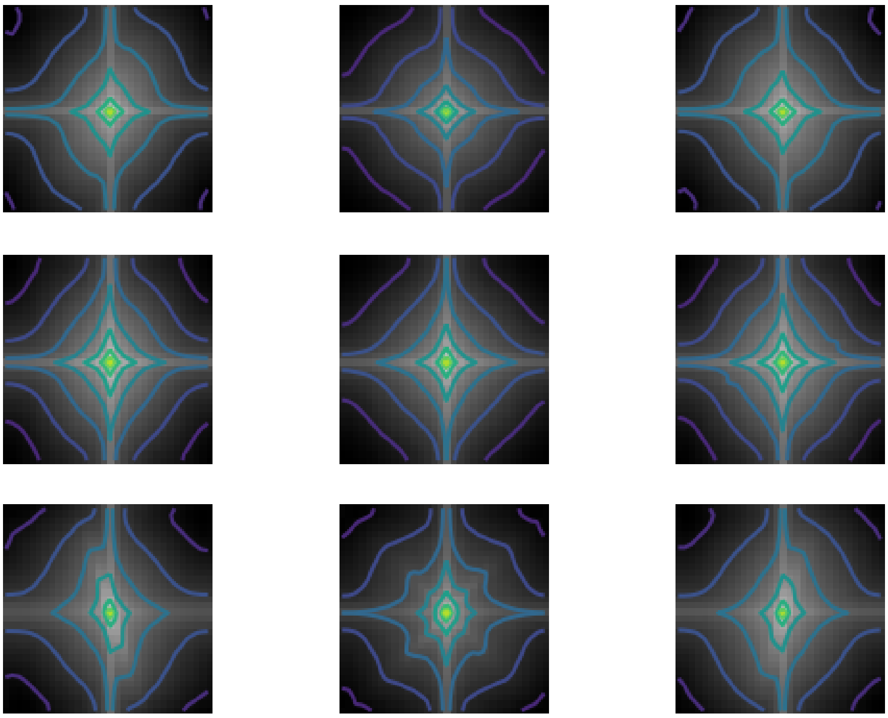


FIGURE 4 – Average Power Spectrum of the local statistics of the images

5 Q5

The denoising whitening filter is built by the equation below :

$$w = \mathscr{F}^{-1}\left\{ \frac{1}{\sqrt{\mathbb{E}[\mathrm{PS}(x)]}} \left\lfloor \frac{\mathbb{E}[\mathrm{PS}(x)] - \sigma_\nu^2 M}{\mathbb{E}[\mathrm{PS}(x)]} \right\rfloor \right\}$$

We choose four levels of noise and the result calculated by our function is shown in Figure 5. We compare these images with a typical image of Retinal Ganglion Cell shown in Figure 6.

We can draw the conclusion that the result of power spectrum whitening method is quite similar to receptive field of retinal ganglion cell, they have similar shapes.

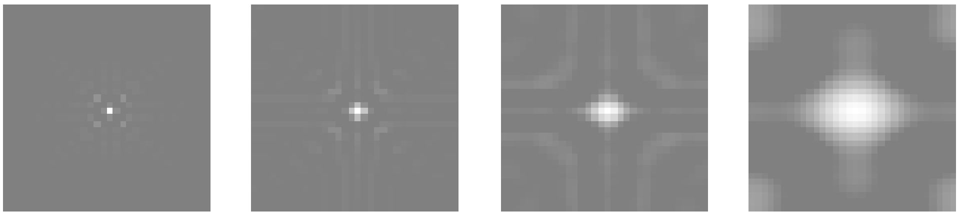
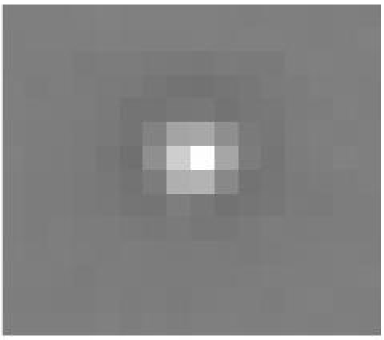


FIGURE 5 – The power spectrum whitening filters



[redacted]

FIGURE 6 – receptive field of retinal ganglion cell

6 Q6

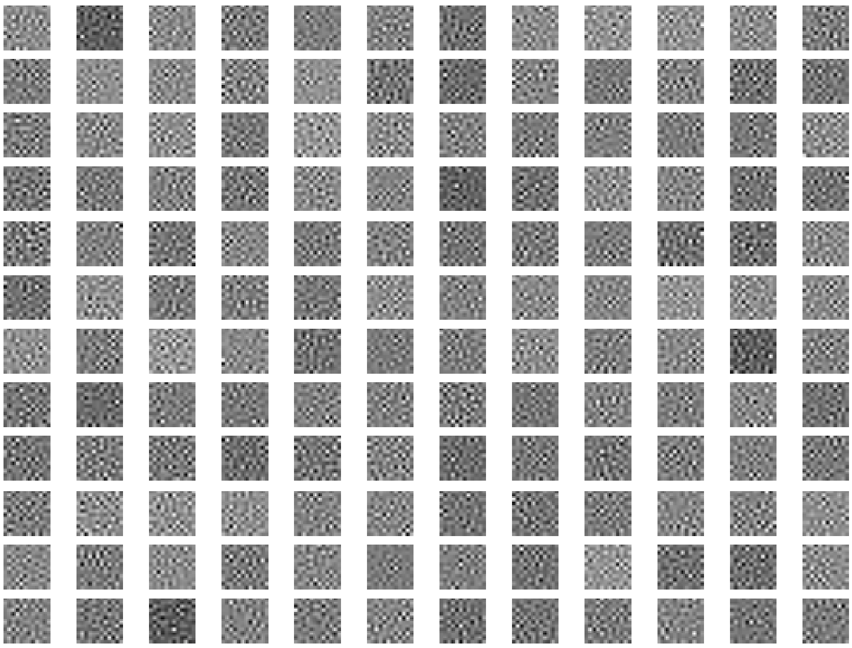


FIGURE 7 – ICA analyse of samples images

The result of our ICA function is Figure 7. We compare these images with receptive field of V1 simple cells, actually they are also quite similar in shape.

The result shows that V1 simple cells have the capacity to extract the independent sources of natural images.

7 Q7

To test the sparseness of image samples, we choose to calculate their kurtosis as sparse mesurement, the function we used is implemented in scipy.stats. The histogram of kurtoisis of image samples and standard Gaussian distribution are shown in Figure 8 and Figure 9.

The kurtosis of standard Gaussian distribution is 0, which is obvious by the defenition of kurtosis. However, the distribution of image samples is similar to gaussian distribution, which means they have been seperated sparsely.

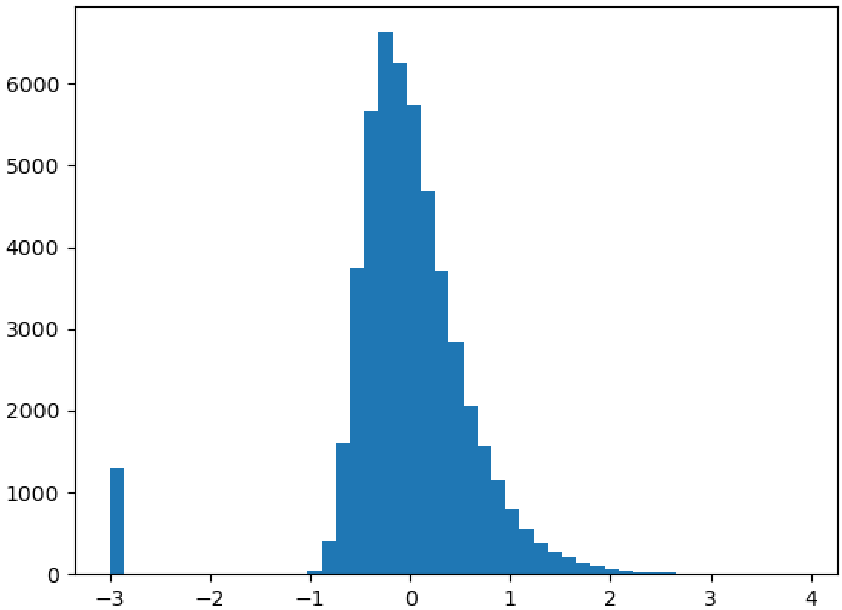


FIGURE 8 – Histogram of kurtosis of image samples

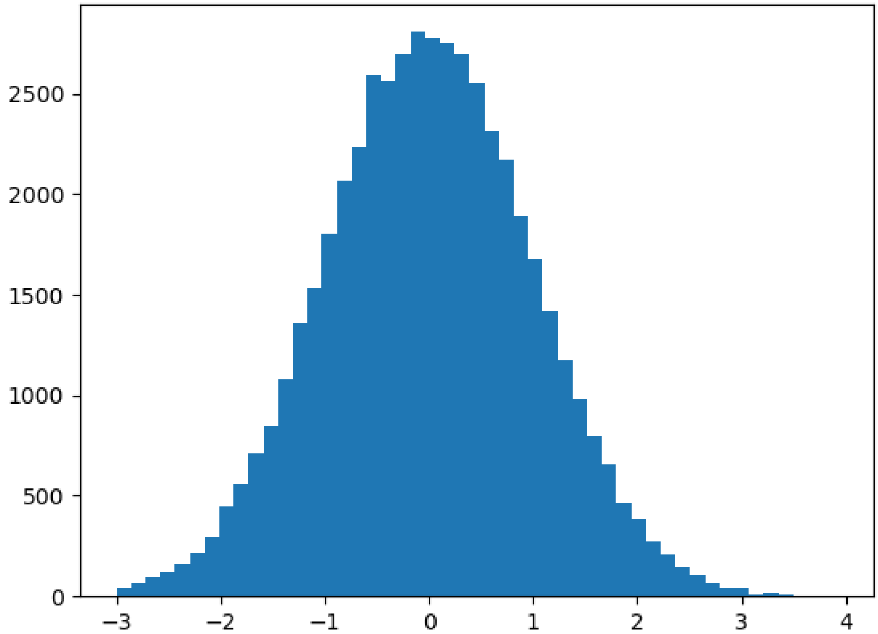


FIGURE 9 – Histogram of standard Gaussian distribution