Predictable blur behaviour for the bilateral filter

AUTHORS

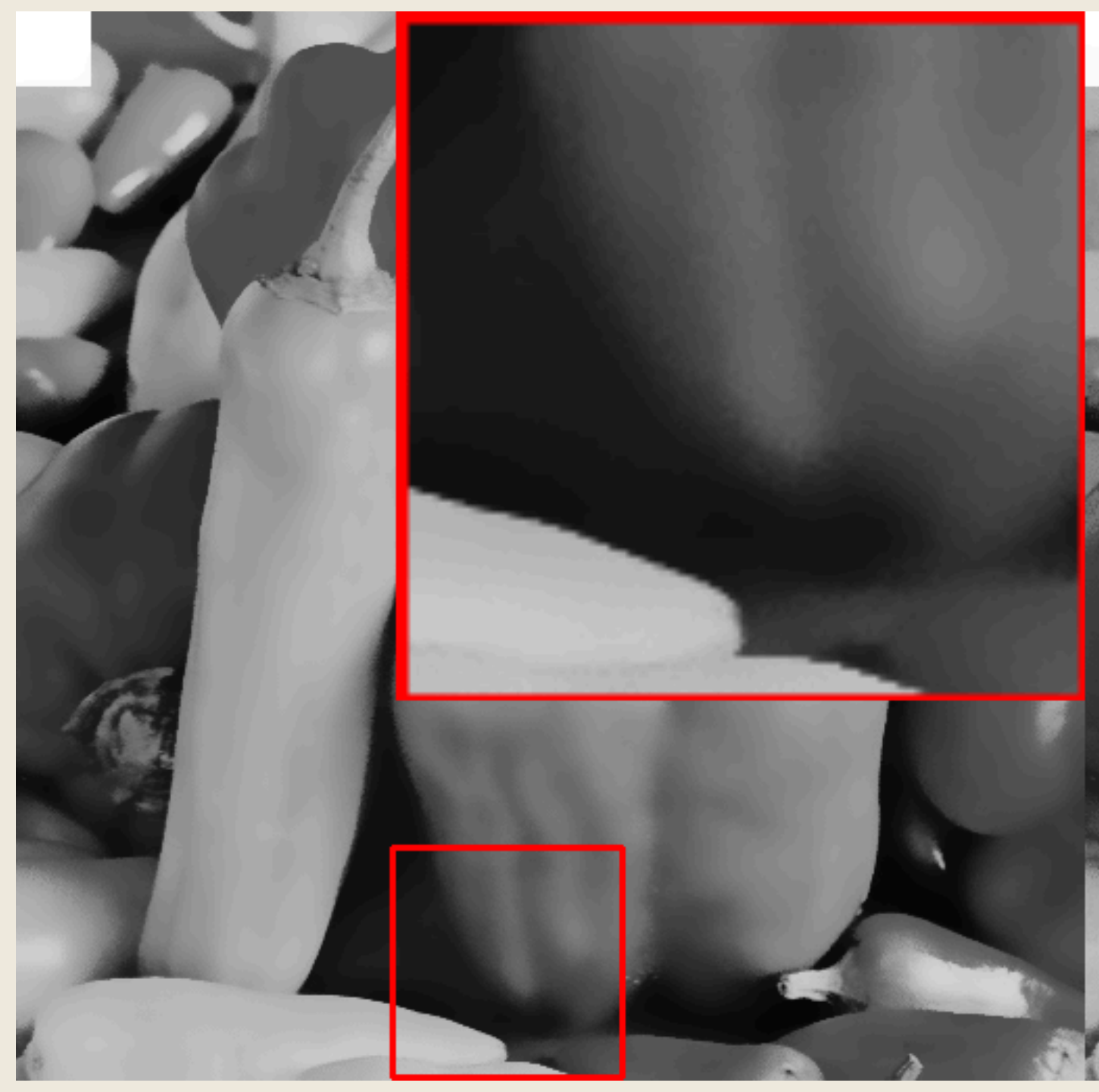
Bram Snelten
B.P.Snelten@student.tudelft.nl
Elmar Eisemann
e.eisemann@tudelft.nl
Mathijs Molenaar
M.L.Molenaar@tudelft.nl

AFFILIATIONS

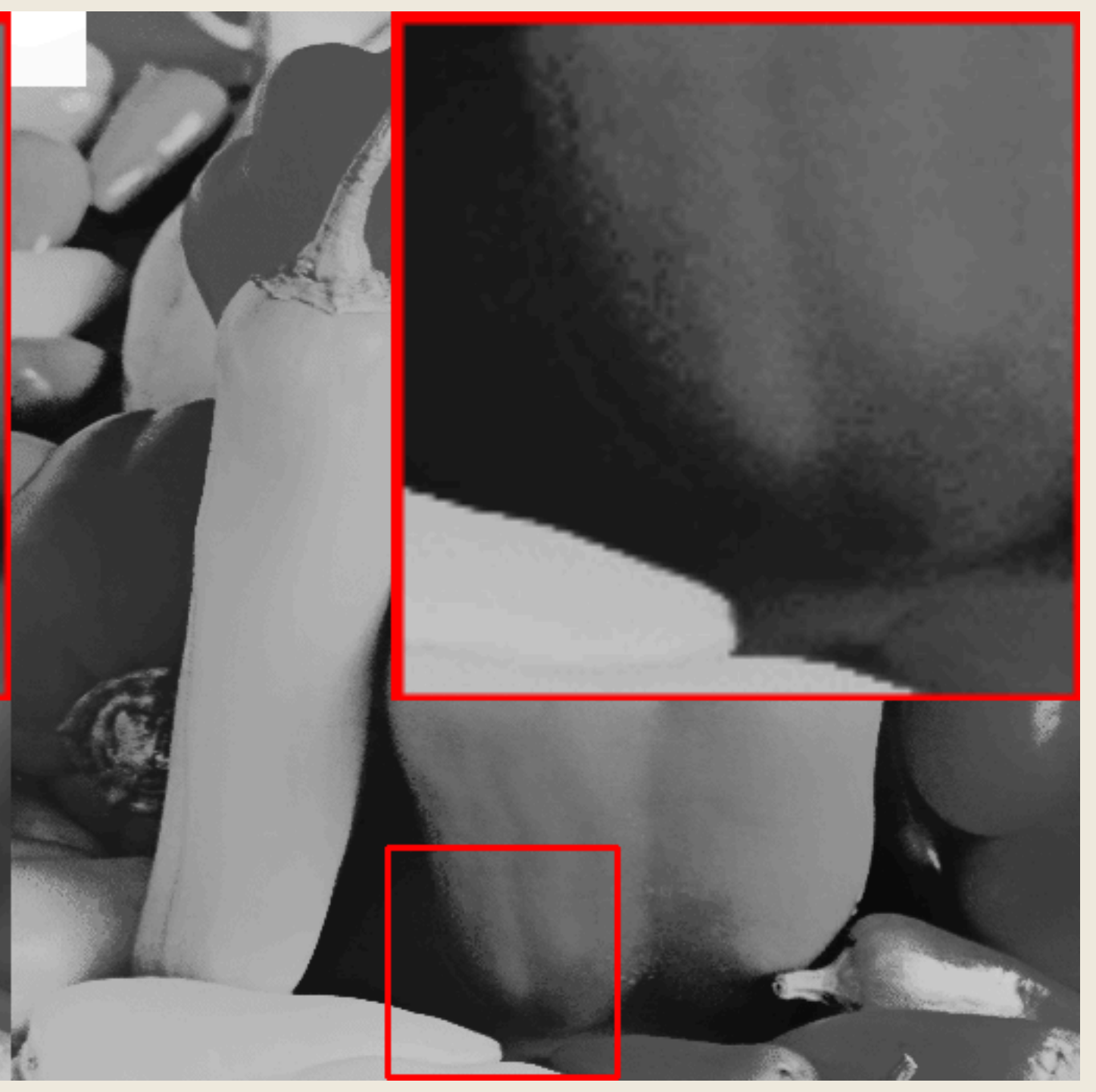
TU Delft

1. Research Question

How to make the bilateral filter's blur scale linearly with respect to kernel size?

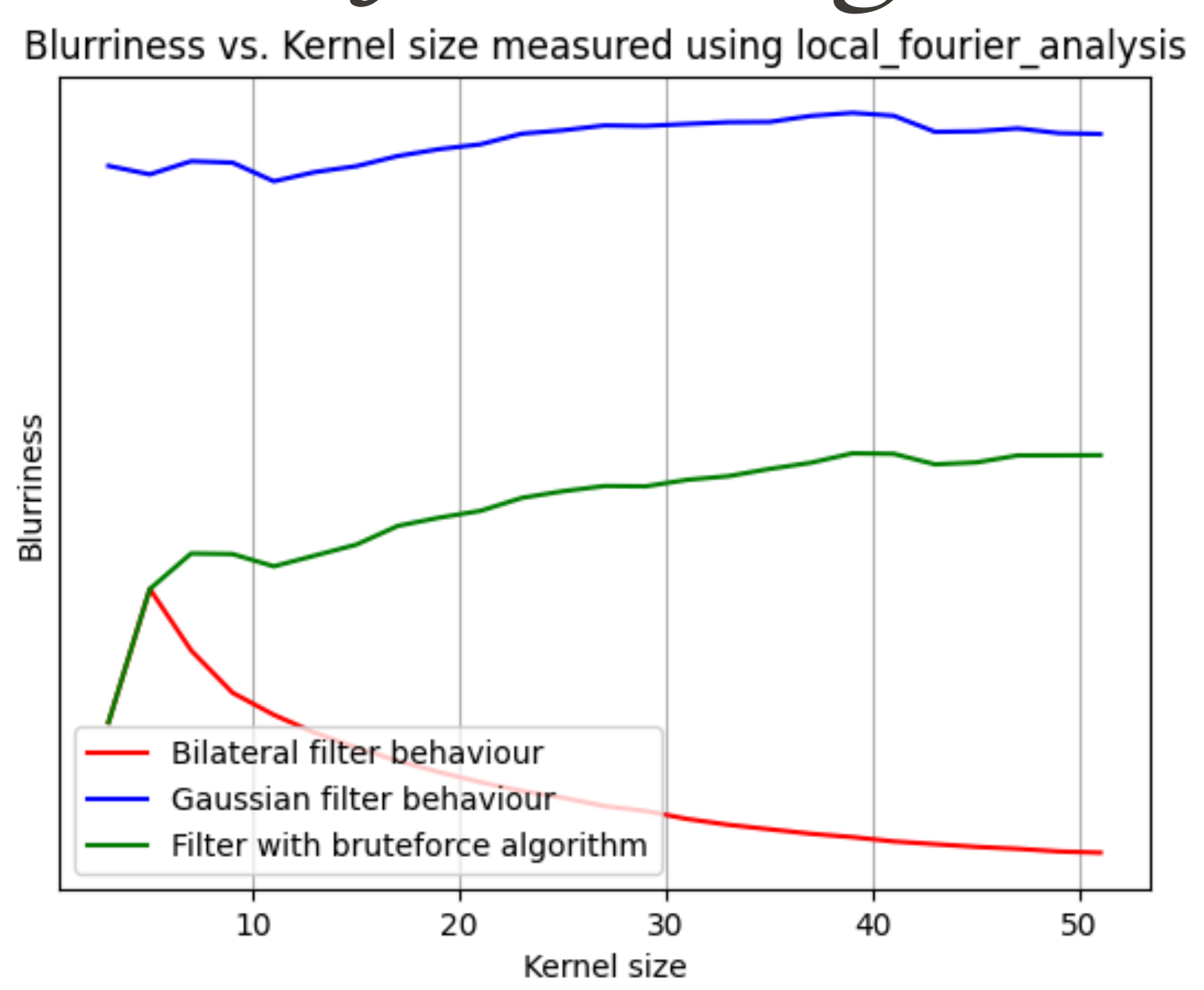


1. σs = 5

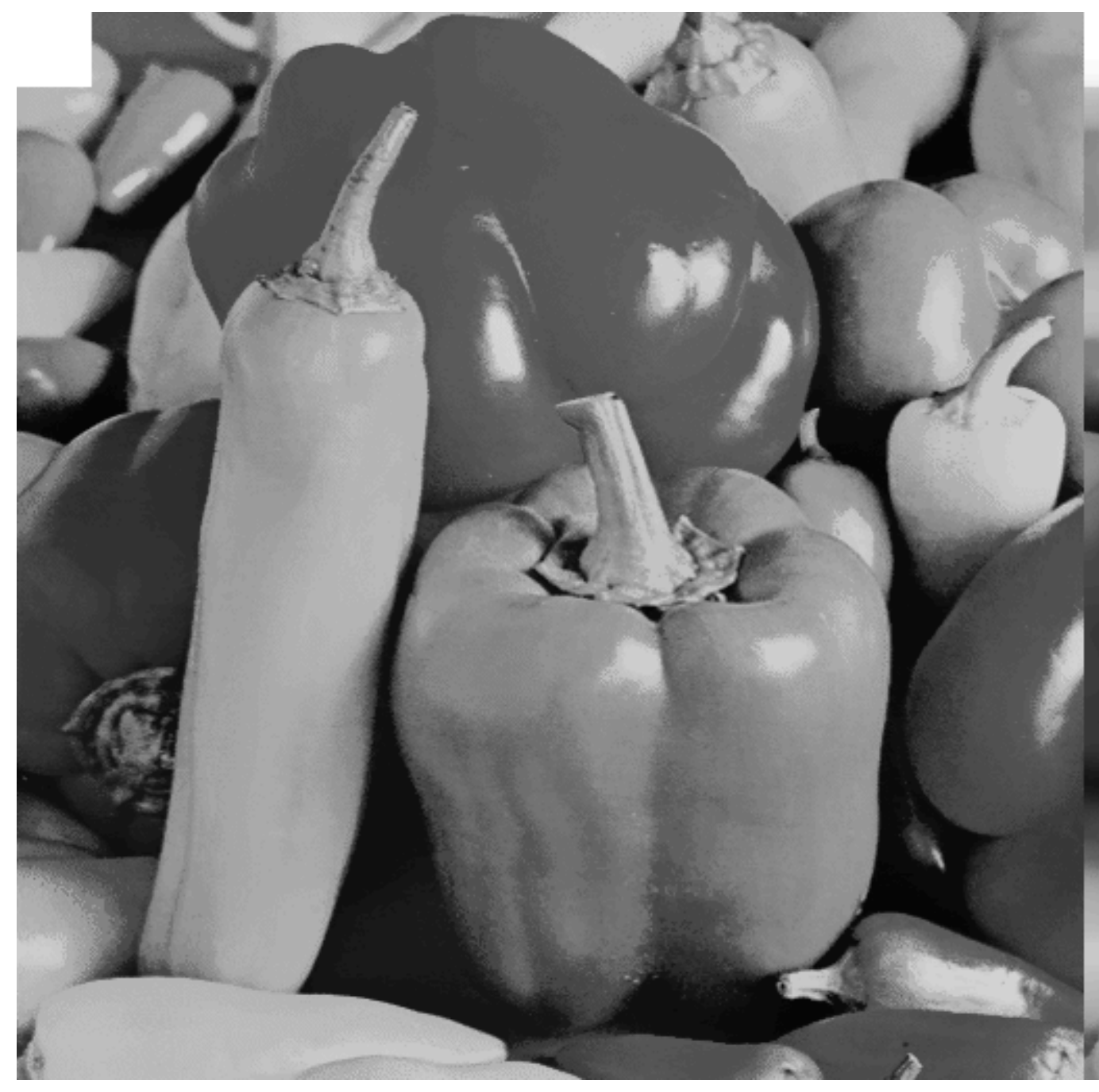


2. σs = 29.

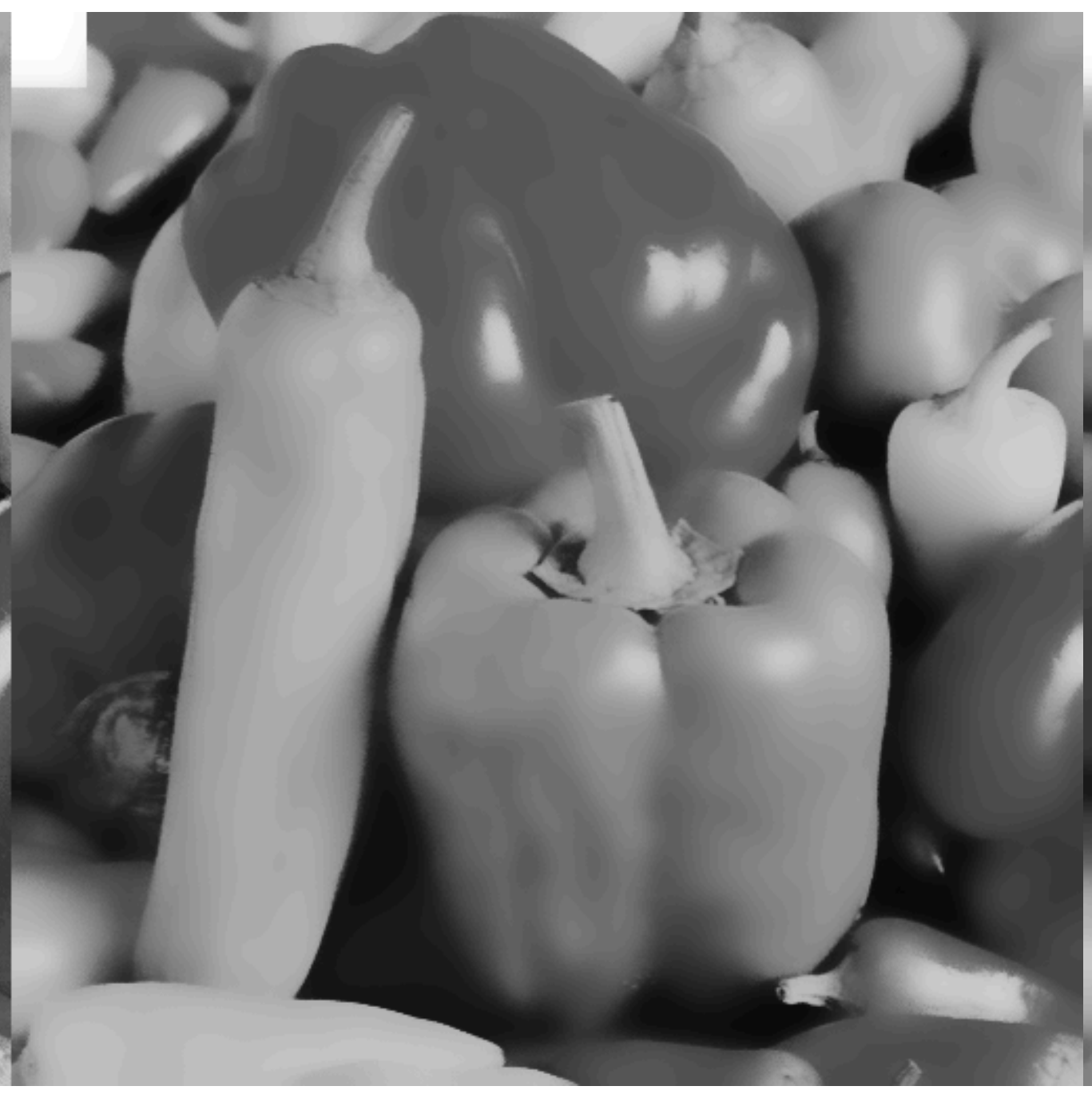
4. Brute force algorithm



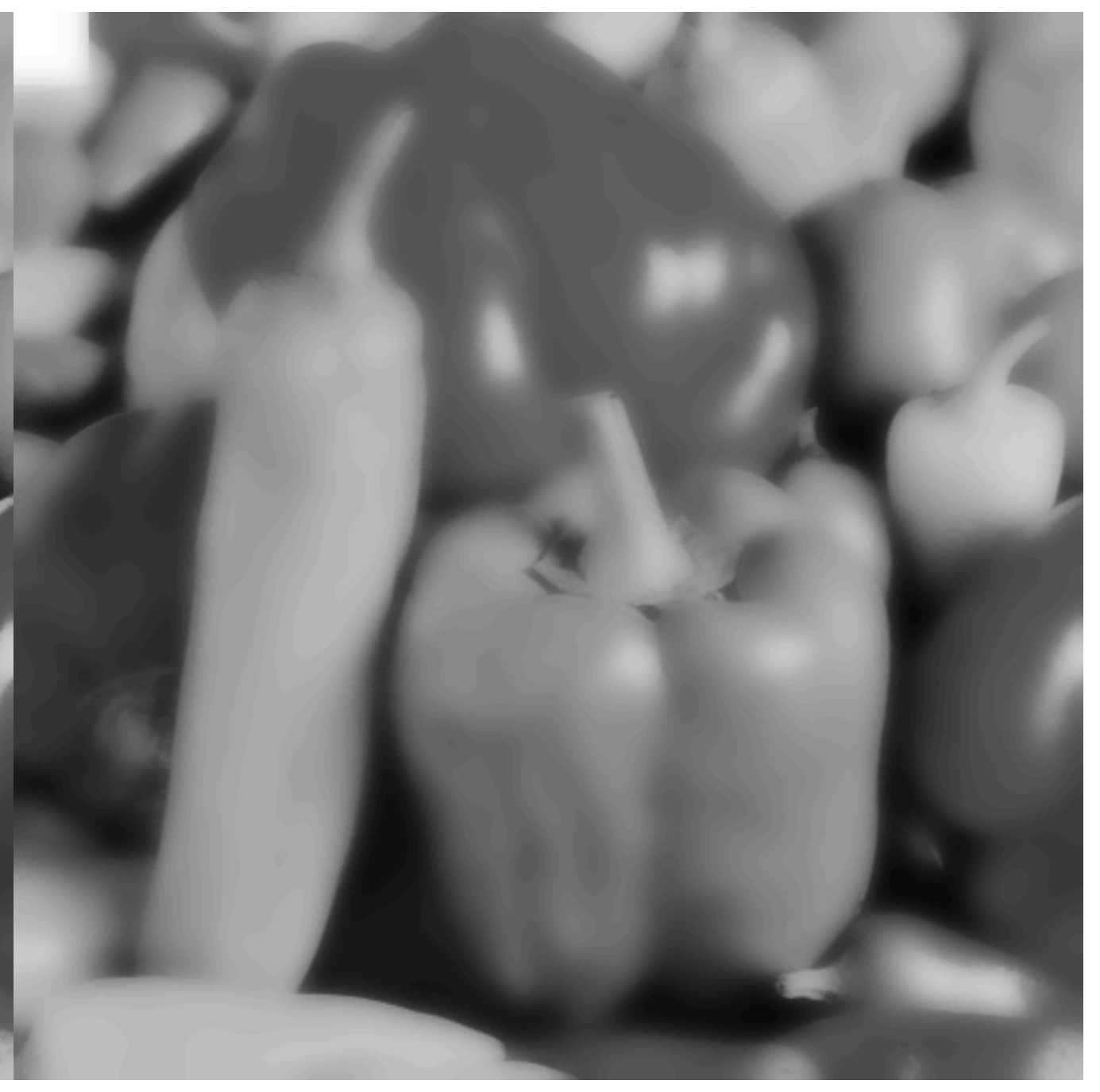
1. Picks σr to imitate slope of Gaussian blur levels.



2. Normal bilateral filter
Kernel size = 51



3. Brute force algorithm
Kernel size = 51



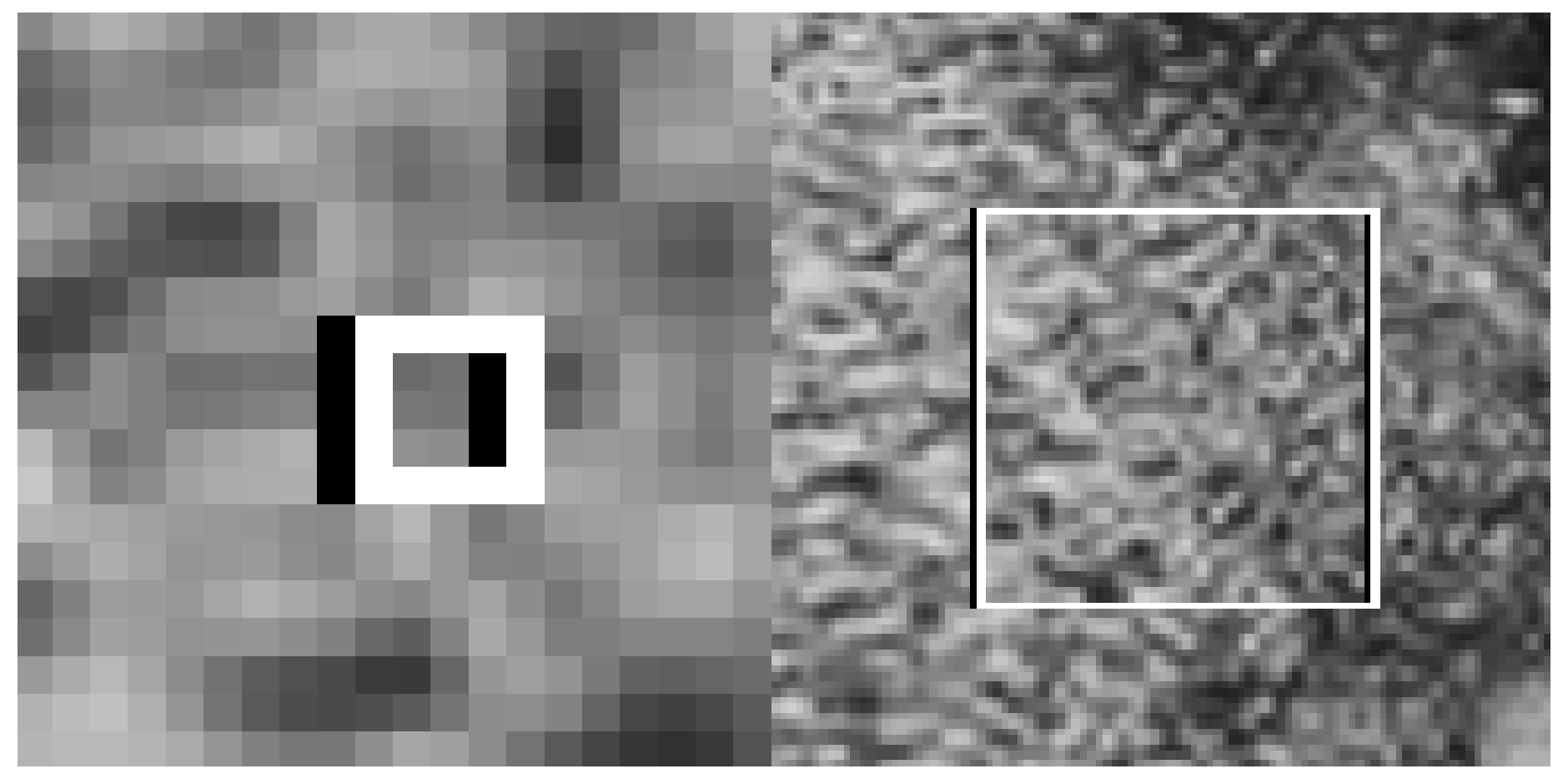
4. Brute force algorithm
Kernel size = 151

2. Why this atypical blur behaviour?

$$BF[I]_p = \frac{\sum_{q\in S} G_{\sigma_s}(\|p-q\|)G_{\sigma_r}(|I_p-I_q|)I_q}{\sum_{q\in S} G_{\sigma_s}(\|p-q\|)G_{\sigma_r}(|I_p-I_q|)}$$

$$BF[I]_p = \frac{\sum_{q\in S} G_{\sigma_r}(|I_p-I_q|)I_q}{\sum_{q\in S} G_{\sigma_r}(|I_p-I_q|)}$$

1. High σs simplifies the formula.

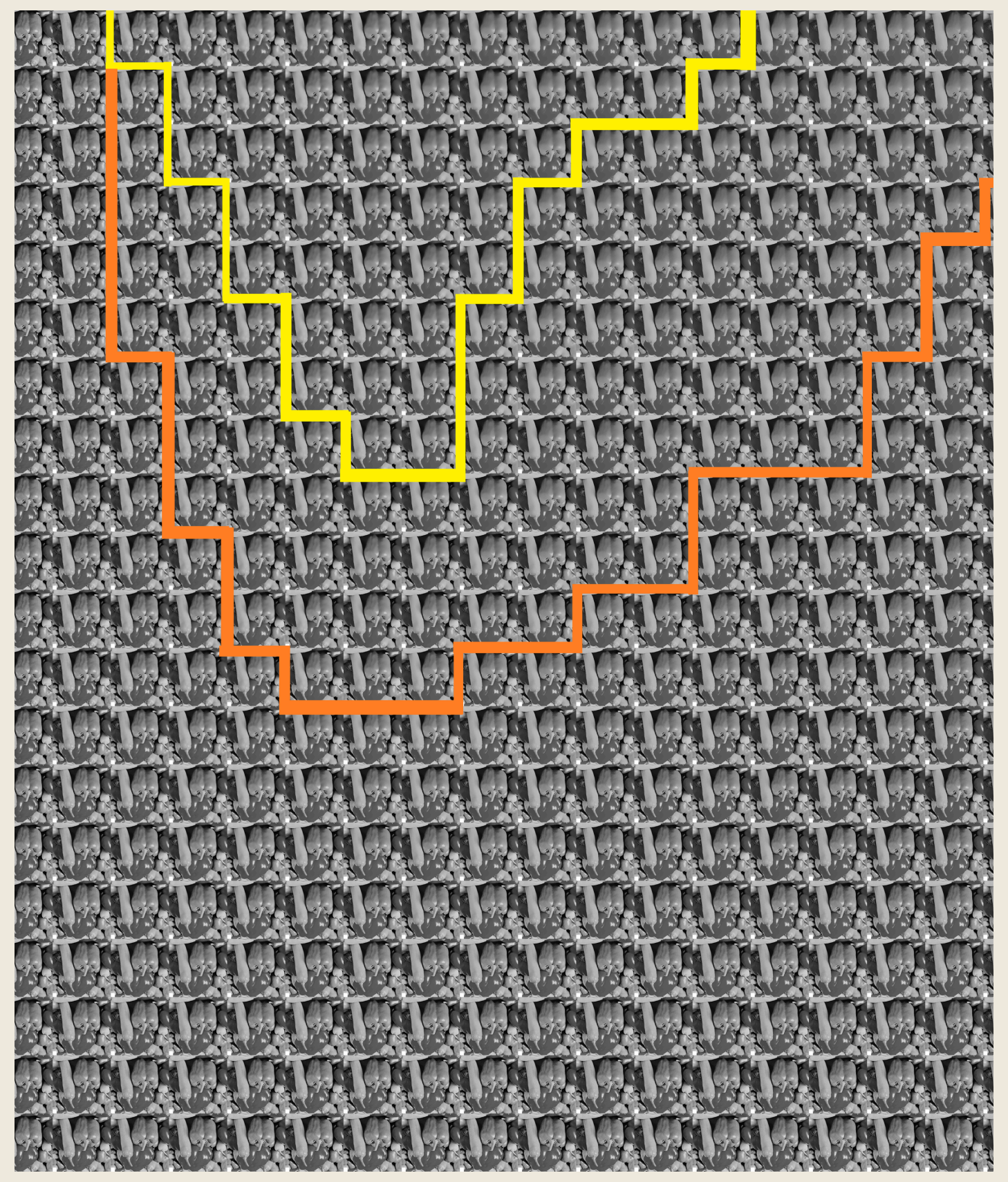


2. Large adjacent neighbourhoods are more similar than small adjacent neighbourhoods.

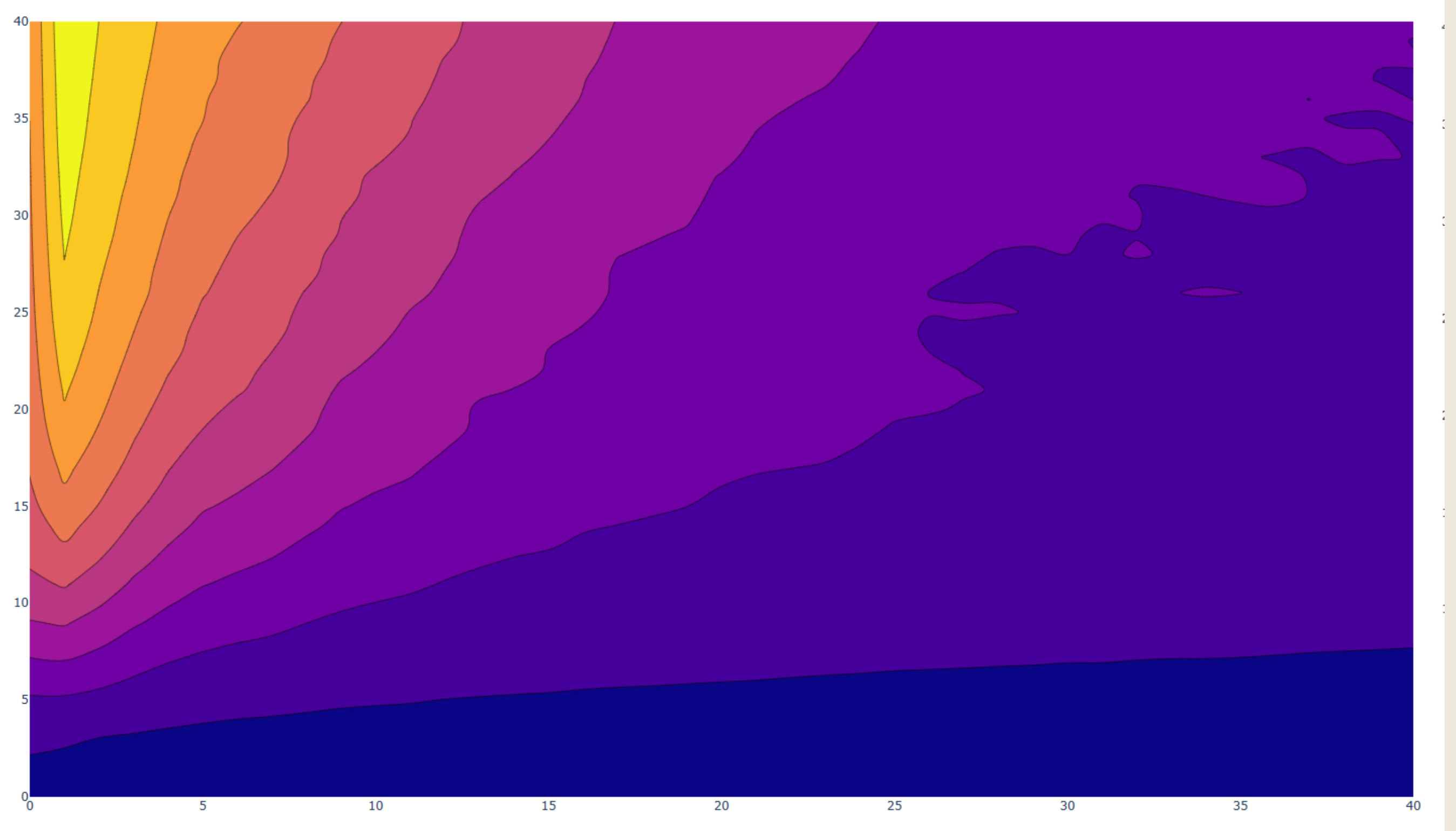
$$GB[I]_p = \frac{\sum_{q\in S} G_{\sigma}(\|p-q\|)I_q}{\sum_{q\in S} G_{\sigma}(\|p-q\|)}$$

3. ||p-q|| is small for neighbouring p and q.
|Ip - Iq| does not have to be small.

3. Measuring blur

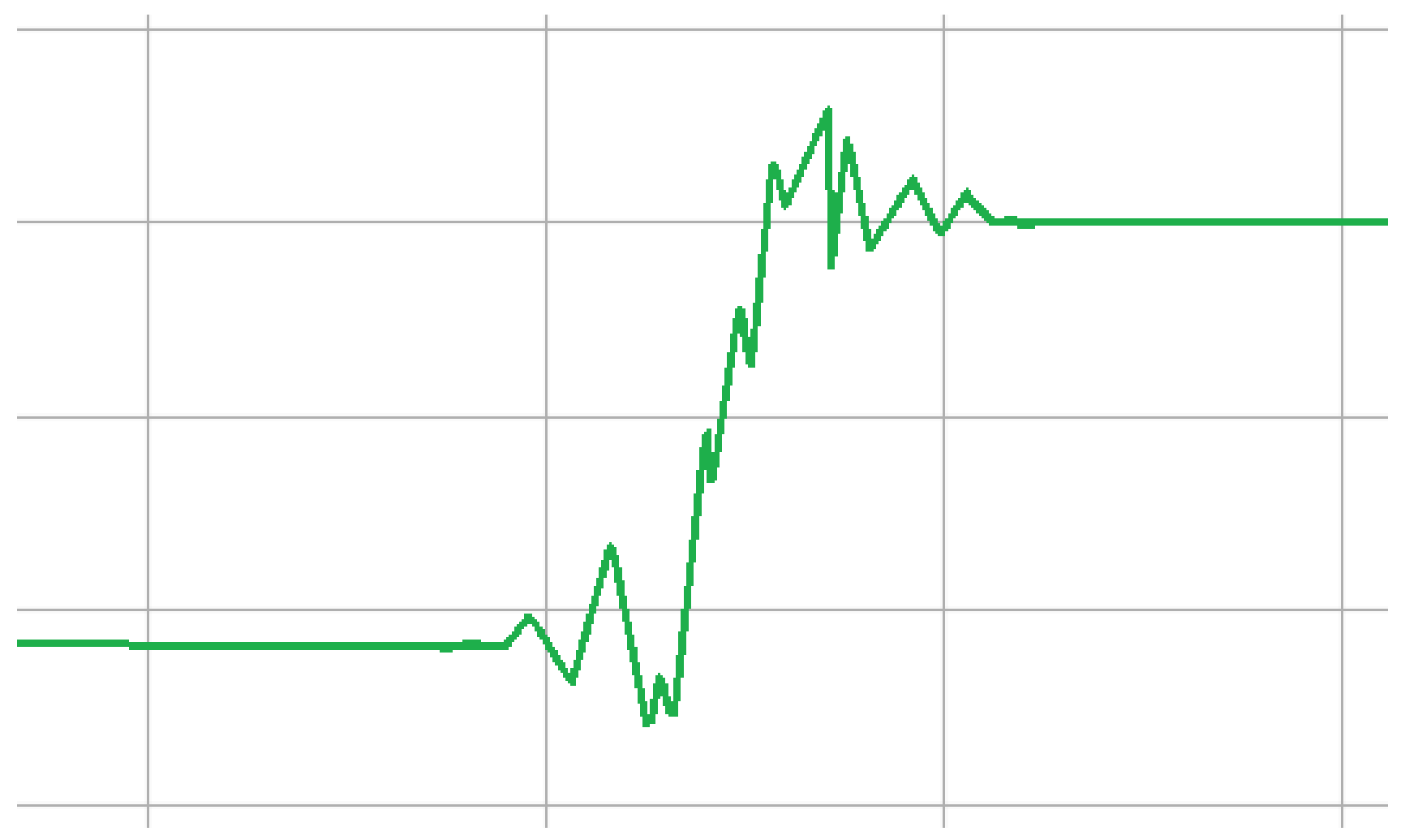


1. Contour lines grouping images with similar perceived blur together. Image inside the yellow contour lines are the most blurred.

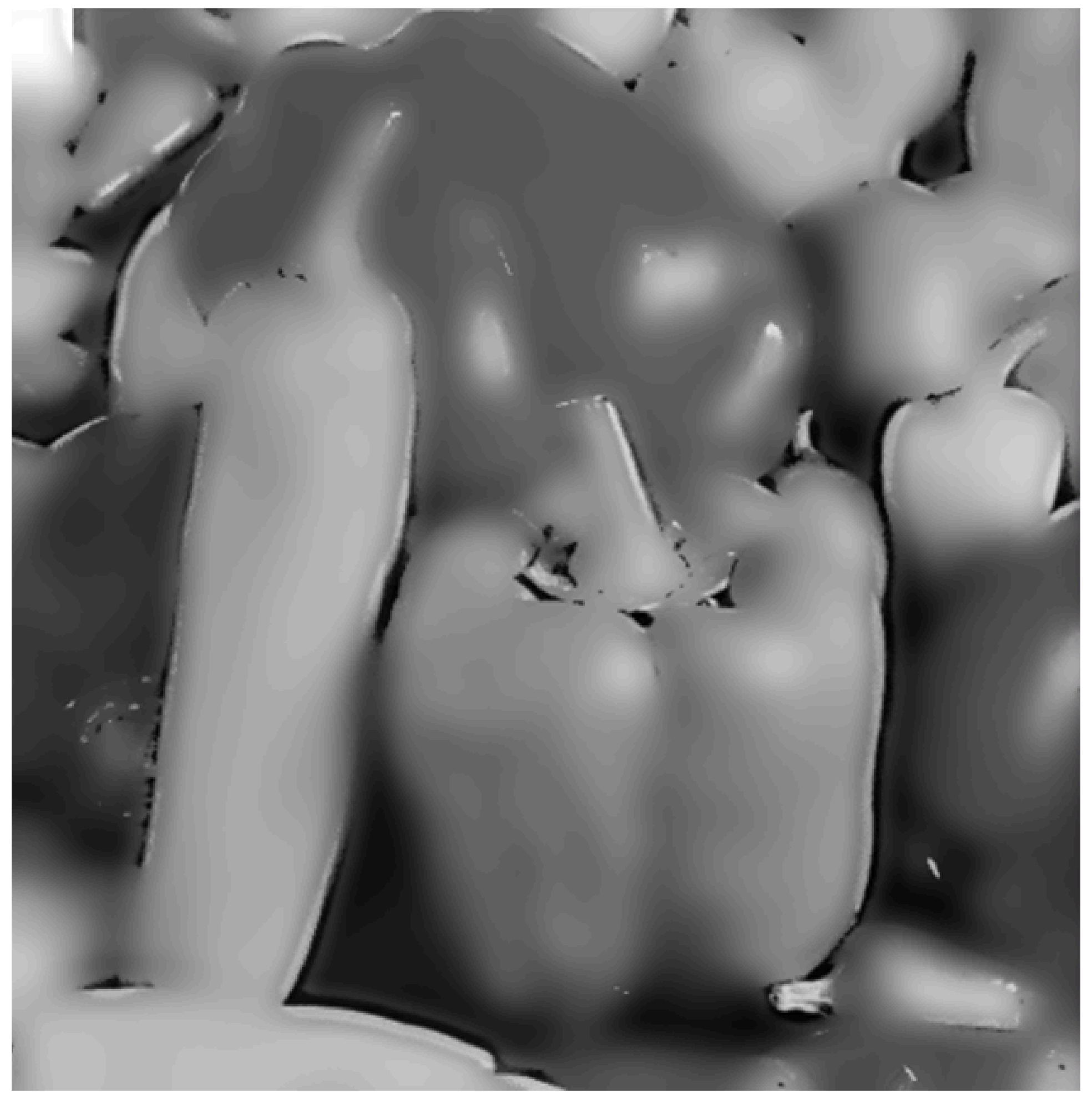


2. Contour lines of local frequency analysis blur metric matches perceived blur contour lines.

5. Edge aware algorithm



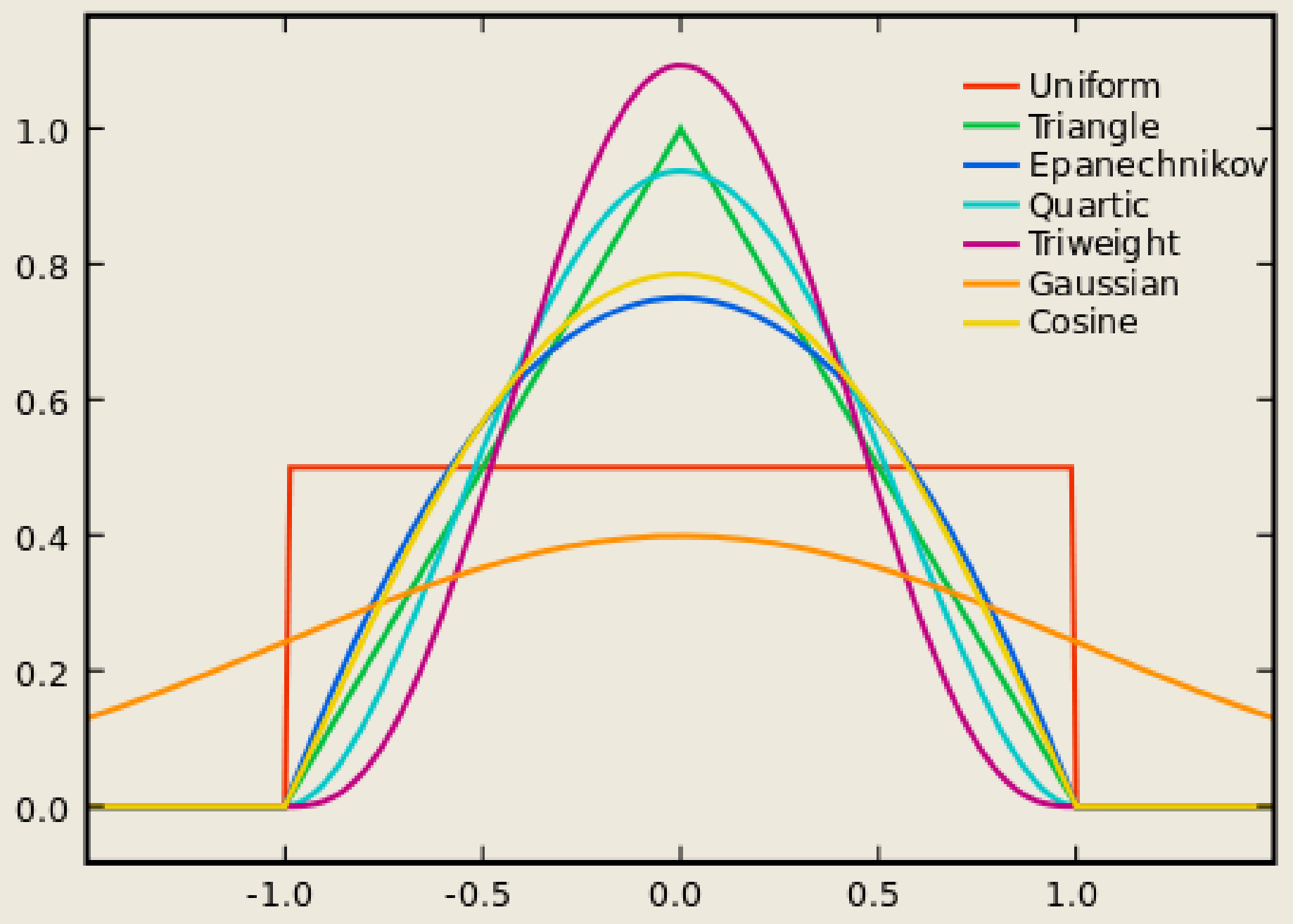
1. Idea: lower σr near edges
higher σr in other regions.



2. Result: Artifacts near edges and not good looking

6. Conclusion

1. Brute force algorithm can be used to abstract away σr parameter. However, it is not useful for very high kernel sizes.



2. Recommended to investigate behaviour with different range kernels. Implementing better edge detection might improve second algorithm.

7. Sources

Mandrill image:
Unknown. Baboon (mandrill) image, n.d. Retrieved from USC-SIPI Image Database.
Peppers image:
Unknown. Peppers image, n.d. Retrieved from USC-SIPI Image Database.