

# Image Deblurring for Medical Applications

A blind-deconvolution approach

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# BACKGROUND

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# THE HUMAN CORNEA



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# ENDOTHELIAL CELLS DENSITY



EPFL

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# ENDOTHELIAL CELLS DENSITY



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# ENDOTHELIAL CELLS DENSITY



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# ENDOTHELIAL CELLS DENSITY



EPFL

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# ENDOTHELIAL CELLS DENSITY

EPFL



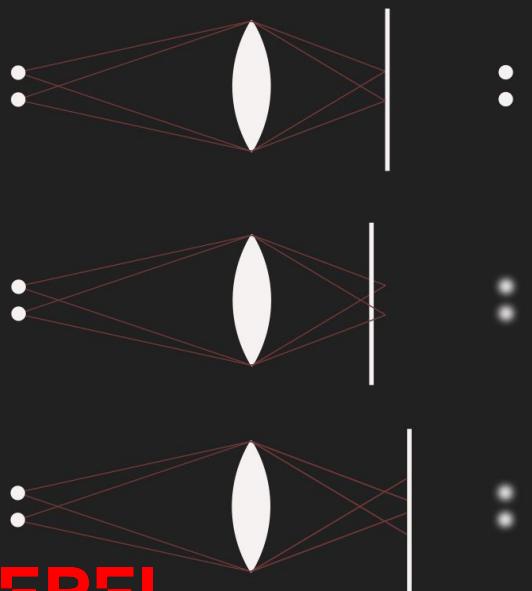
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# ENDOTHELIAL CELLS DENSITY



EPFL

# BLUR FROM DEFOCUS



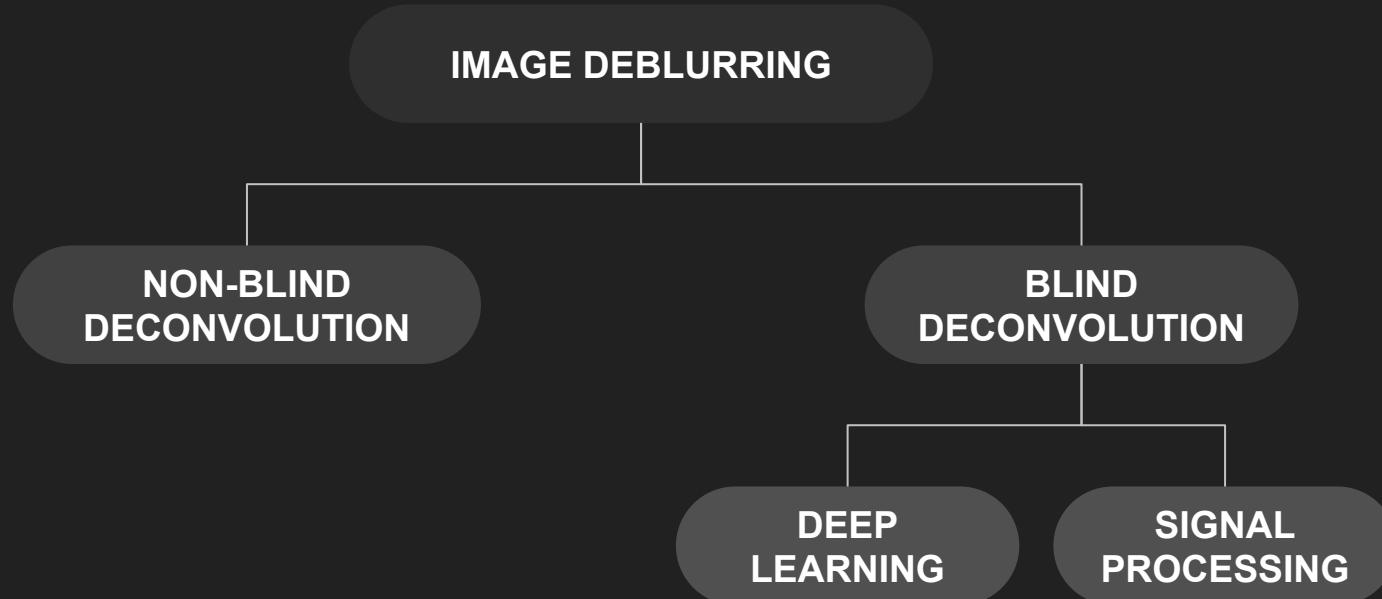
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# THE POINT SPREAD FUNCTION



Blurred = Ideal  $\otimes$  PSF

# EXISTING SOLUTIONS



# OUR SOLUTION

OBSERVE GROUND-TRUTH  
KERNELS

ESTIMATE DEPTH  
FROM BLUR

MODEL GAUSSIAN  
KERNELS

KERNELS LOOKUP  
TABLE

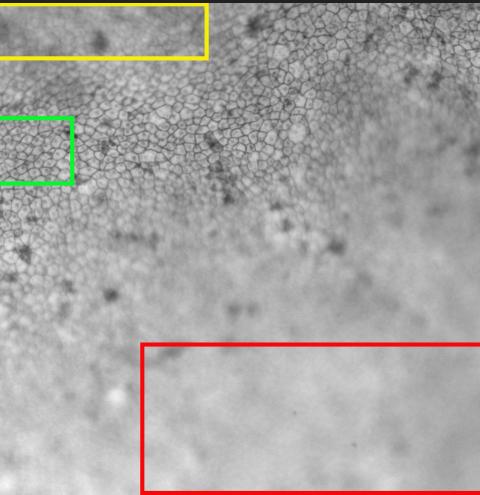
DECONVOLUTION

DECONVOLUTION

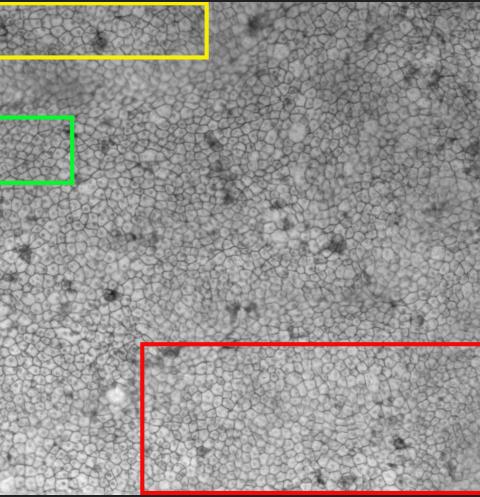
# ESTIMATING GROUND-TRUTH KERNELS

$$\underset{k}{\text{minimize}} \{ \|B - k \circledast I\|^2 + \|\lambda k\|^2 \}$$

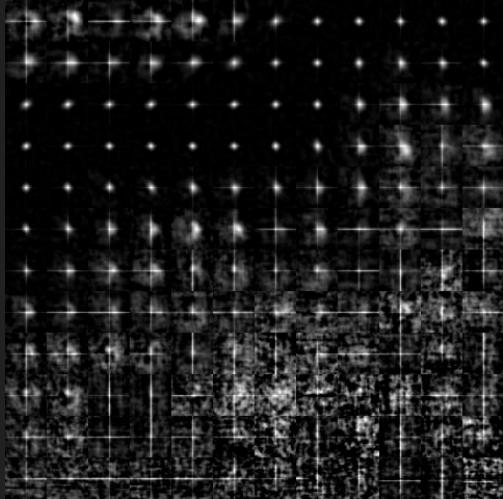
BLURRY IMAGE



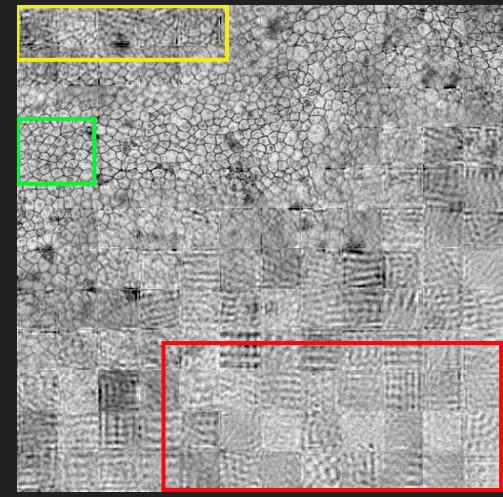
IDEAL IMAGE



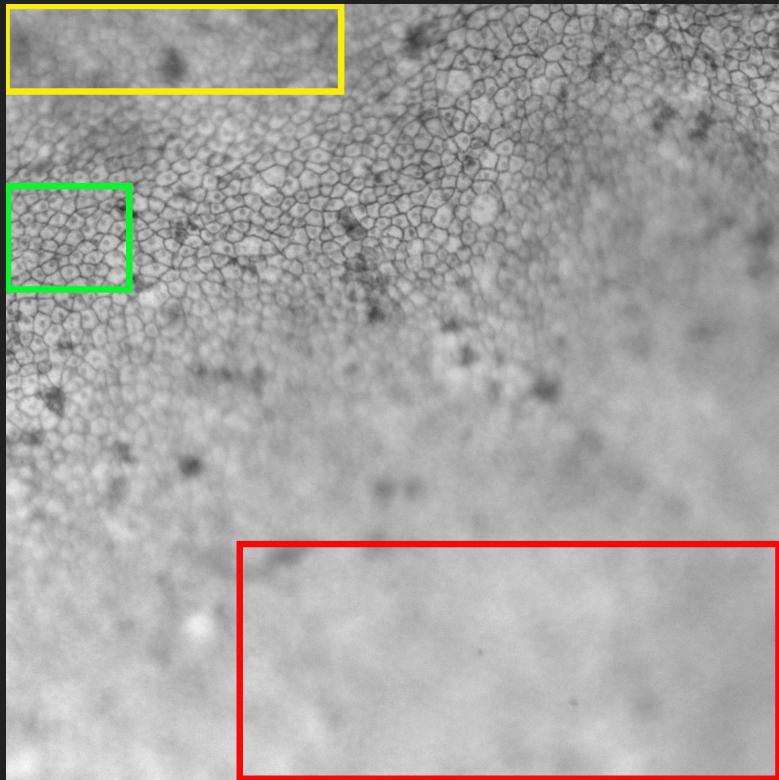
KERNEL MAP



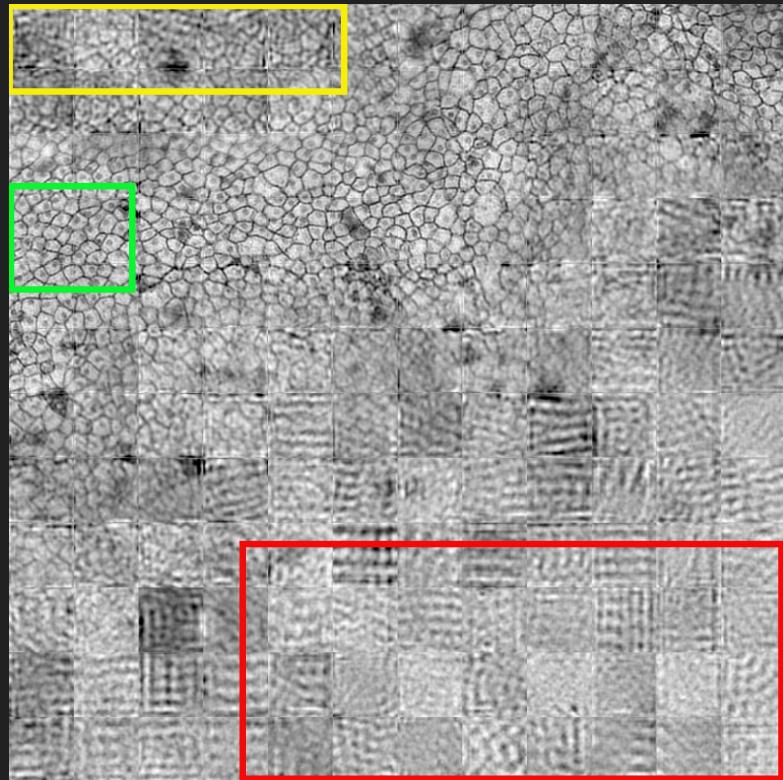
RECONSTRUCTED IMAGE



**BLURRY IMAGE**

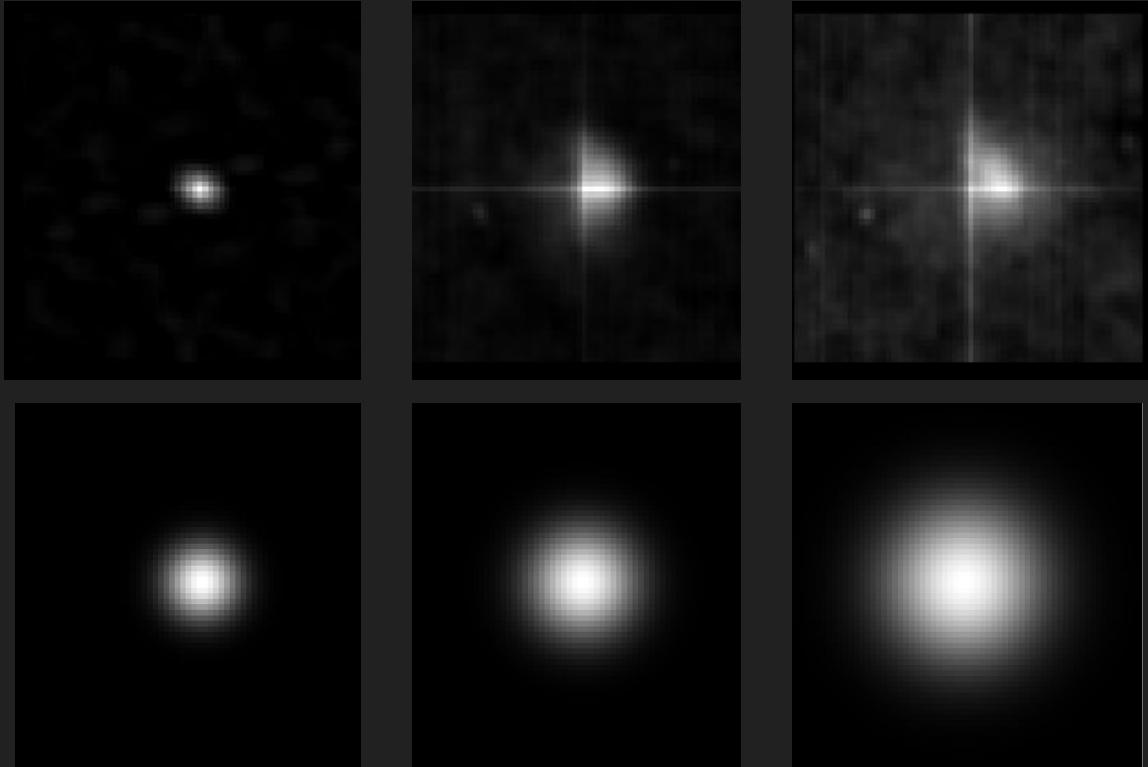
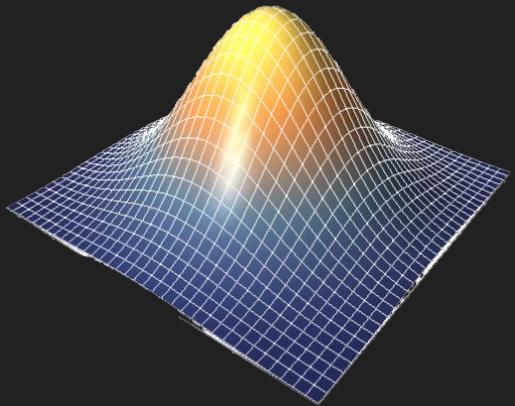


**RECONSTRUCTED IMAGE**



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# ESTIMATE KERNELS



$$PSF_{gaussian}(d) = \frac{1}{2\pi\sigma} \exp\left(-\frac{d^2}{2\sigma^2}\right)$$

# DEPTH FROM BLUR



ORIGINAL IMAGE



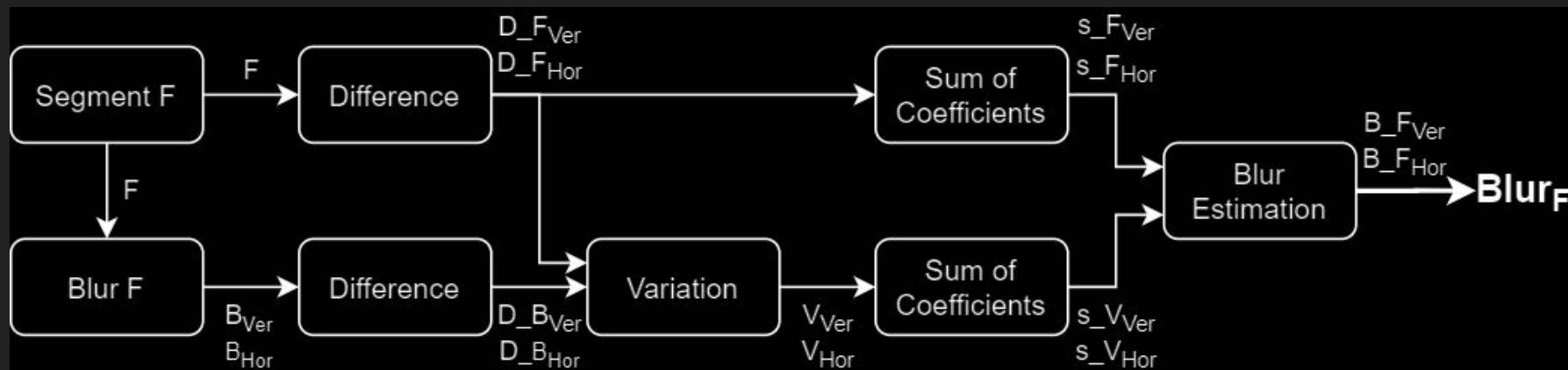
BLURRED ONCE



BLURRED TWICE

# DEPTH FROM BLUR

## CRÉTÉ METHOD



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# DEPTH FROM BLUR



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# DEPTH FROM BLUR

## RESULTS and CONCLUSIONS

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## ImageJ Reconstruction

GROUND  
TRUTH



EPFL

Original image microscope

BLURRY  
IMAGE



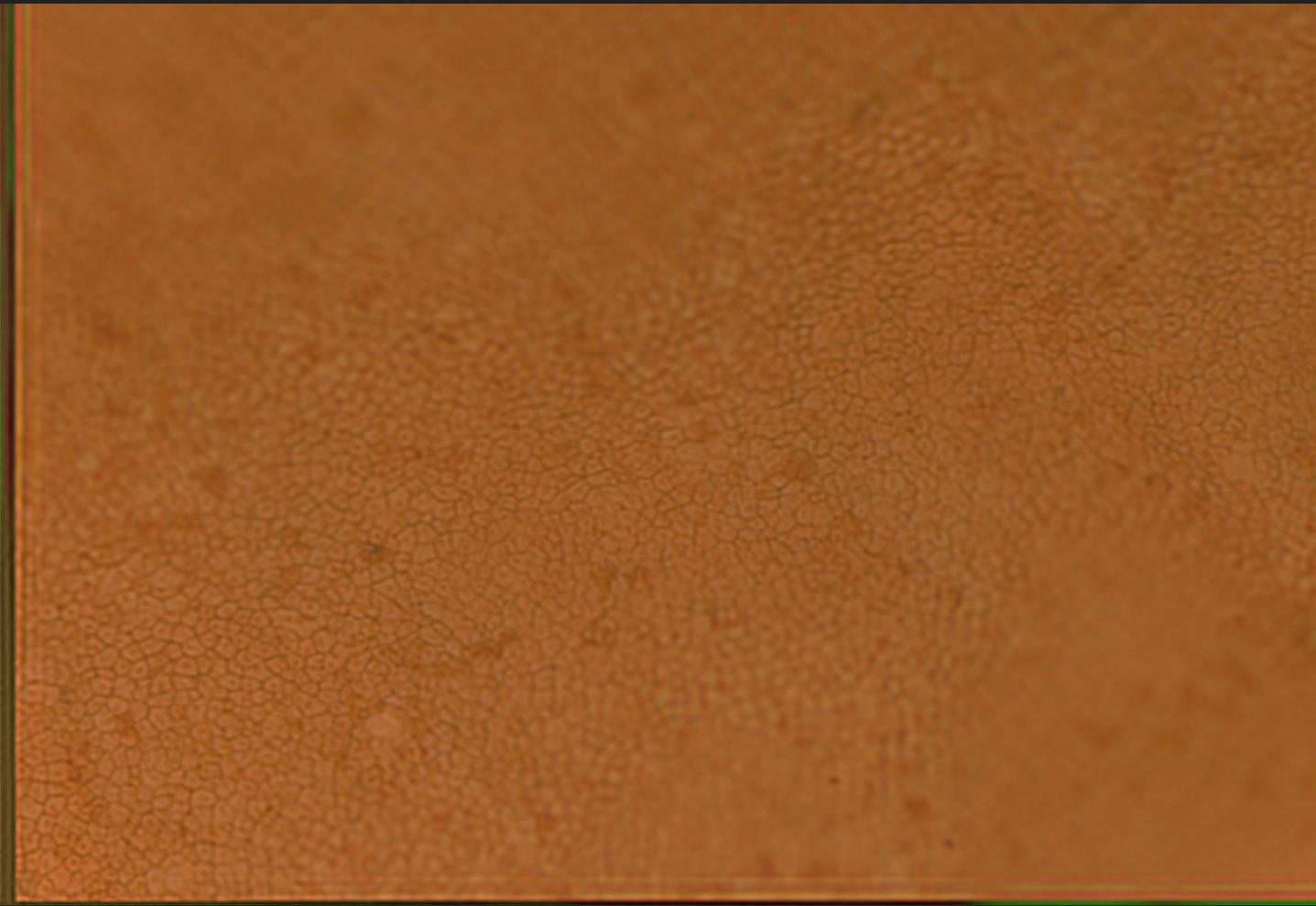
EPFL

Deblur with kernels from look up table

# SOLUTION 1

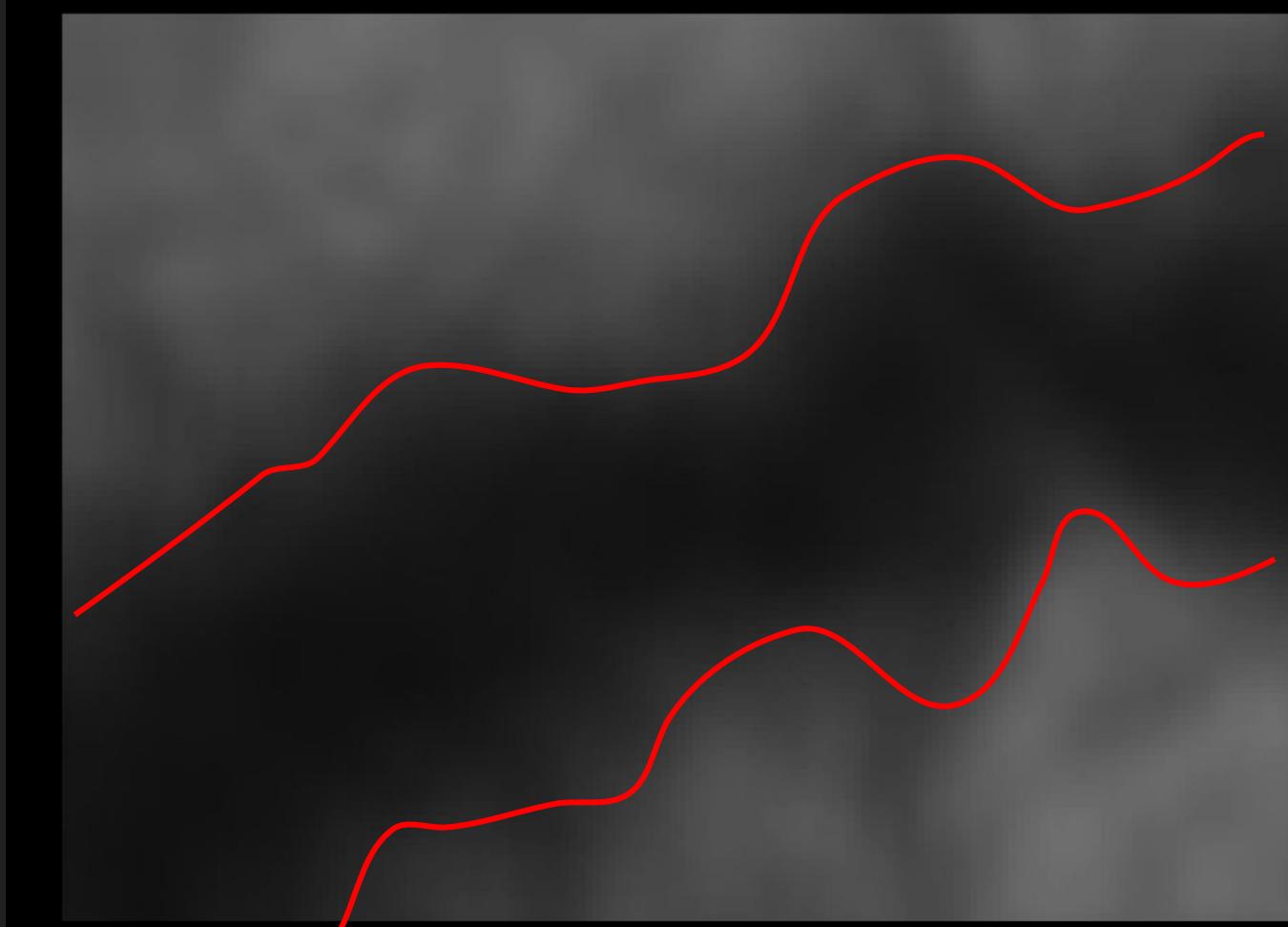


## SOLUTION 2



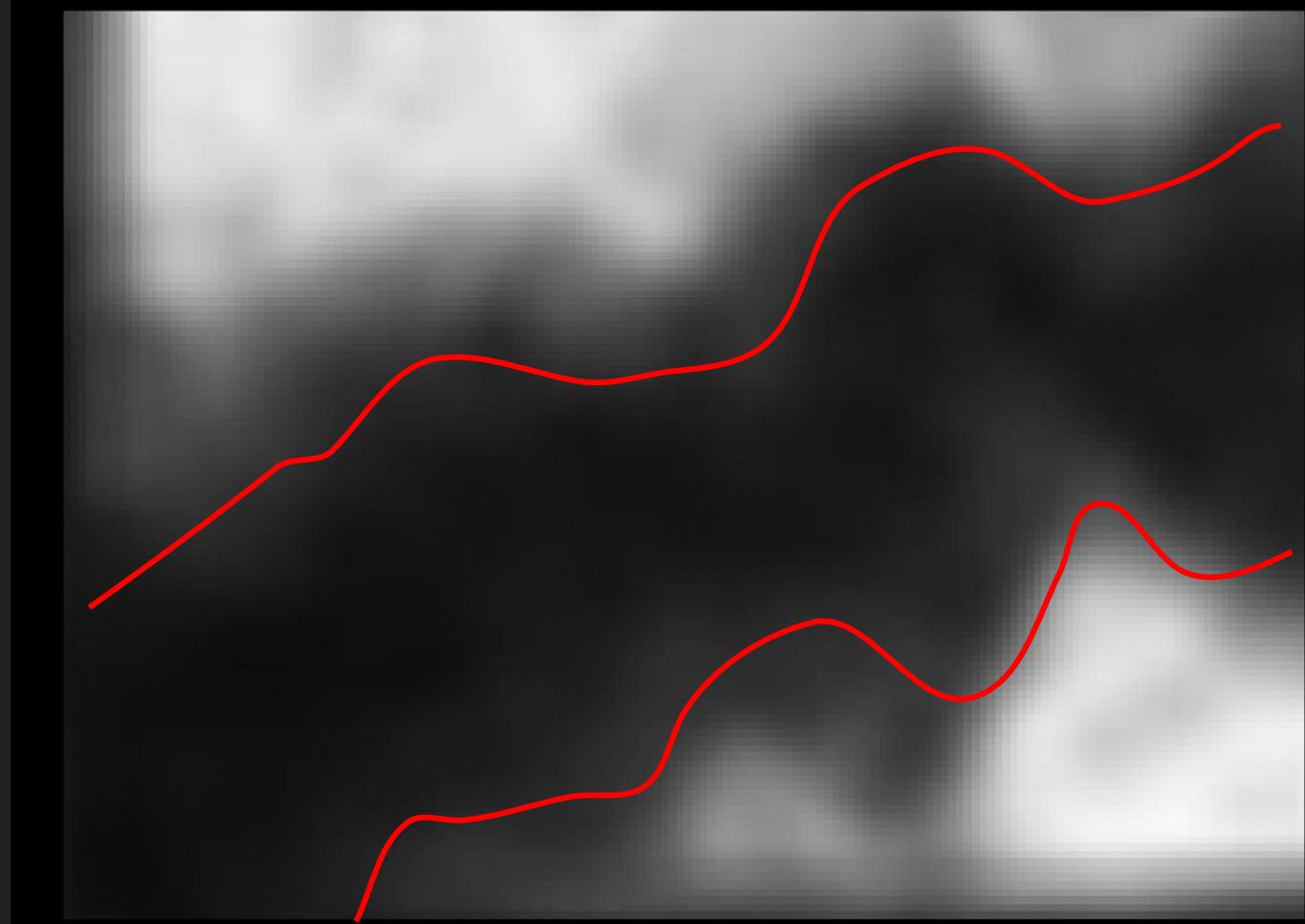
# RESULTS: BLUR MAP

Original



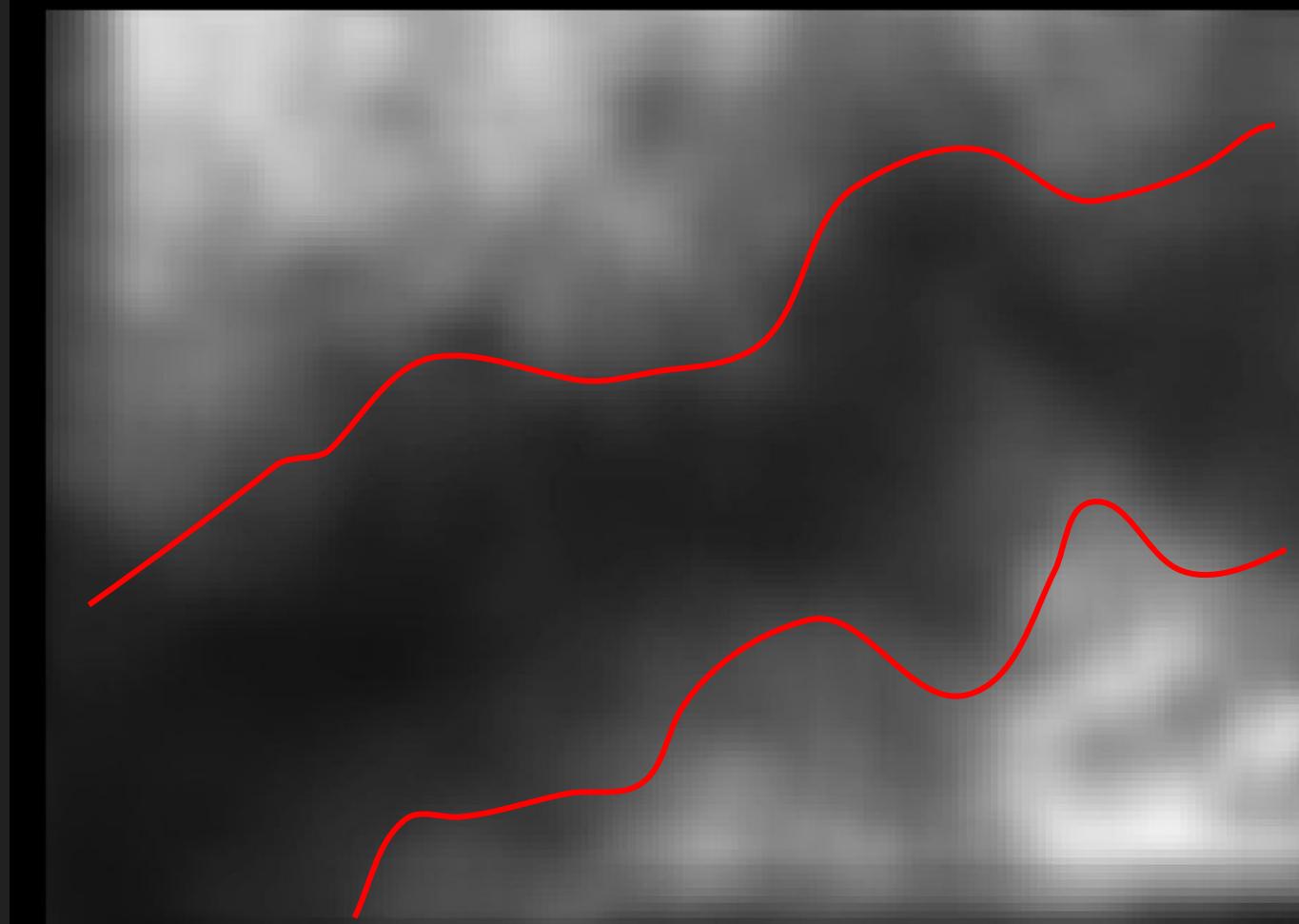
## Gaussian Kernels

# RESULTS: BLUR MAP



## Kernels from Lookup Table

# RESULTS: BLUR MAP



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## CONCLUSIONS:

- Both methods shown limited improvement
- The Gaussian kernels estimation method was slightly superior
- A sight on possible improvements: shifted kernel centers, improving blur map to indicate closer/farther to camera area

THE END

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