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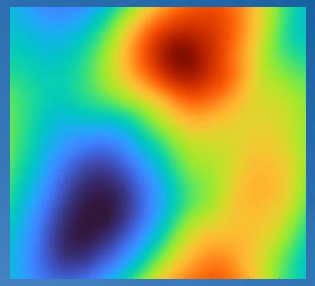

What? Why? How?
Deblurring Images

Viktor Palm

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Oskar Tamm

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Aravind Simon

Tiia Lillemaa

Vijayakumar Anand

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29th October 2022

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OUTLINE

- What and Why Deblurring
- Concepts of linear imaging systems
- Forms of correlation - MATLAB
- Lucy-Richardson algorithm
- Summary

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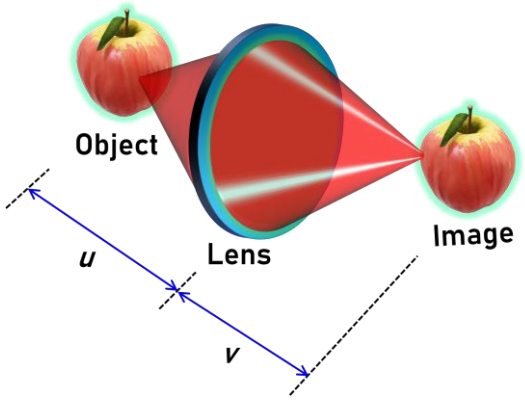
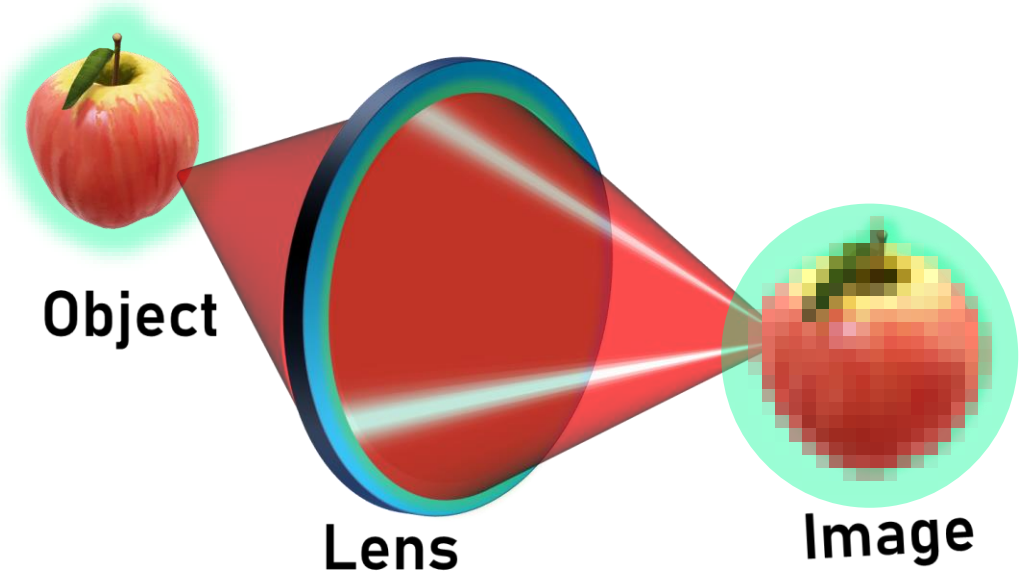
What and Why Deblurring

Blurring occurs due to a variety of reasons

1. Out of focus
2. Motion





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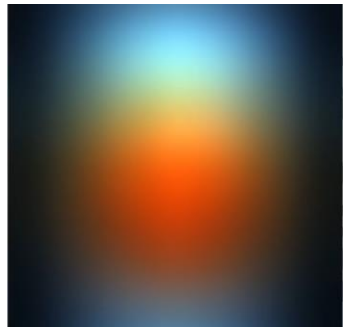
What and Why Deblurring

Blurring occurs due to a variety of reasons

1. Out of focus
2. Motion

Object

Camera image



Computational reconstruction

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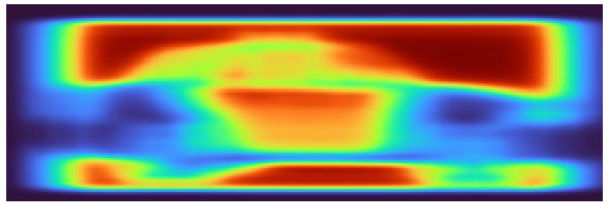
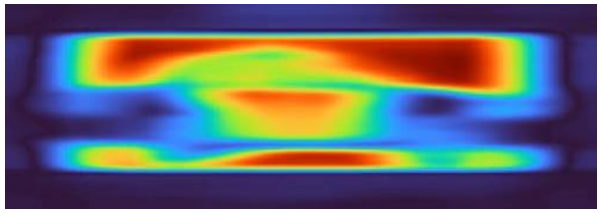
Object in motion



Camera image



Computational reconstruction

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Linear imaging systems – Vending machine concept

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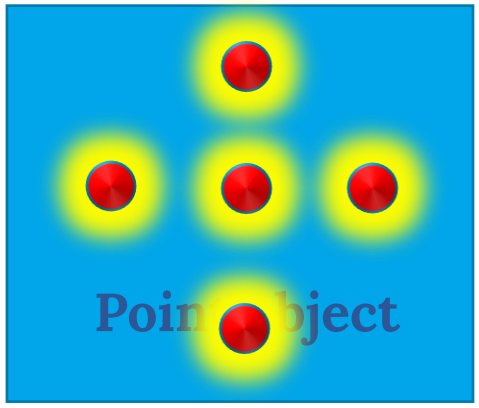
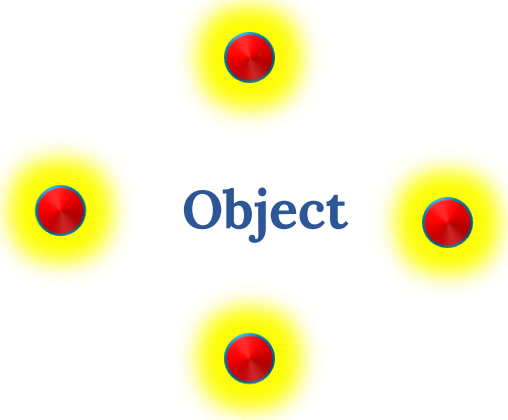
Linear imaging systems – Vending machine concept



Monitor

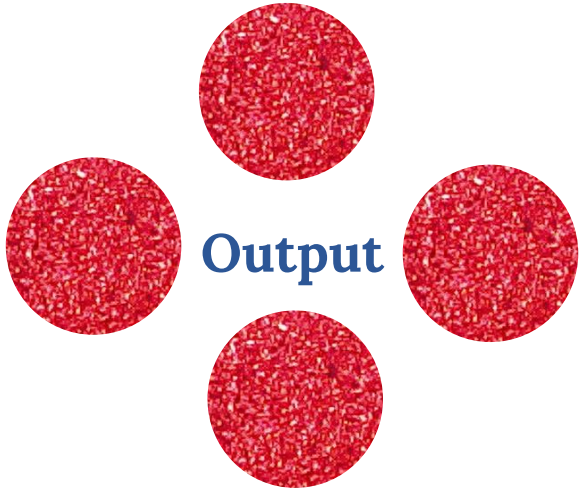
Optical system

PSF



Object

Optical system



Output

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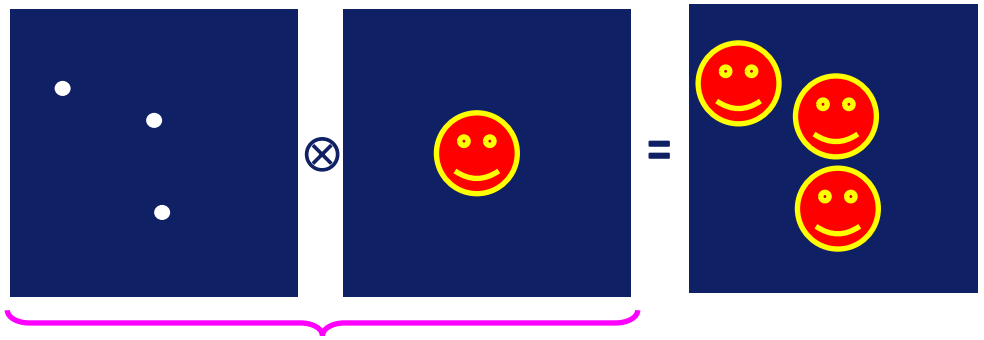
Convolution & Correlation – Mathematical form



$$F^{-1}\left[F\{ \quad \} \times F\{ \quad \} \right]$$

Convolution

$$F^{-1}\left[F\{ \quad \} \times F\{ \quad \} \right]$$

Correlation

$\overline{\quad}$ **Complex conjugate**

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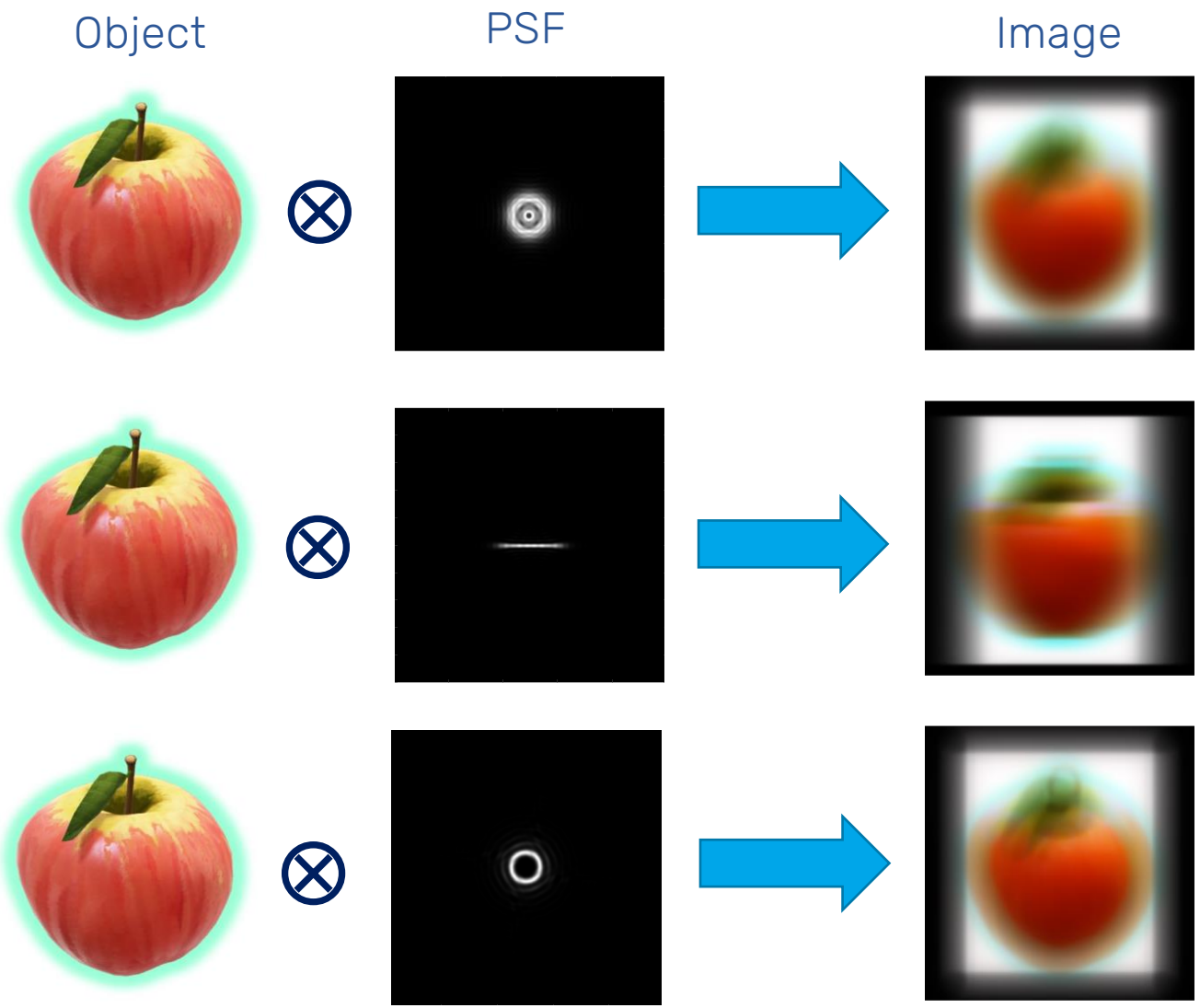
Examples of convolution with PSFs



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OUTLINE

- Direct and Indirect imaging concepts
- Infrared microspectroscopy
- Forms of correlation - MATLAB
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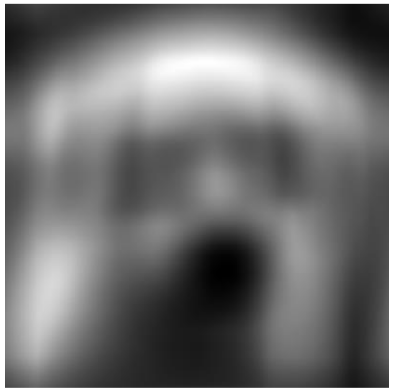
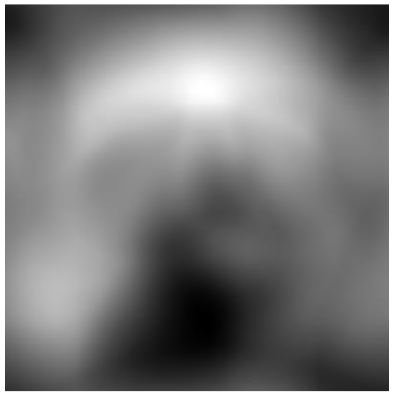
Forms of Correlation

1. Matched Filter (α=1,β=1)
2. Phase-only filter (α=0,β=1)
3. Weiner Filter or Inverse filter (α=-1,β=1)
4. Non-linear filter (α,β)
5. Regularized filter (PSF with noise)

Ground truth

Blurred





Deblurred

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MATLAB code – Participants 1.m

https://bit.ly/ciphr-ws211

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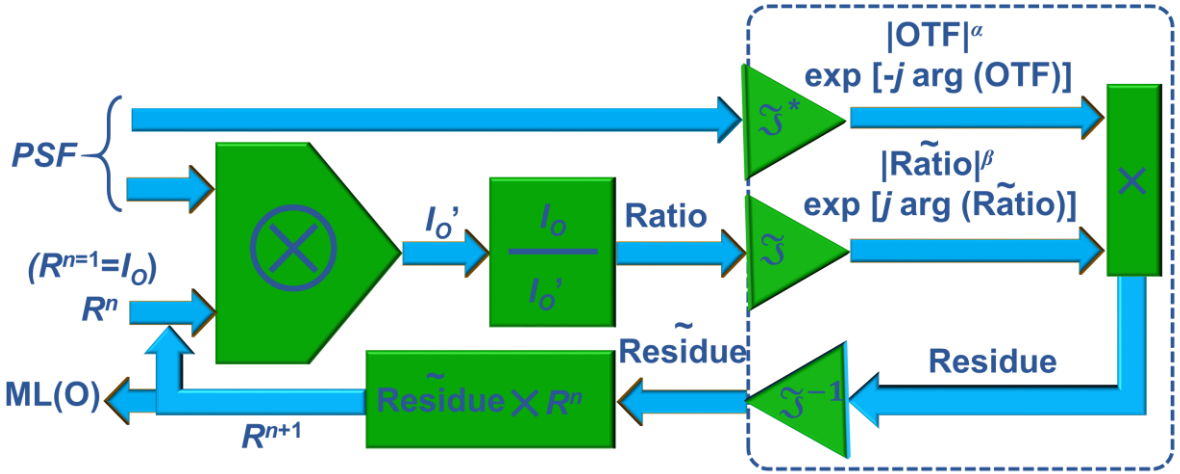
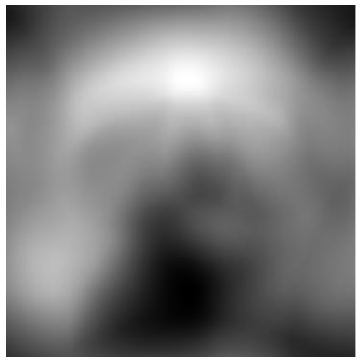
Lucy-Richardson-Rosen algorithm

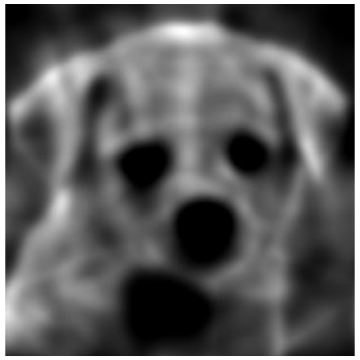
Lucy-Richardson Algorithm: The LRA approach is iterative where the $(n+1)^{th}$ reconstructed image is given as $I_R^{n+1} = I_R^n \left\{ \frac{I_p}{I_R^n \otimes I_{PSF}} \otimes I_{PSF}' \right\}$, where I_{PSF}' refers to the complex conjugate of I_{PSF} and the loop is iterated until an optimal reconstruction is obtained.



Ground truth



Blurred



Deblurred

MATLAB code – Participants 1.m

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Summary

- The fundamentals of blurring and deblurring have been discussed.
- Convolution and correlation concepts have been presented.
- Different types of deblurring methods discussed and demonstrated.

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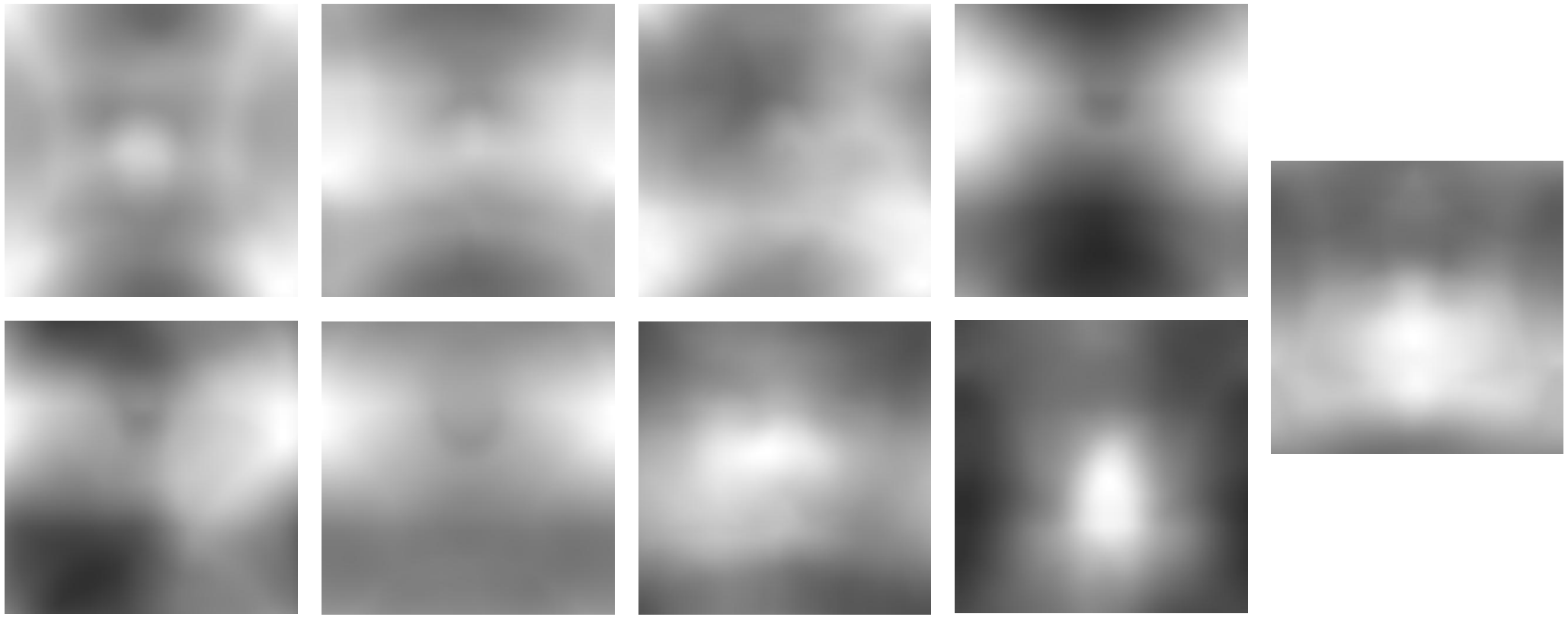
Challenge – 2

Who is who?



Clue (PSF) – I am a uniform disc. My radius (in pixels) is the sum of 8 consecutive prime numbers after the number 5.

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Questions ???

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