

Learning where to look: A foveated visuomotor control model

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CNS*2019, 15/7/2019

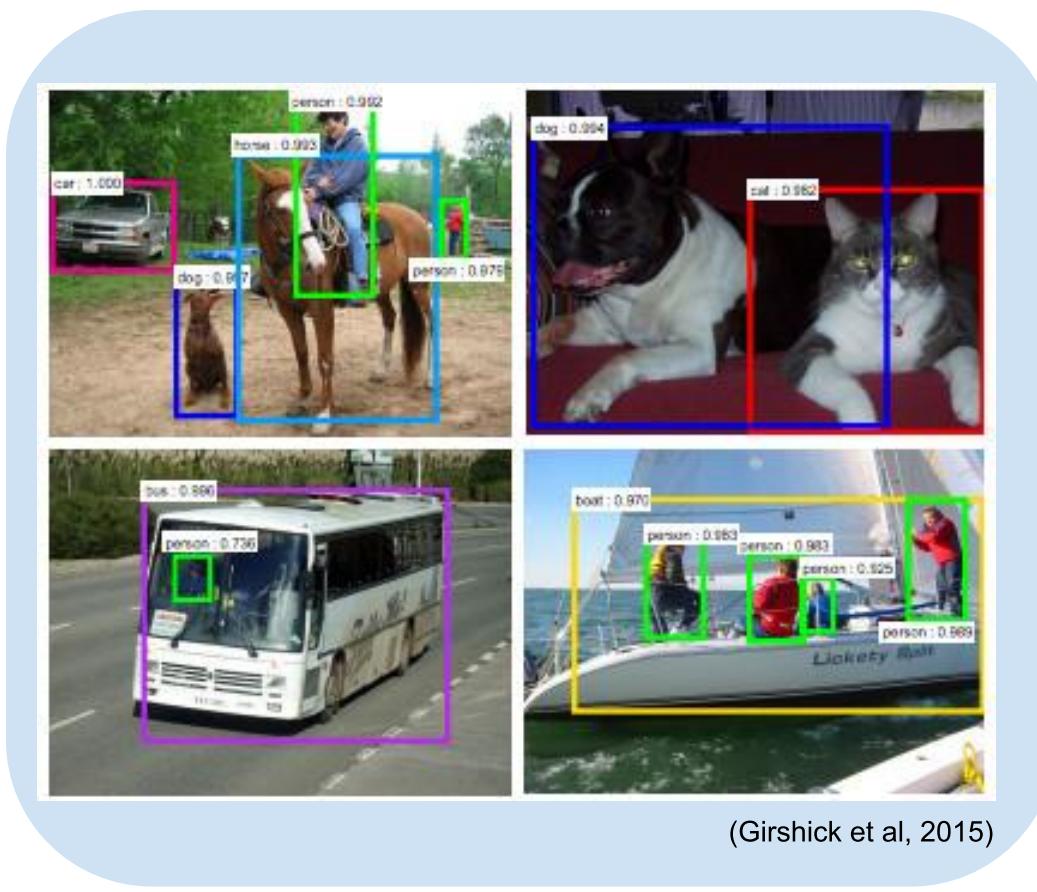
Outline

1. Motivation
2. Methods
3. Results
4. Conclusion

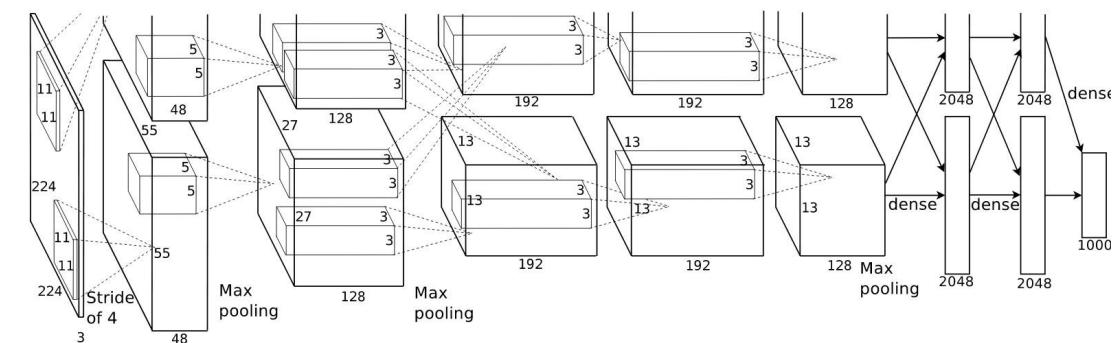
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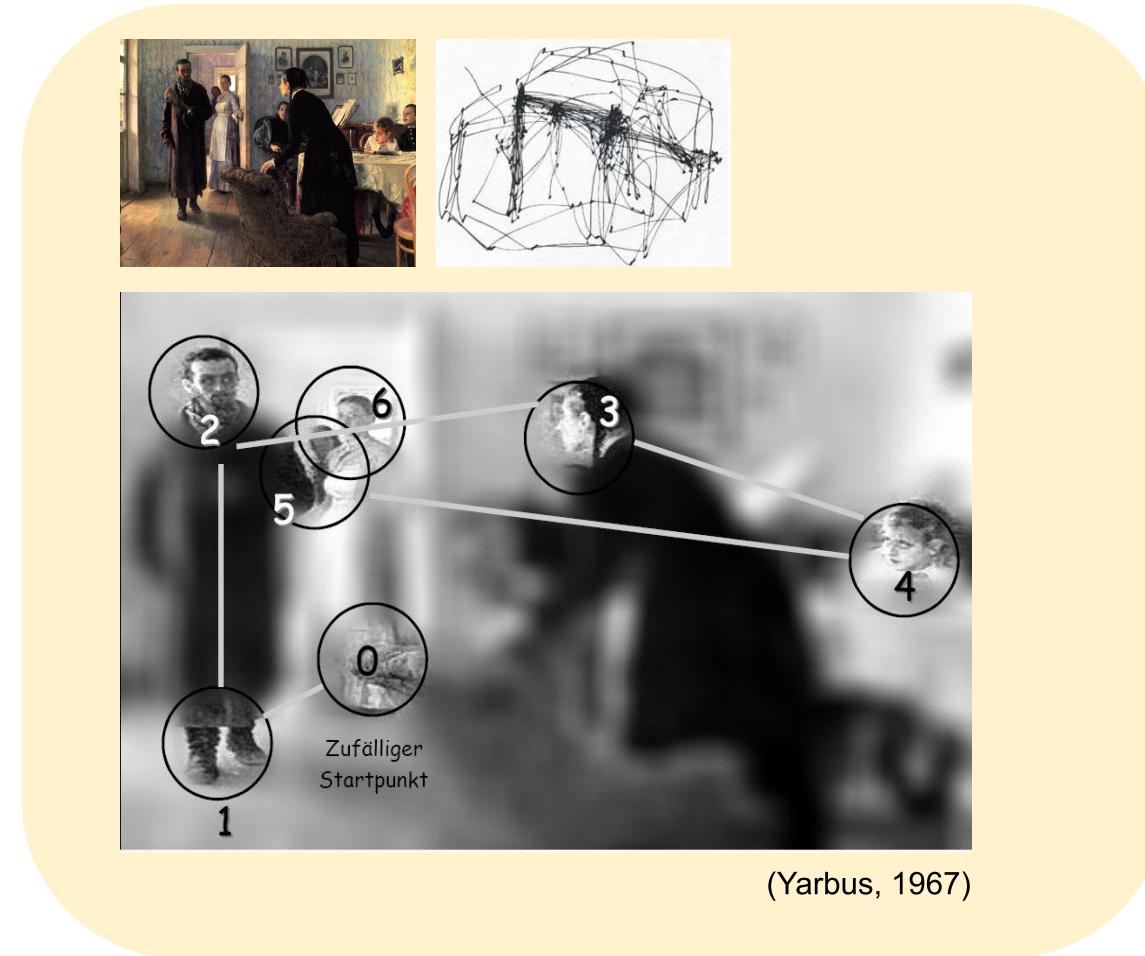
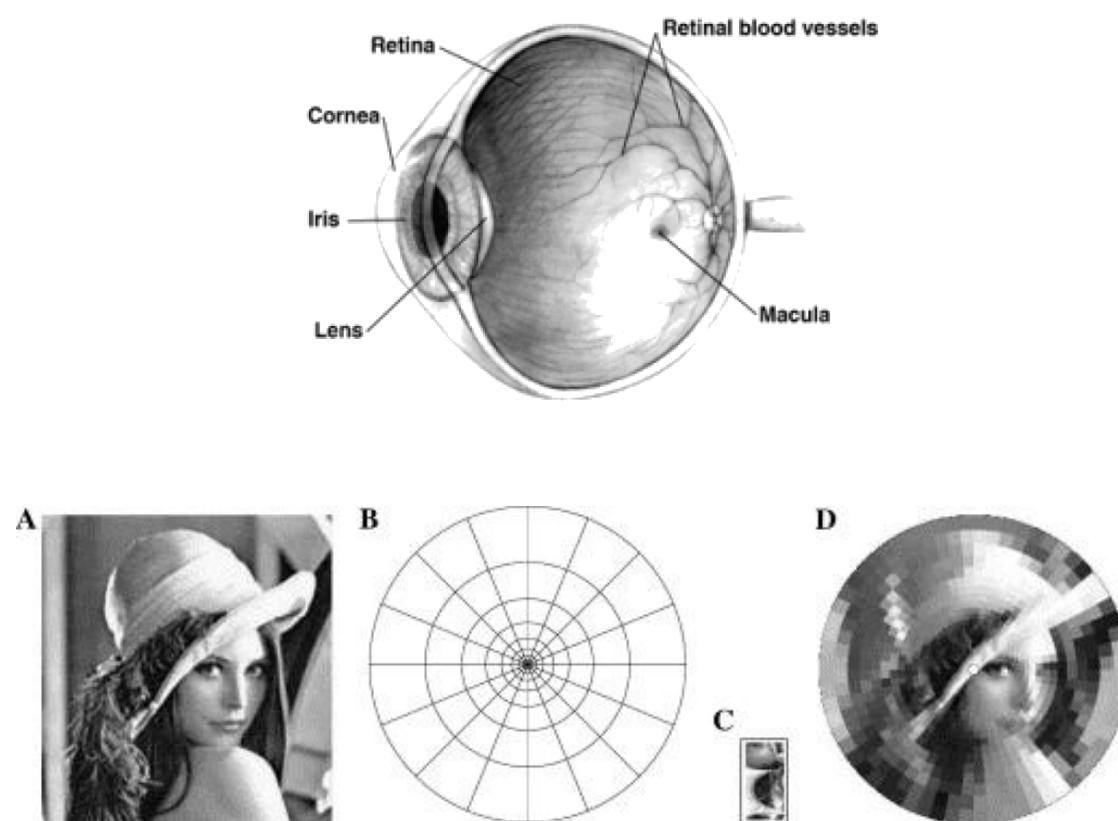
Computer vision



+

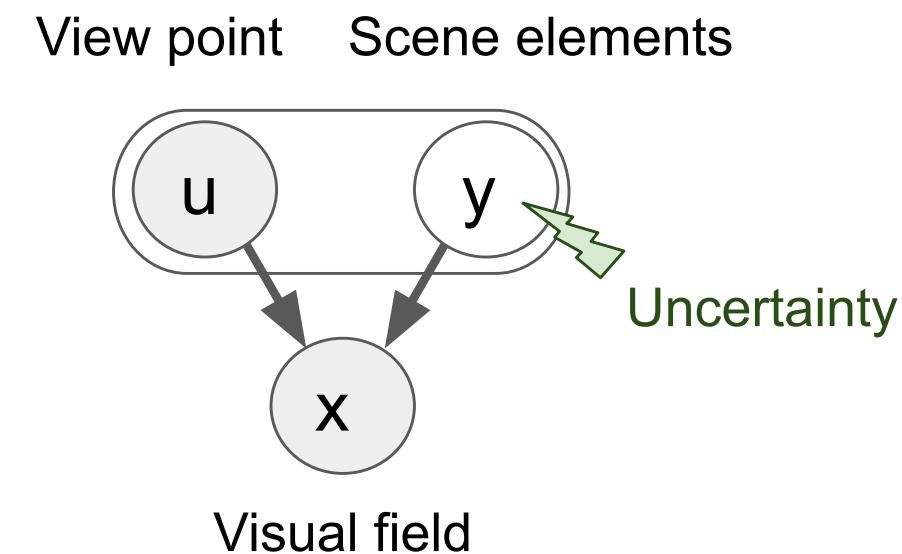
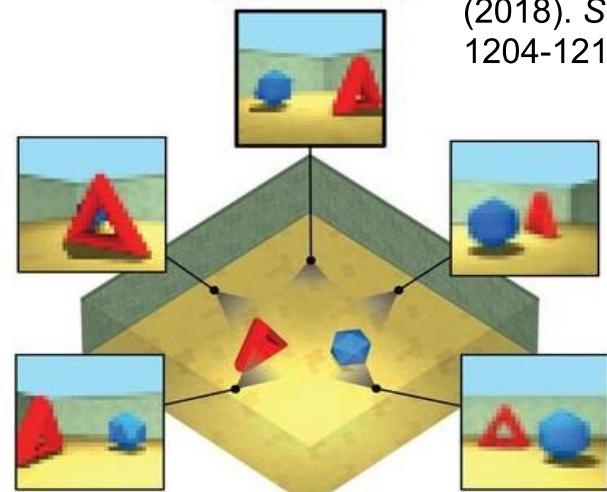


Human vision



Statistical Viewpoint

Eslami, S. A., Rezende, et al.
(2018). *Science*, 360(6394),
1204-1210.



Attention vs. Scene Understanding

Bayesian surprise
(Information Gain)

(Itti & Baldi, 2009)

$$E_y [\log P(Y|x, u) - \log P(Y)]$$

B O T T O M - U P

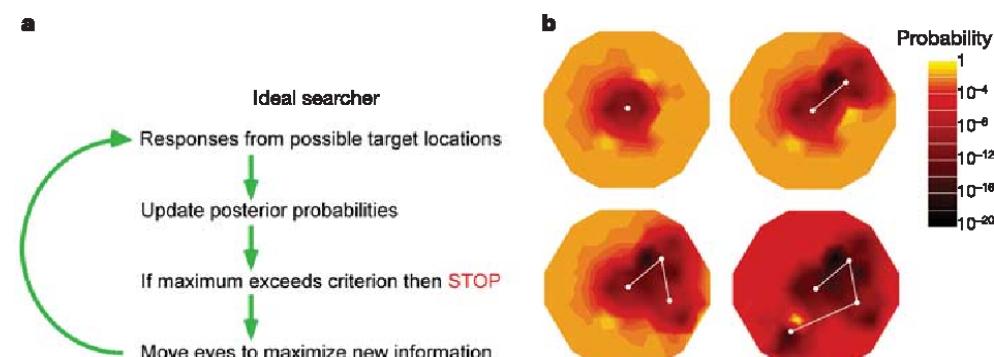
Visual attention
Saliency Maps



Itti and Koch (2000)
Kümmerer et al (2015)

T O P - D O W N

Active Inference
Recurrent Attention



Najemnik, J., & Geisler, W. S. (2005)
Butko & Movellan (2010)
Fu et al (2017)

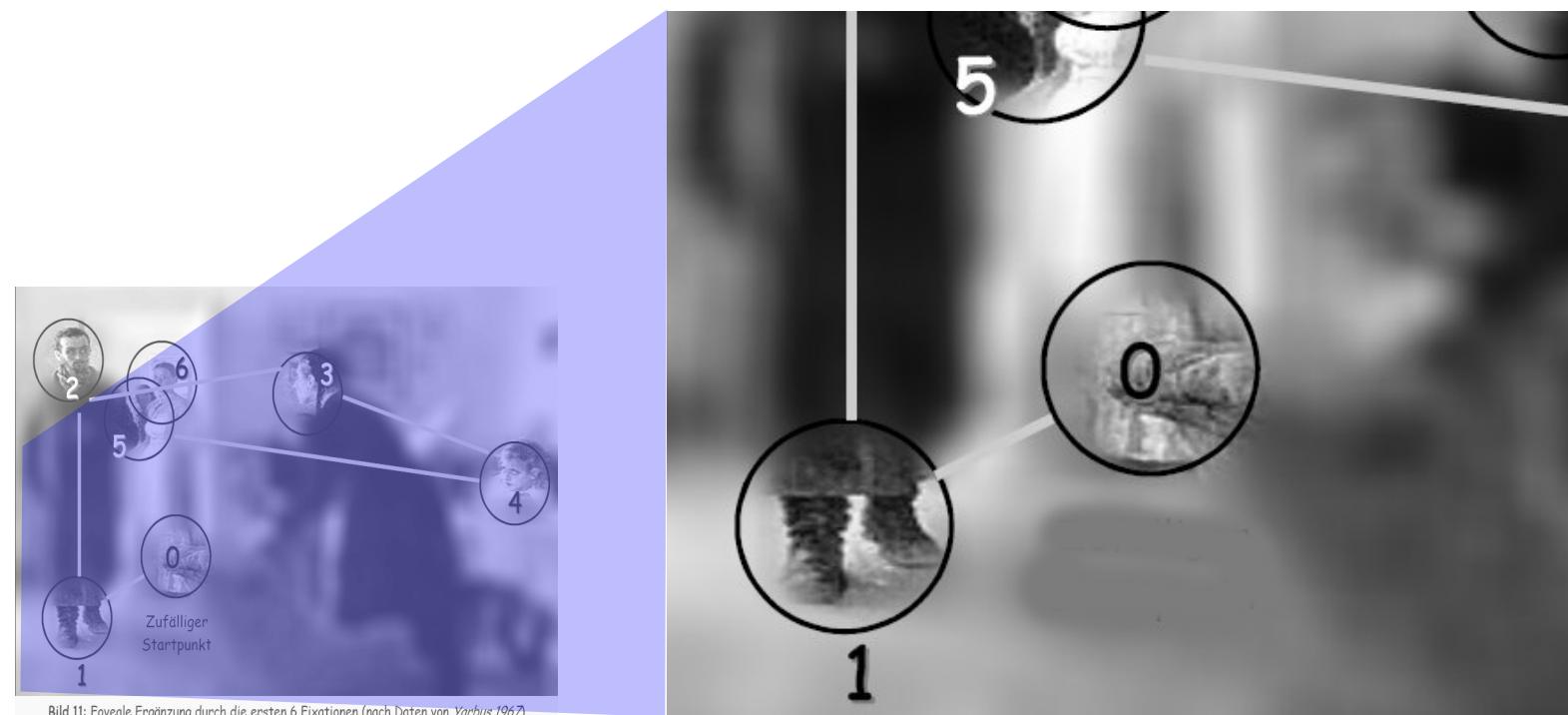
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Principles for central and peripheric vision

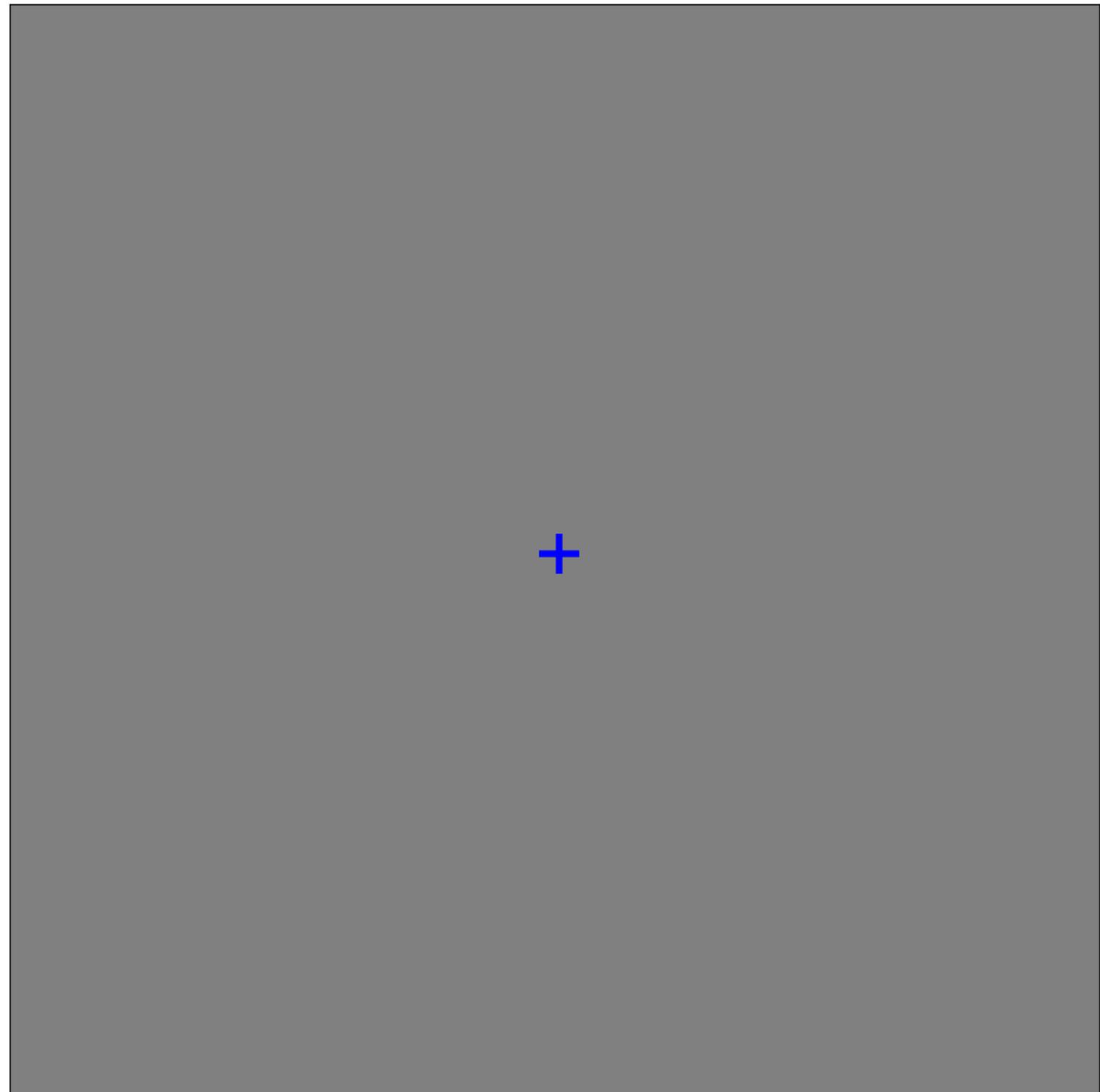


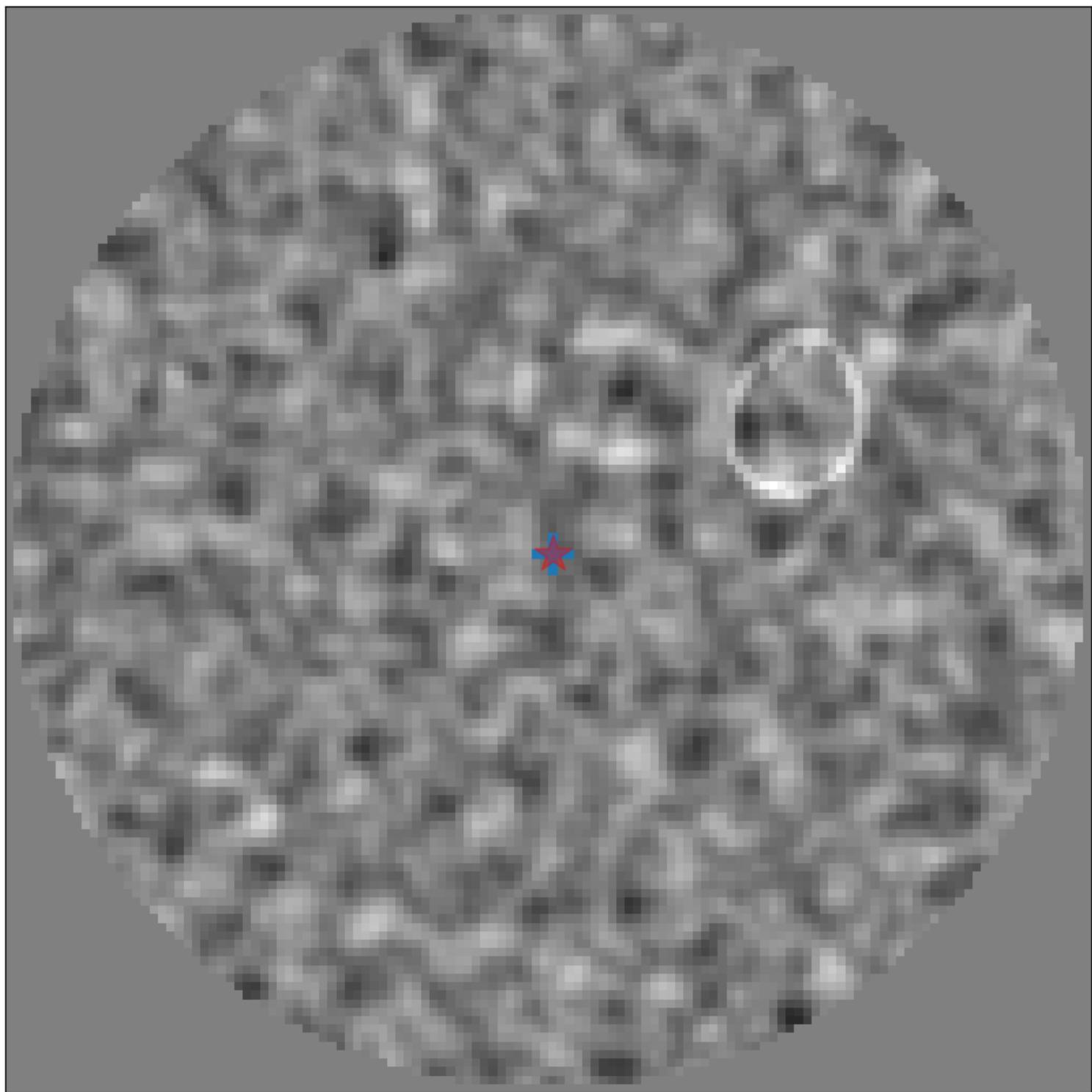
Information Gain :

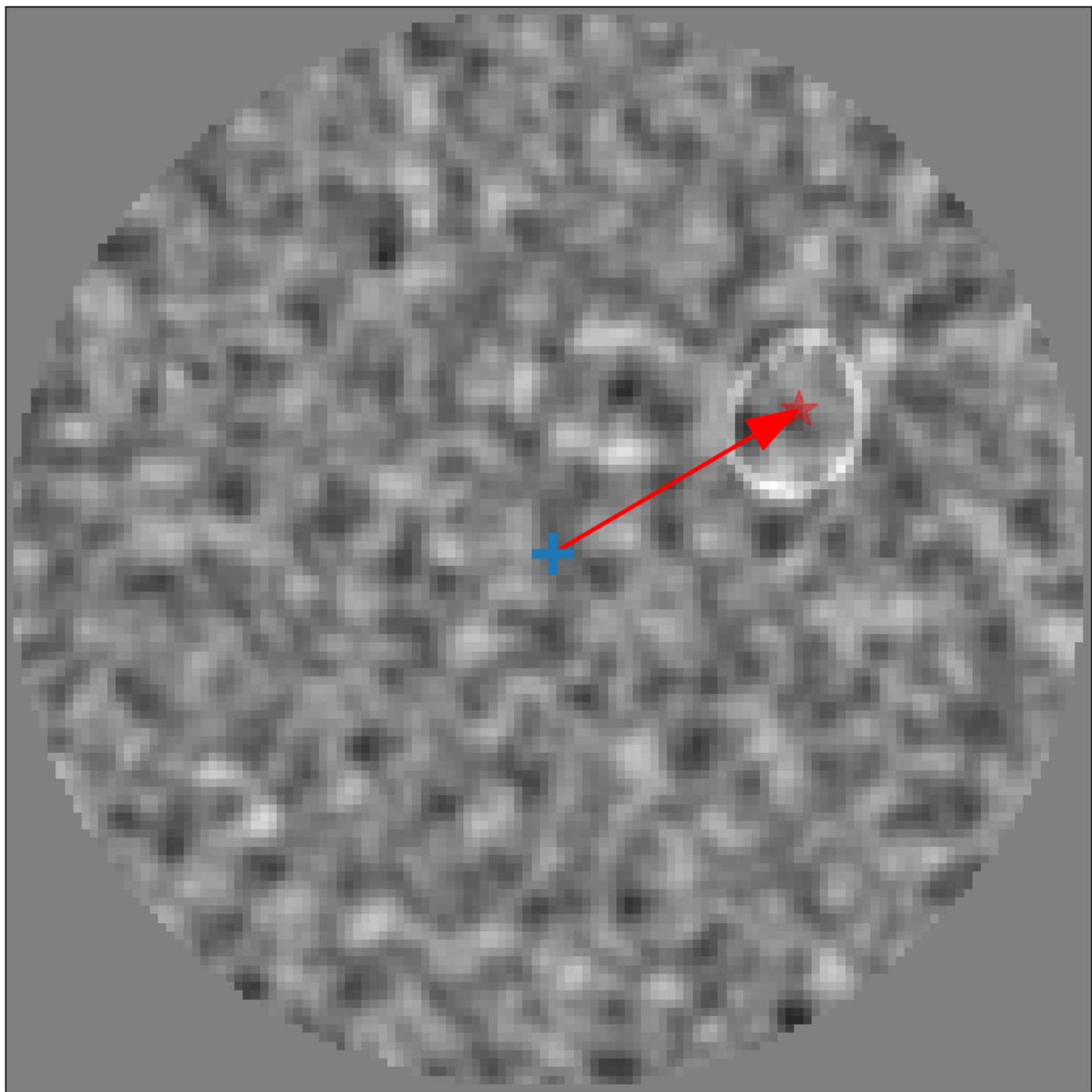
$$E_y [\log P(Y|x, u) - \log P(Y)]$$

Peripheral processing

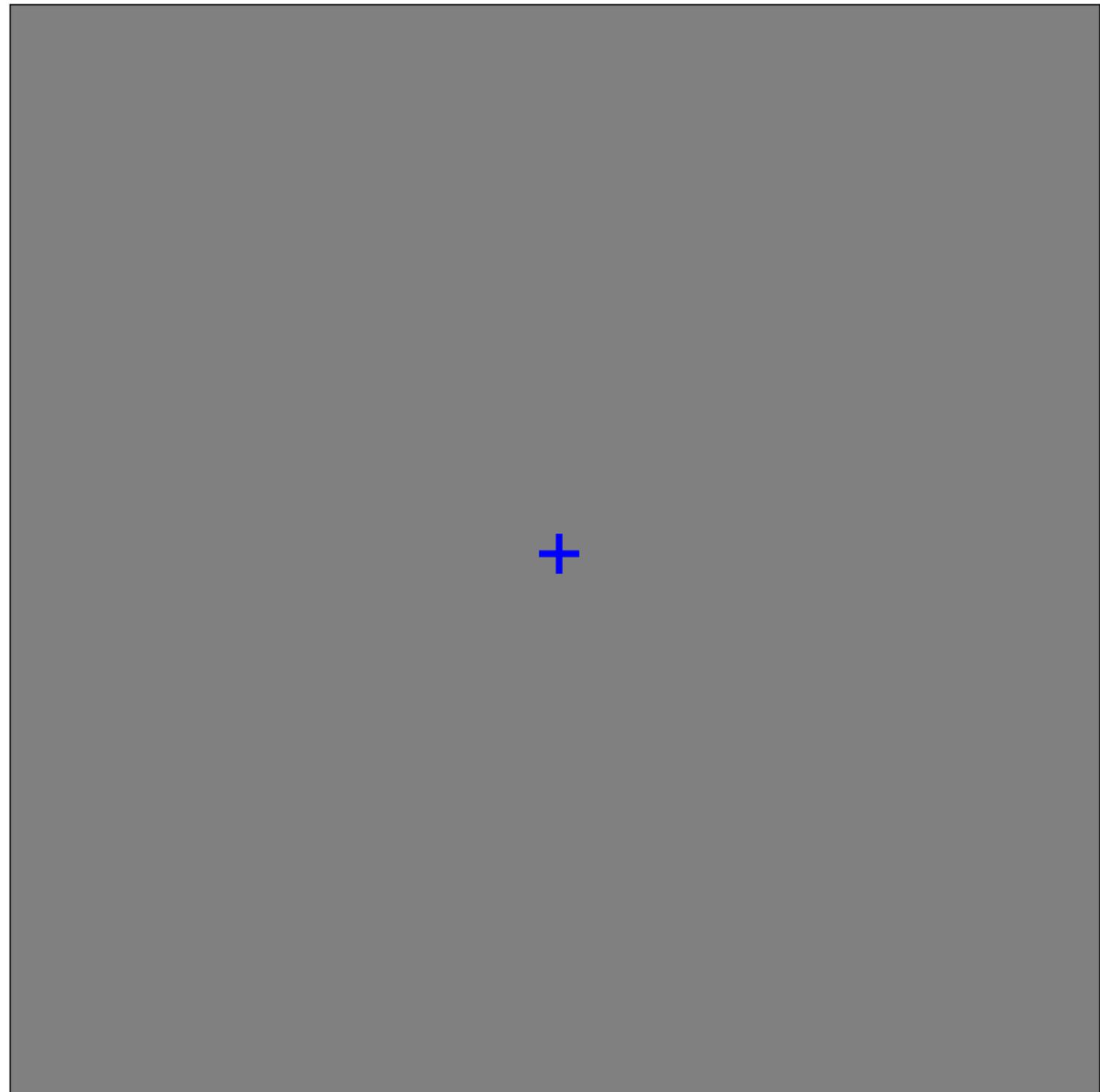
Central processing

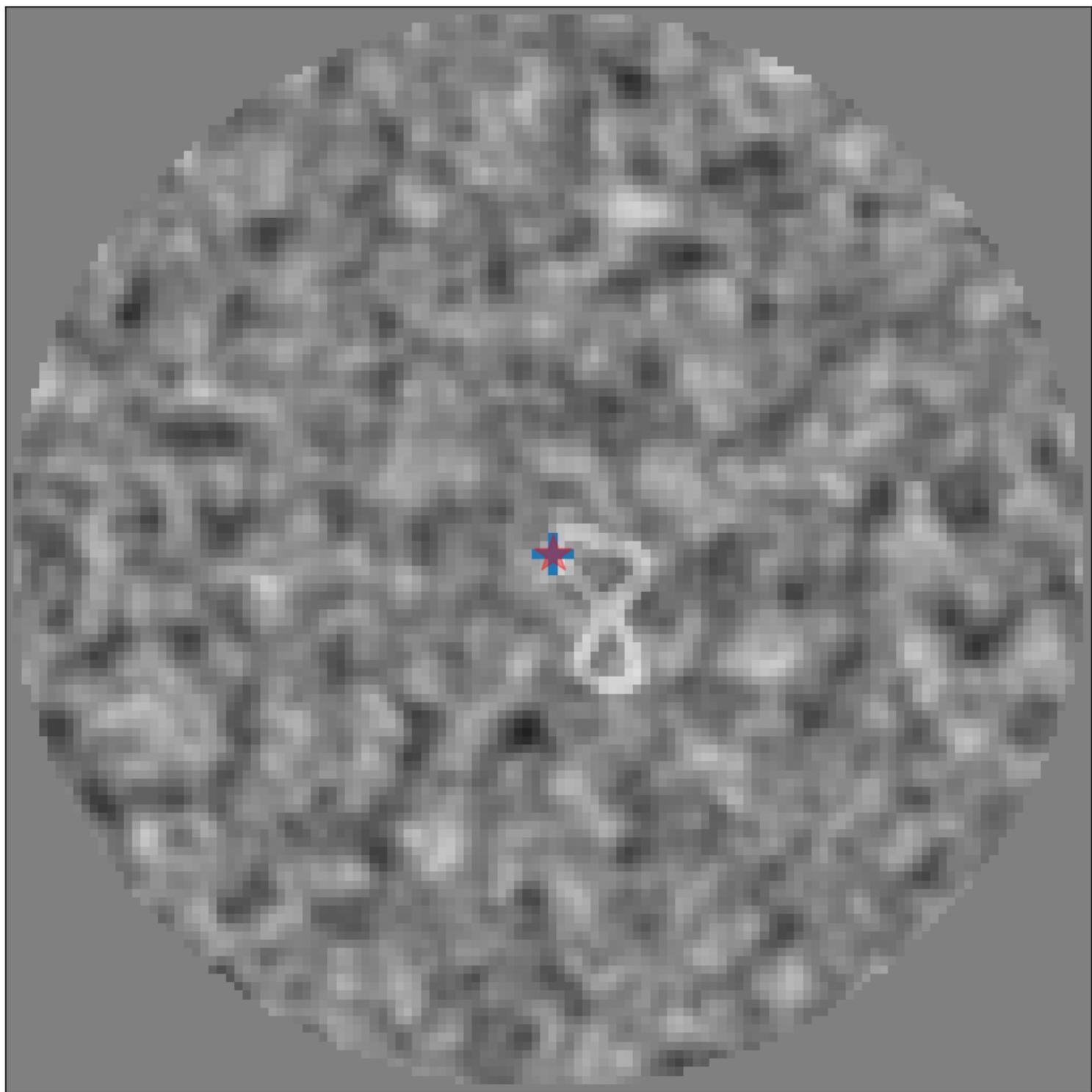


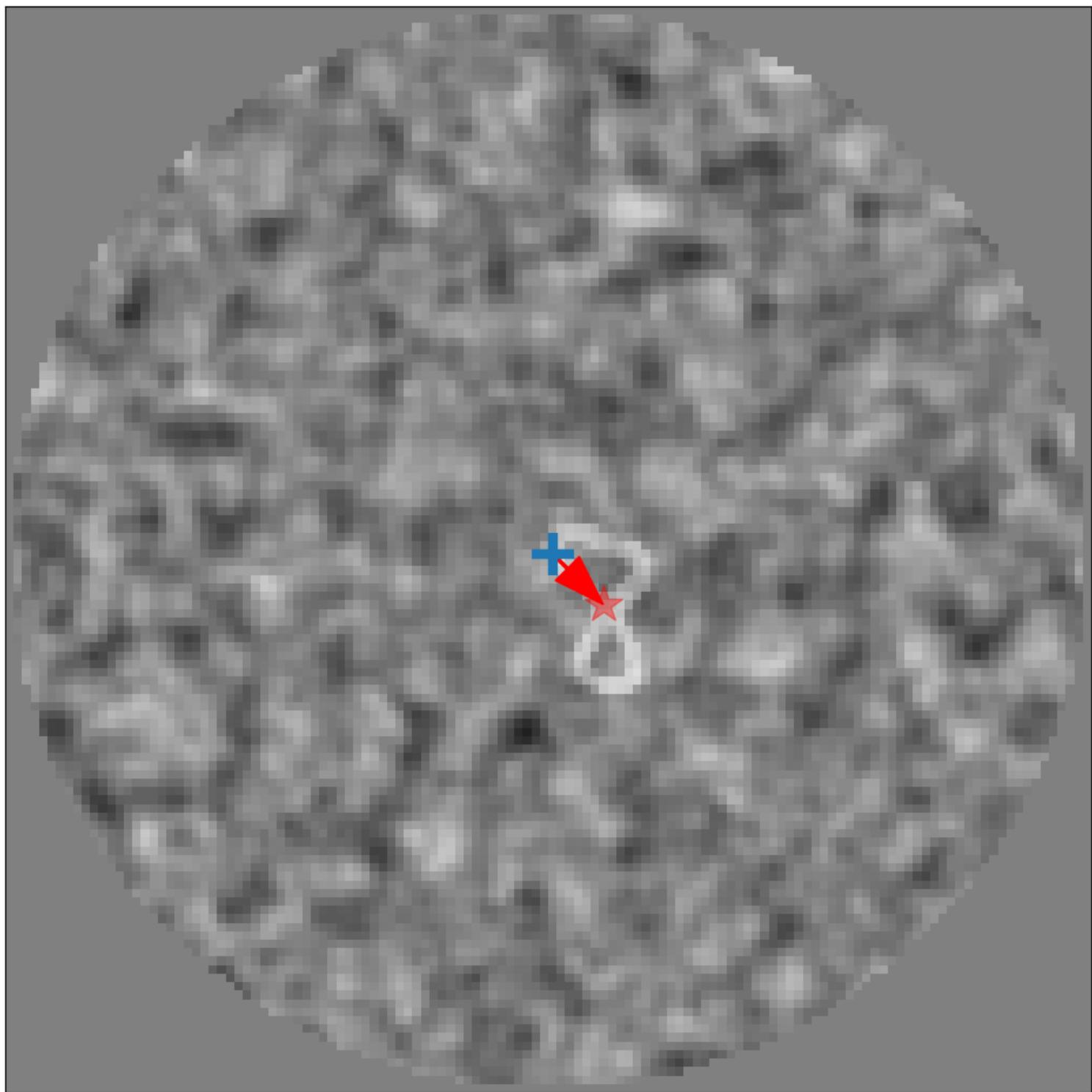




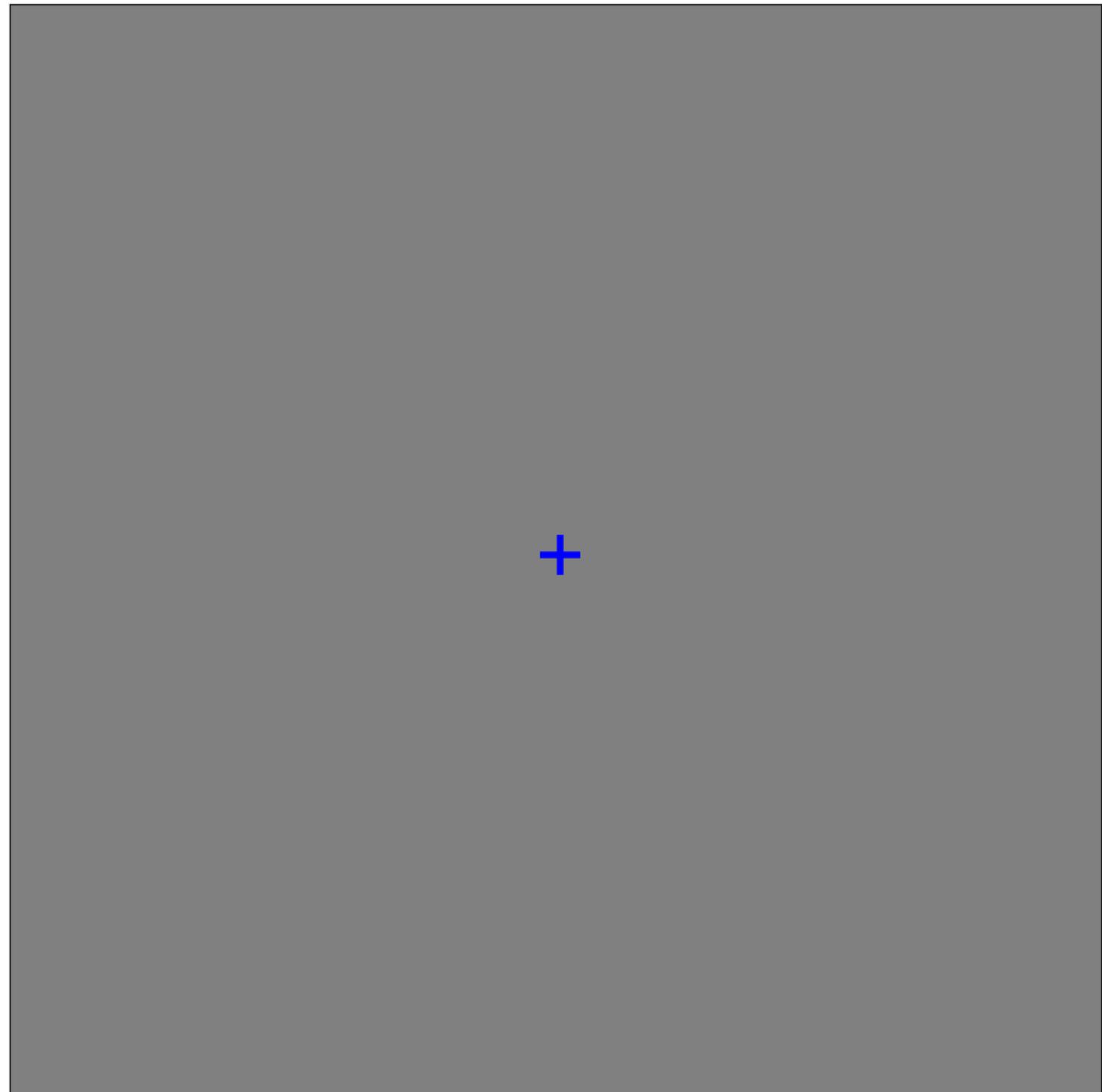
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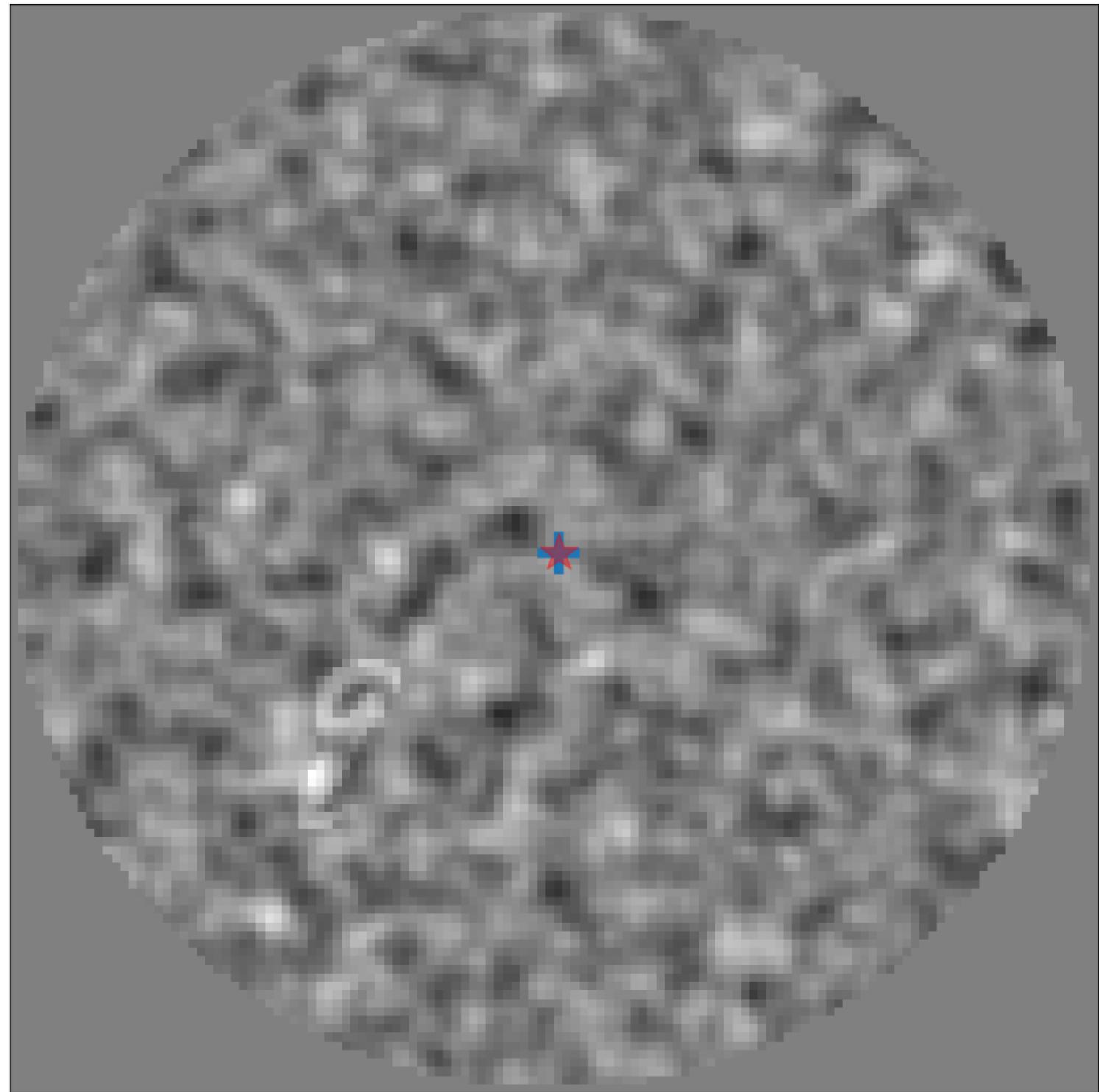


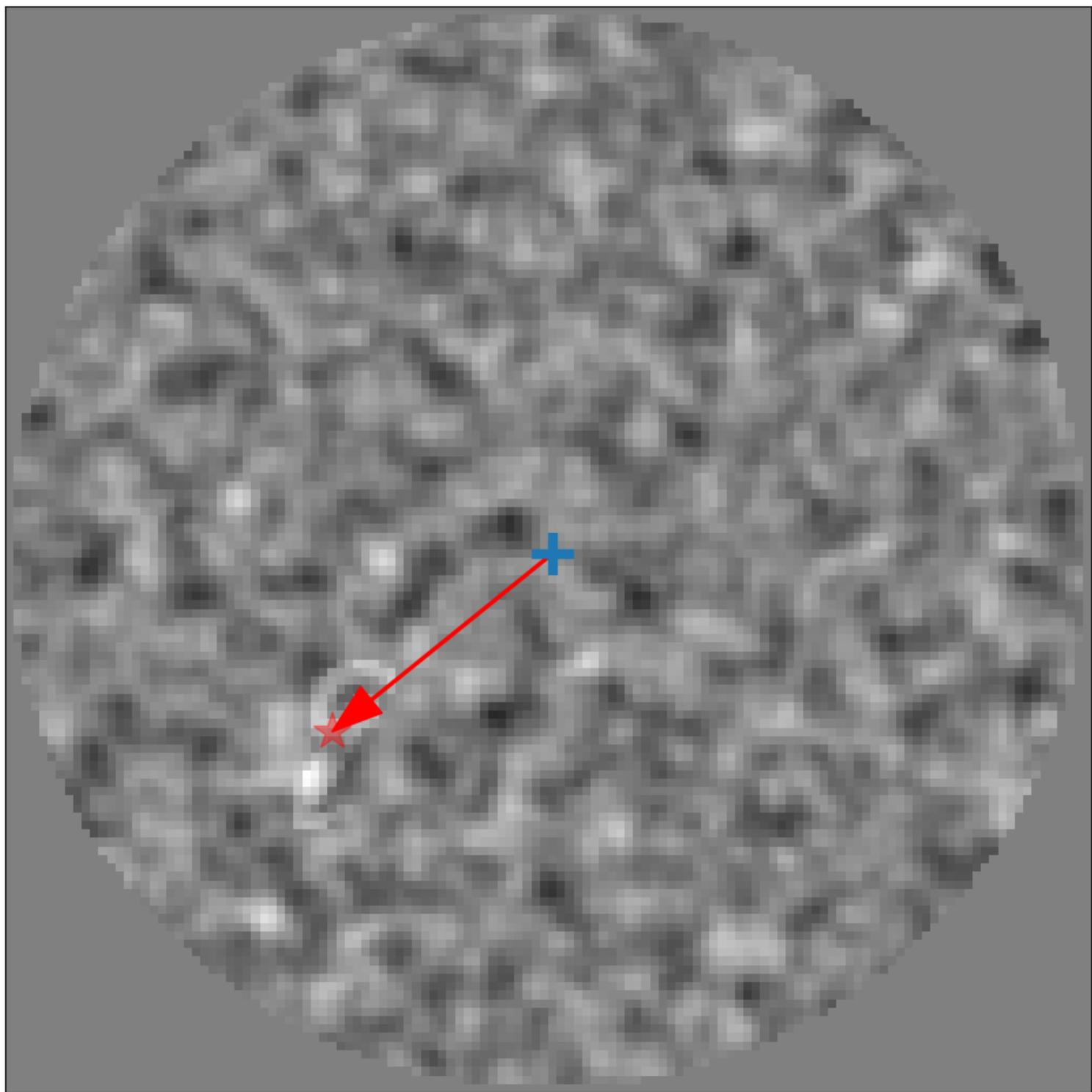




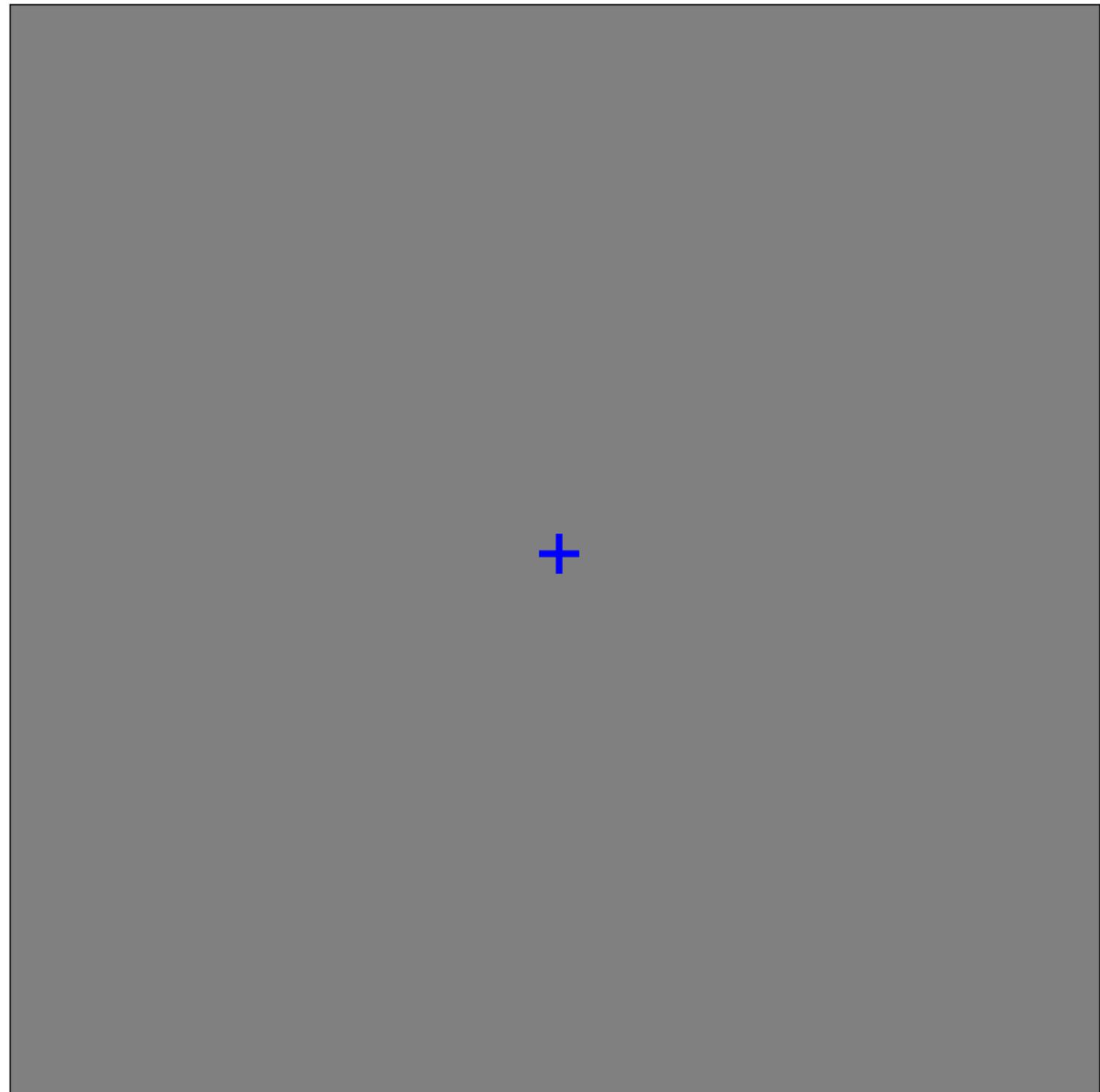
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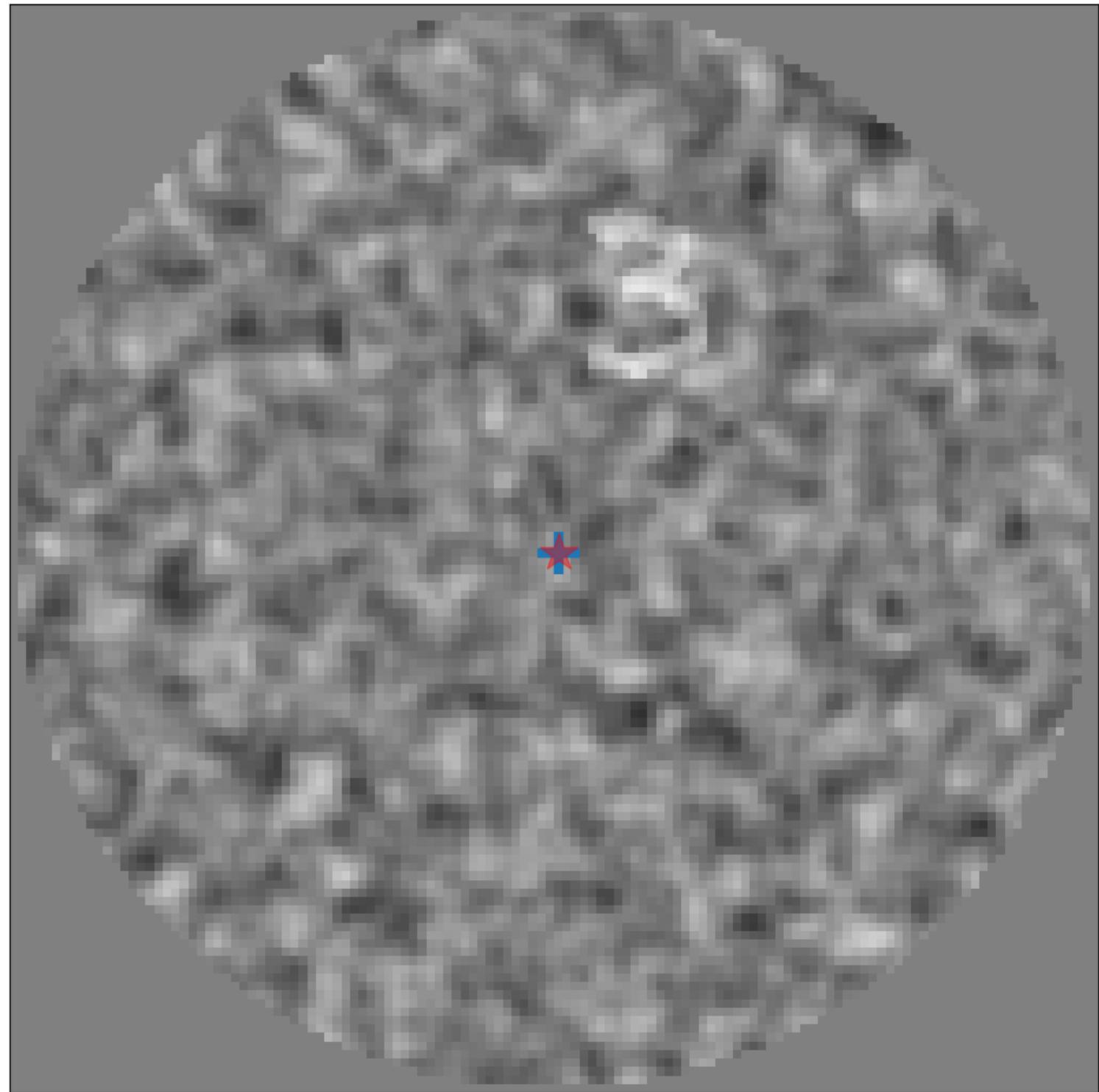


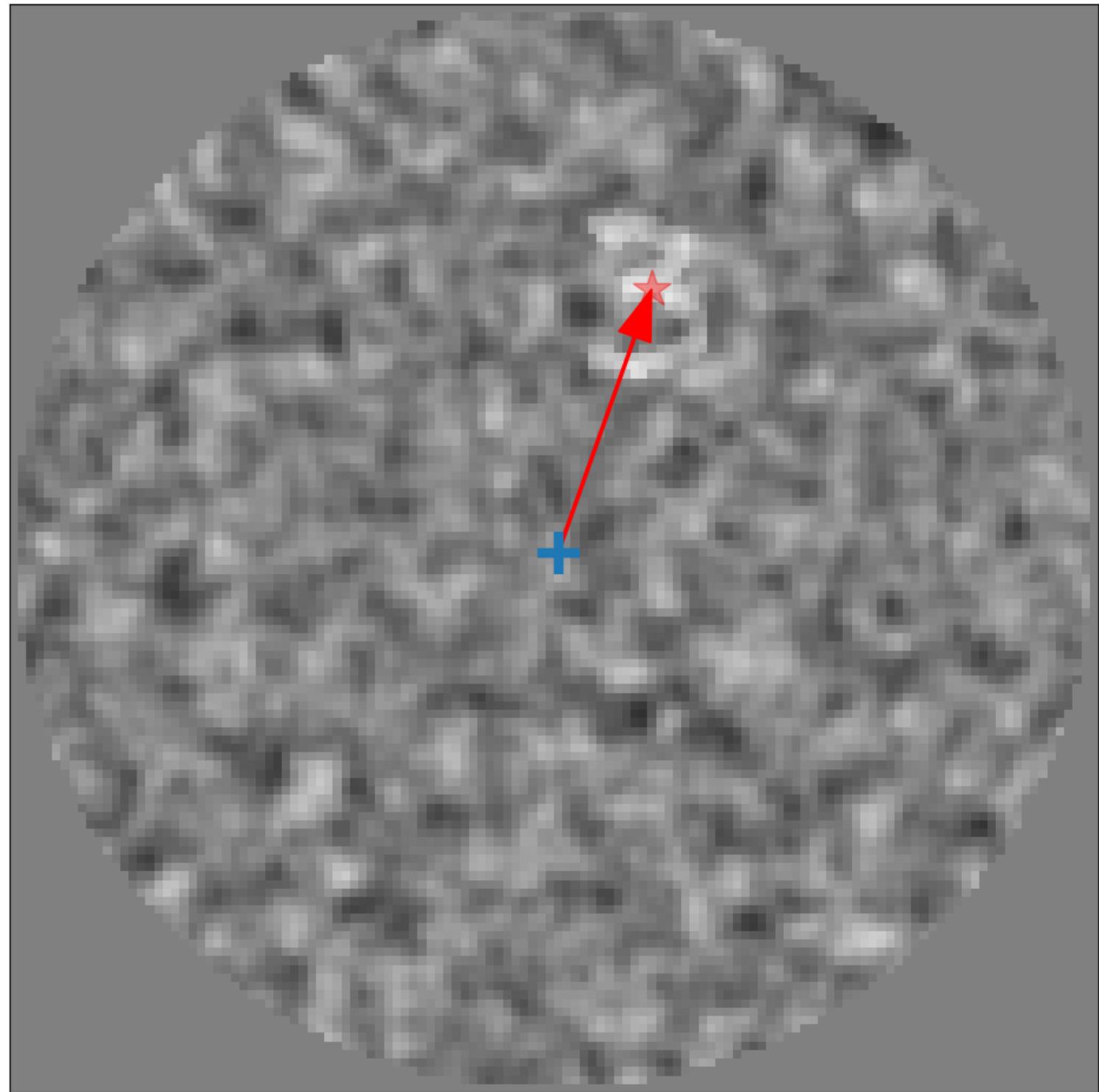




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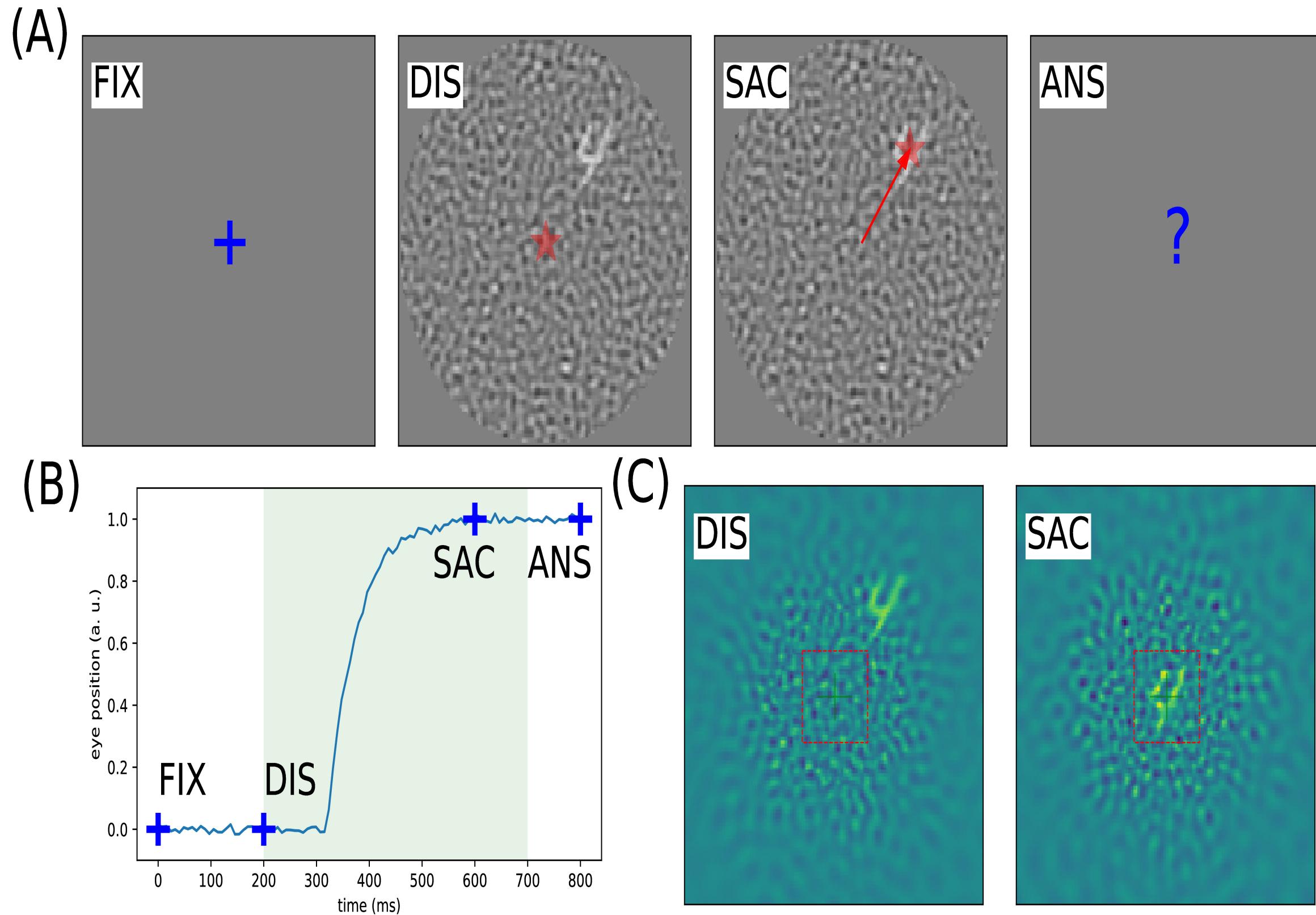




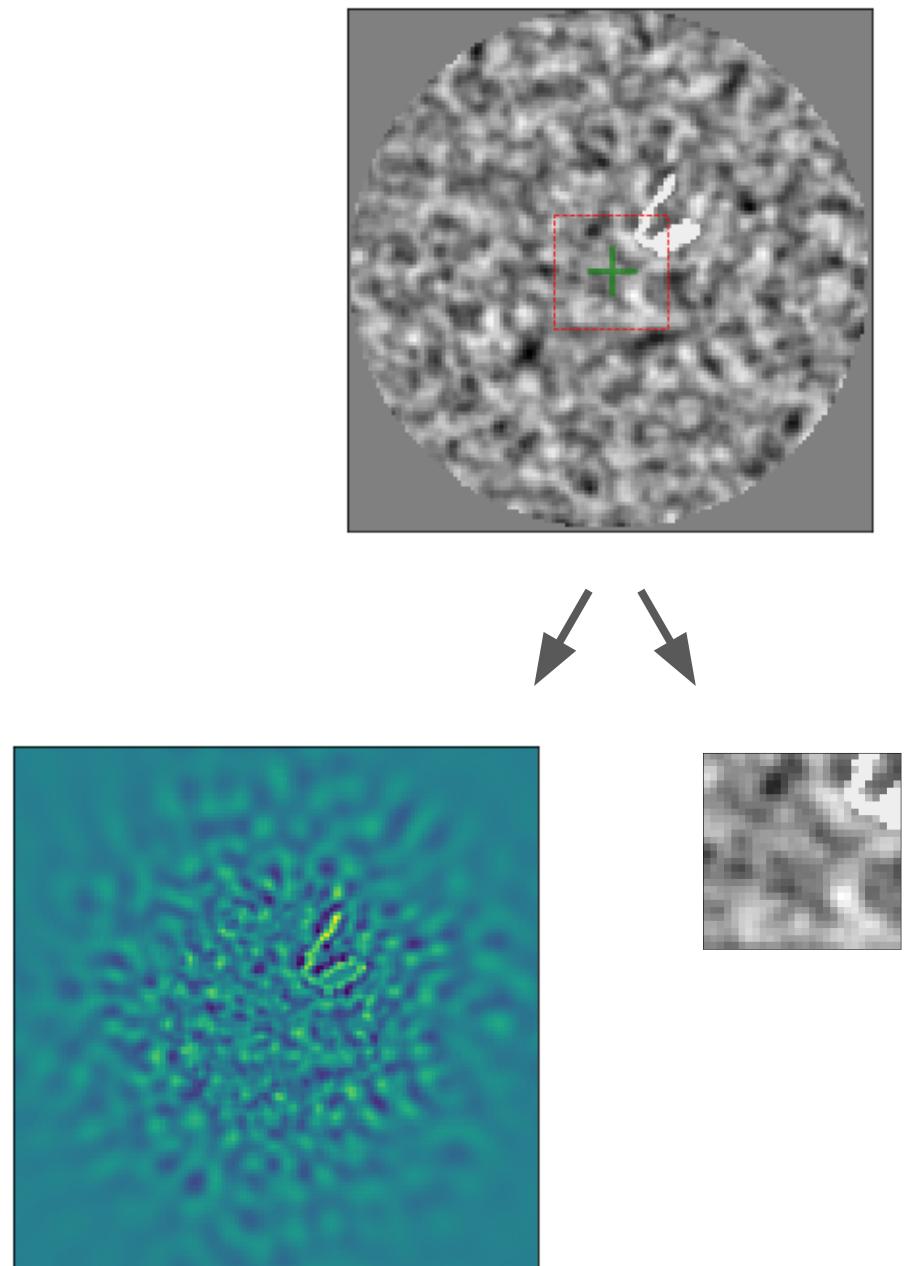


?

Methods - "Experimental" setup



Methods: What/Where separation



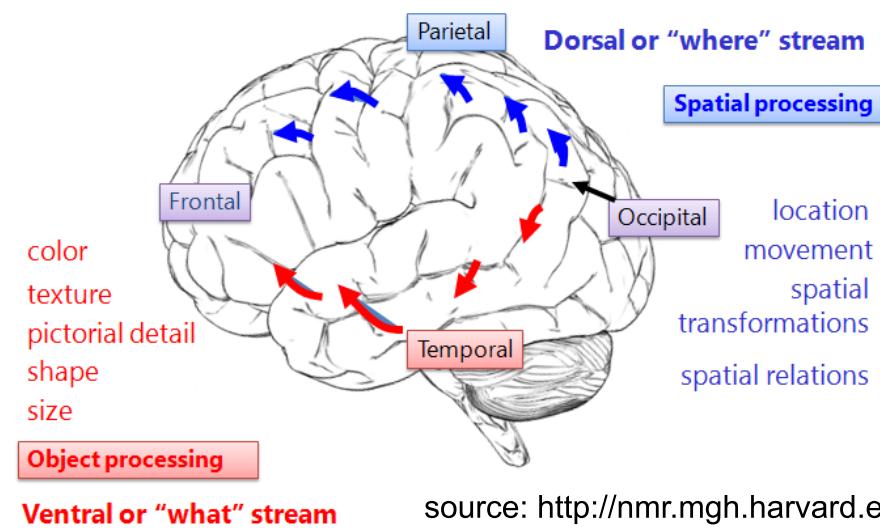
Approximate Information Gain :

$$E_y [\log P(Y|x, u) - \log P(Y)] \approx \log P(\hat{y}|x, u) - \log P(\hat{y})$$

Future Central
Accuracy
(after saccade)

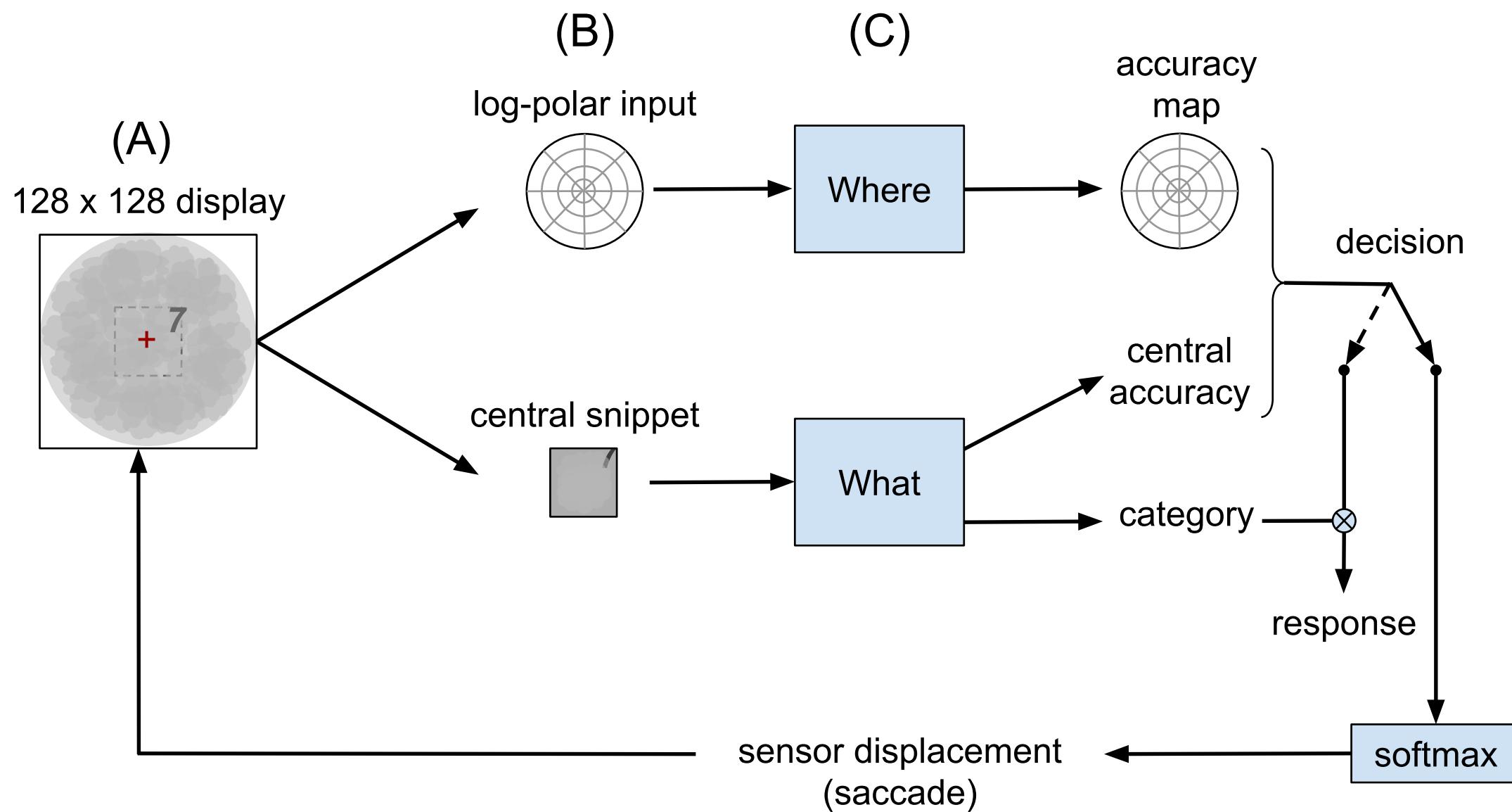
Central Accuracy

What/where pathways in visual processing
Mishkin, M., Ungerleider, L. G., & Macko, K. A. (1983).

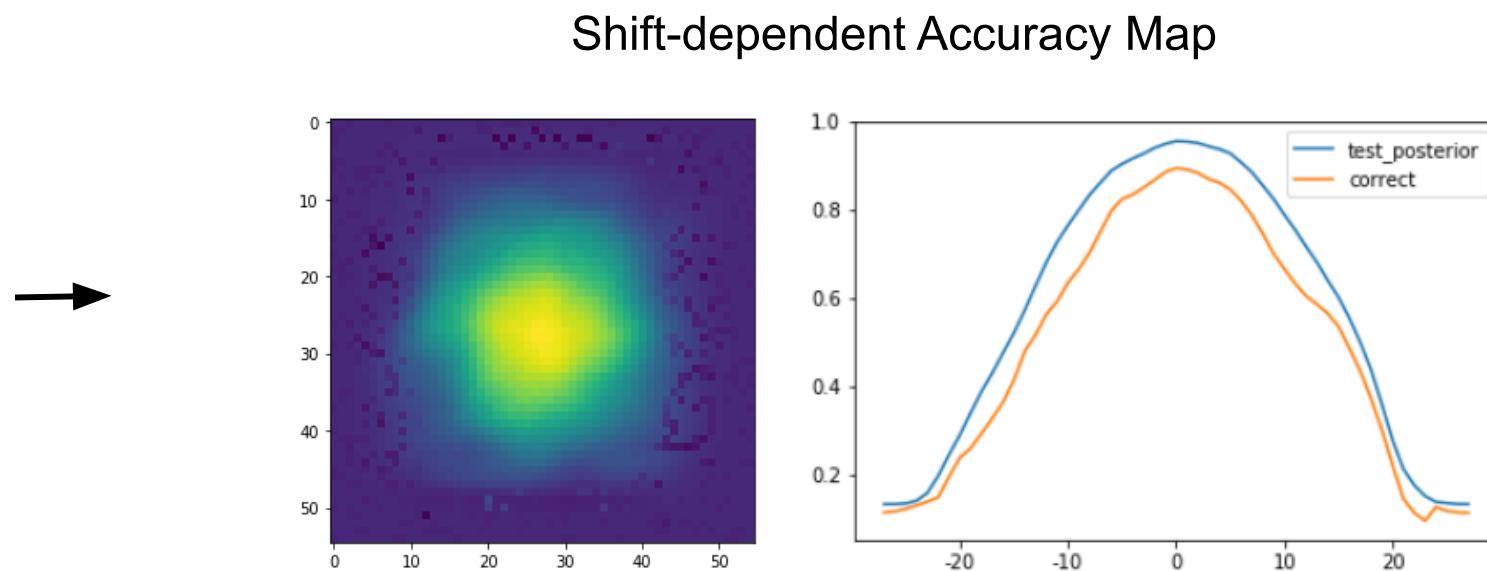
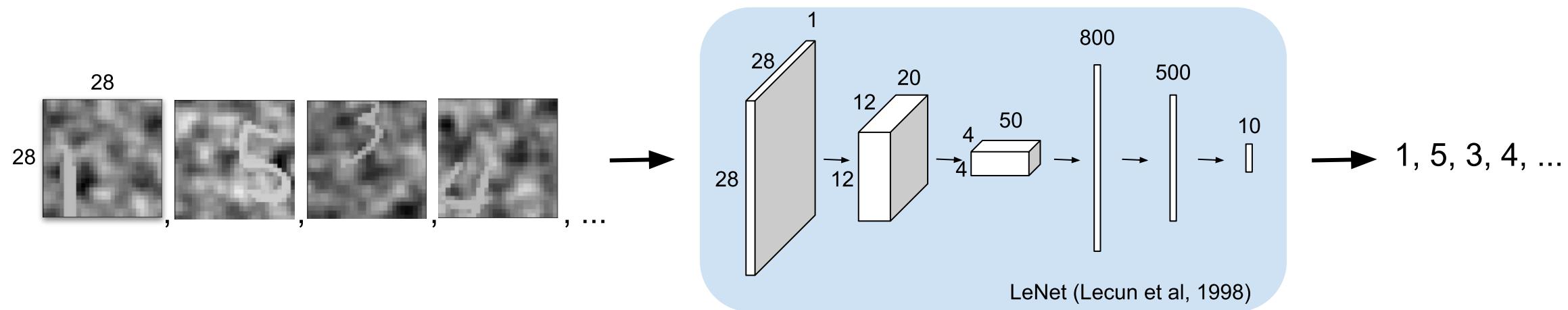


source: <http://nmr.mgh.harvard.edu>

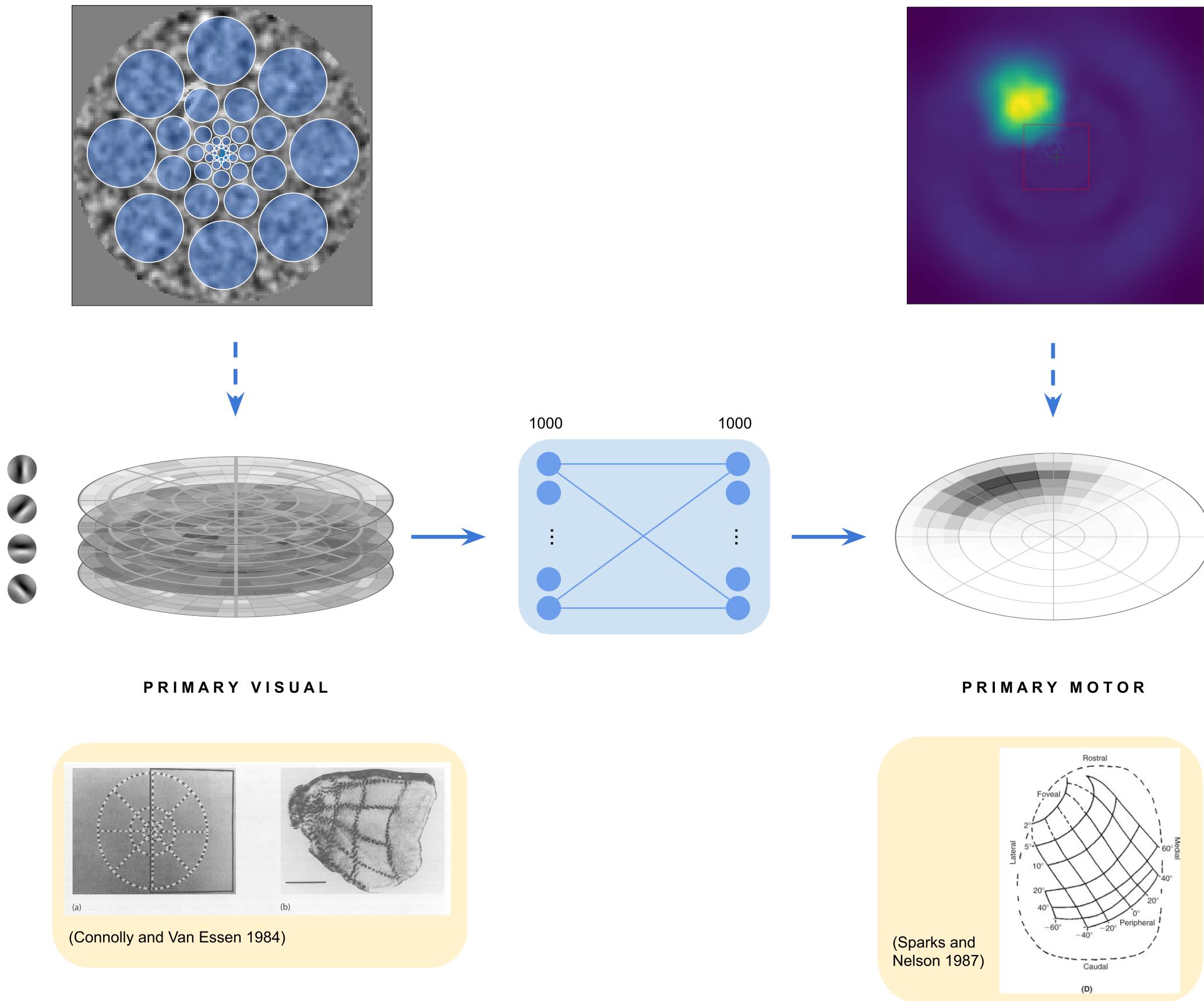
Methods: Computational Graph



Methods: What



Methods: Where



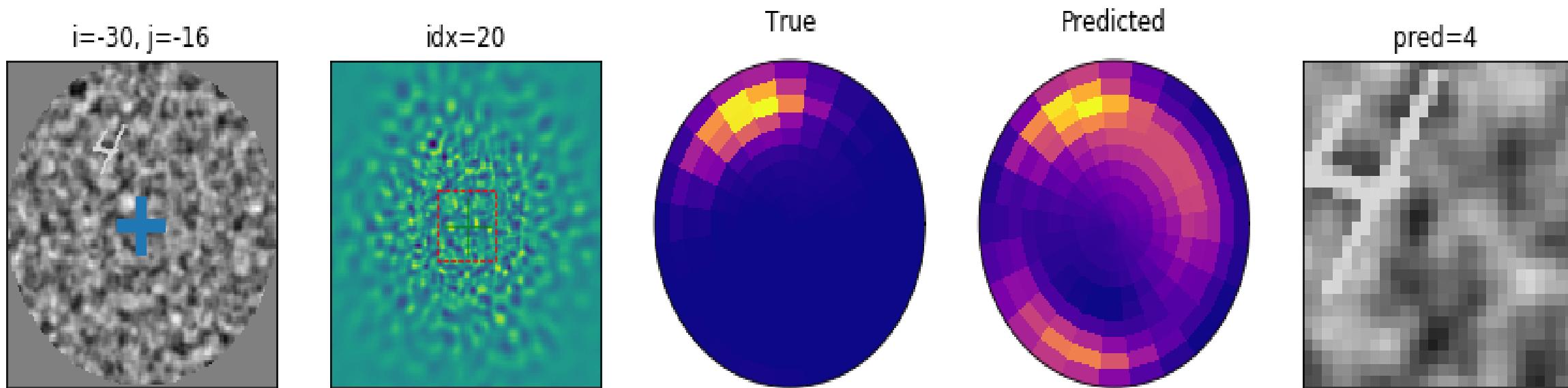
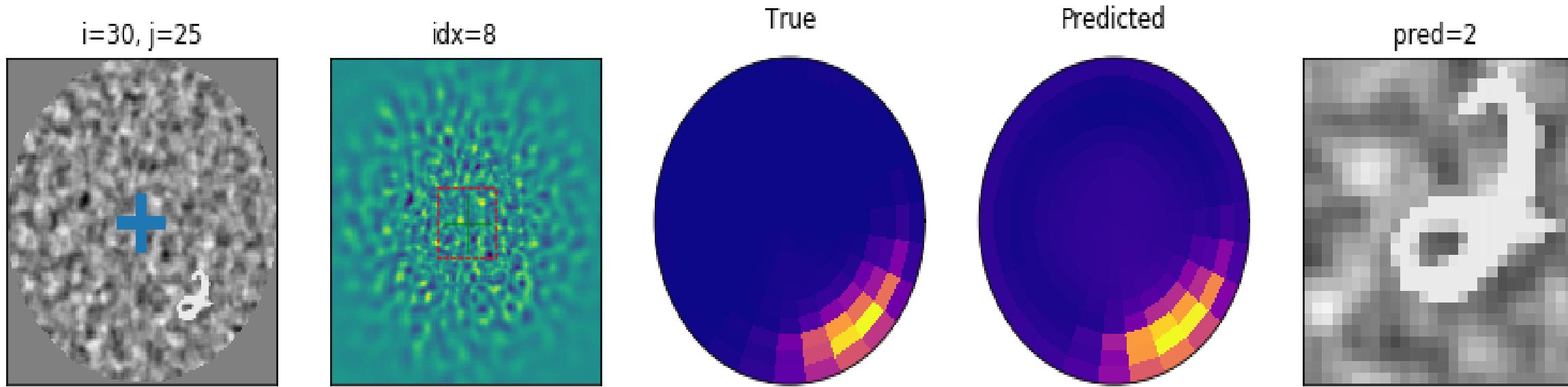
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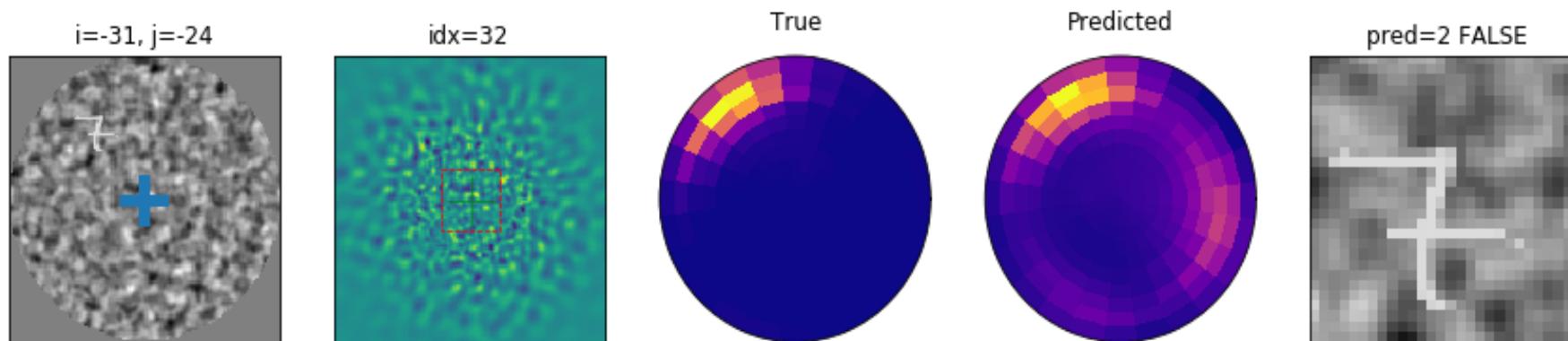
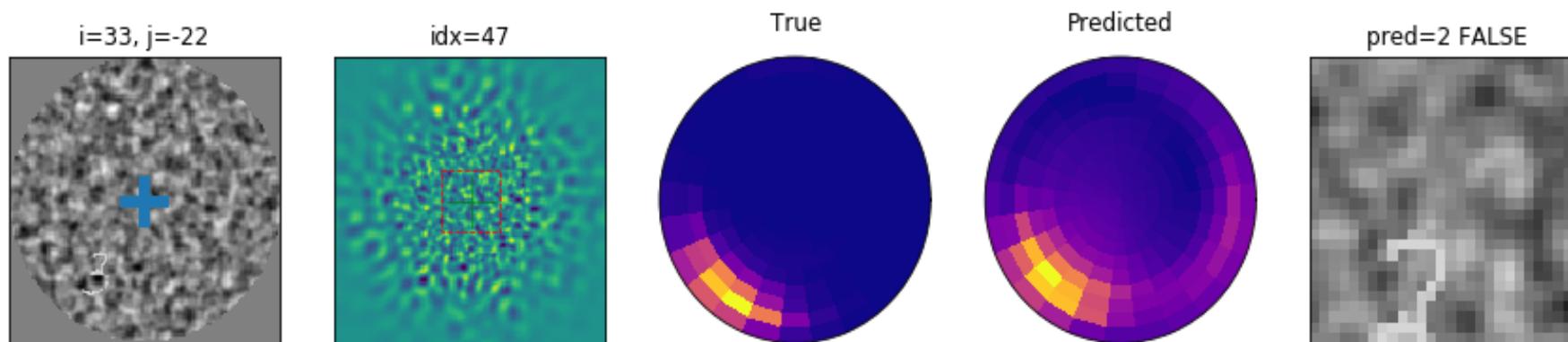
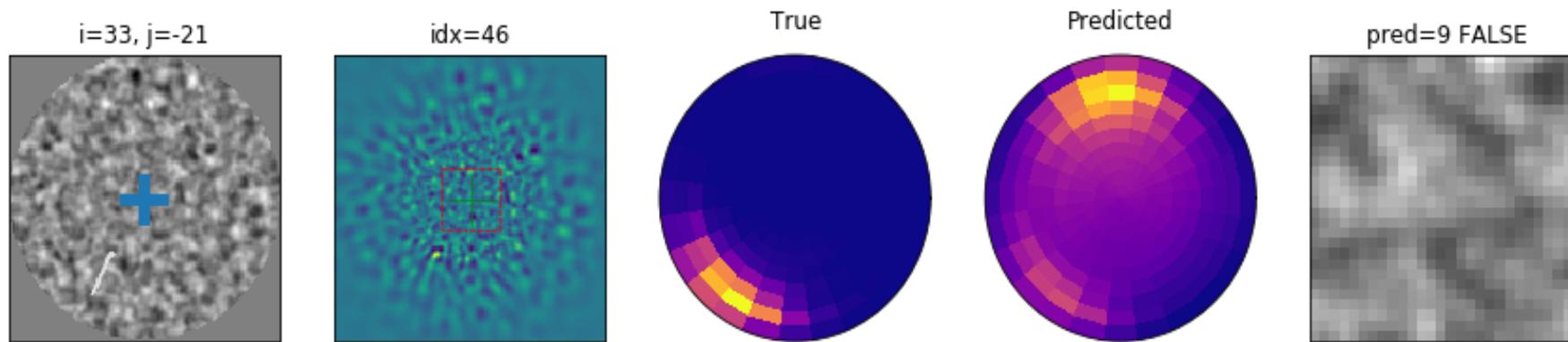
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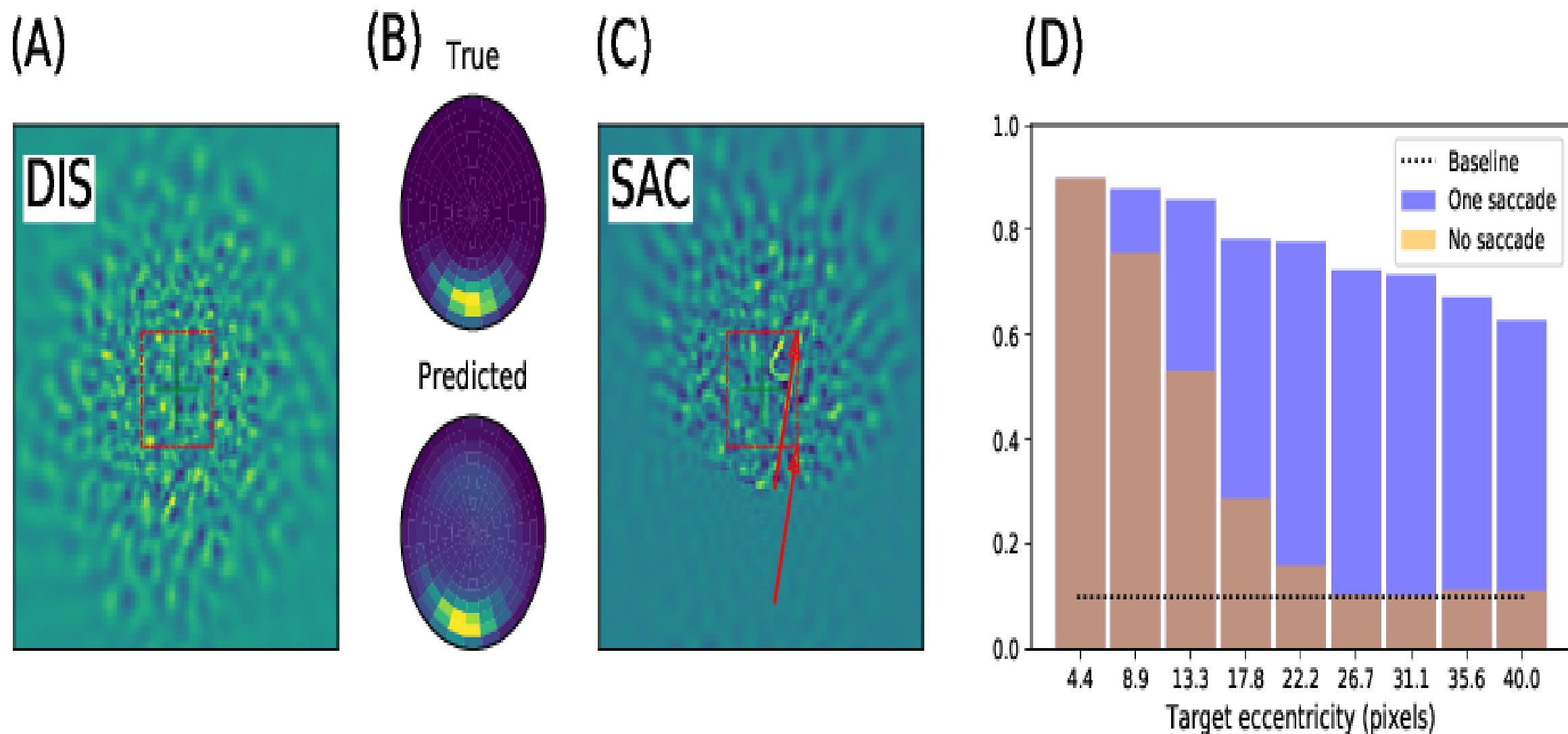
Results: success



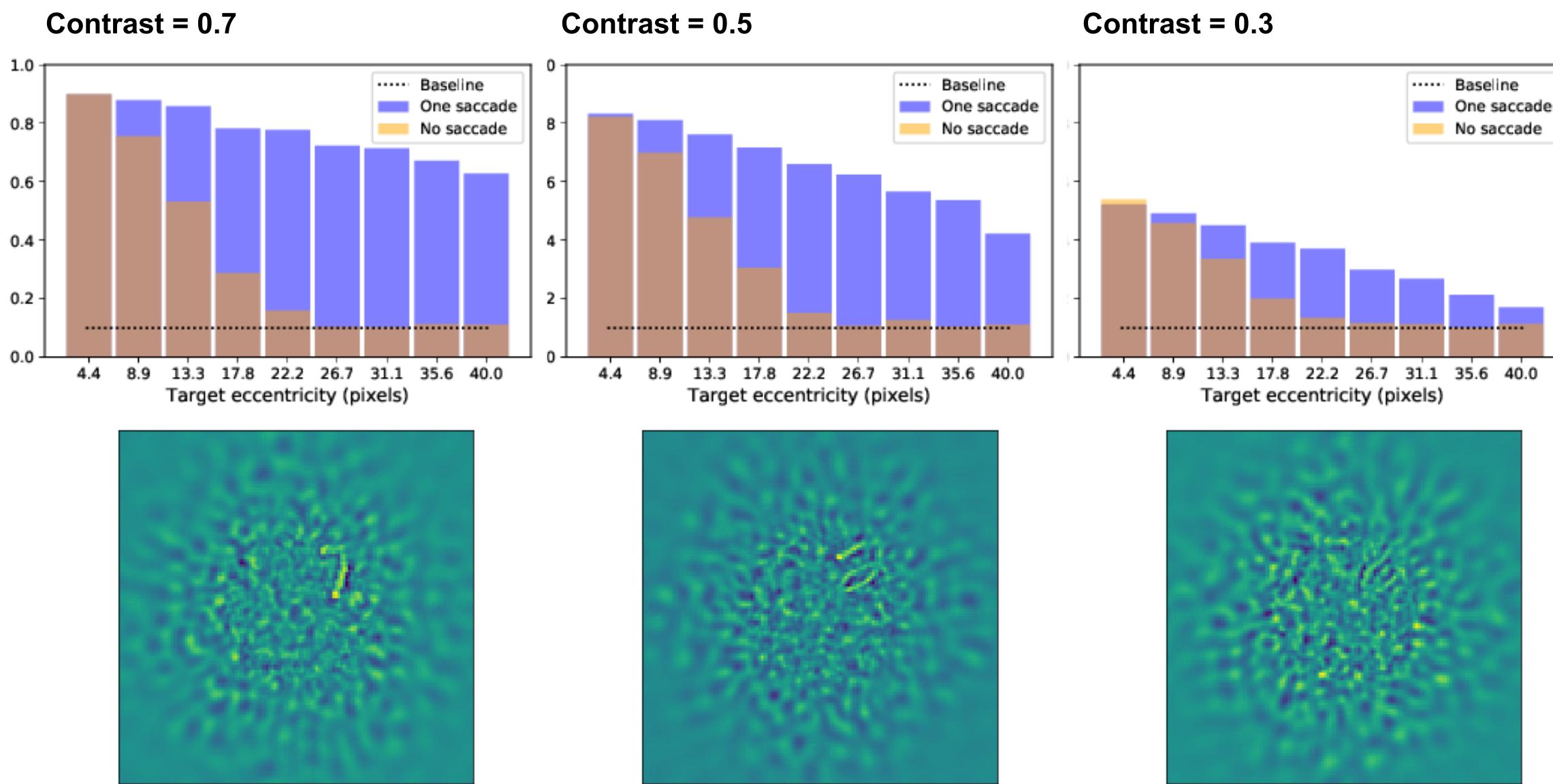
Results: failure



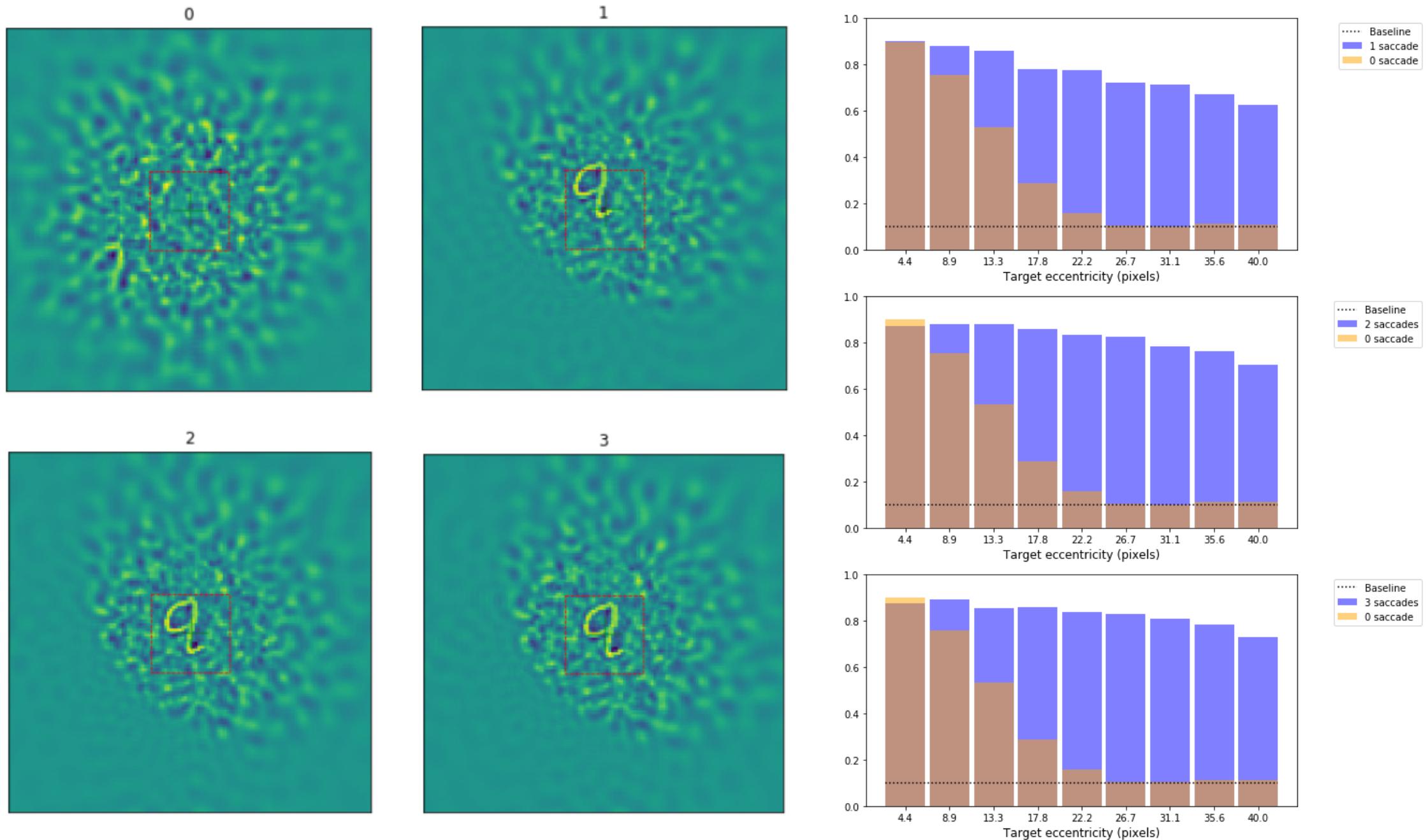
Results: one saccade



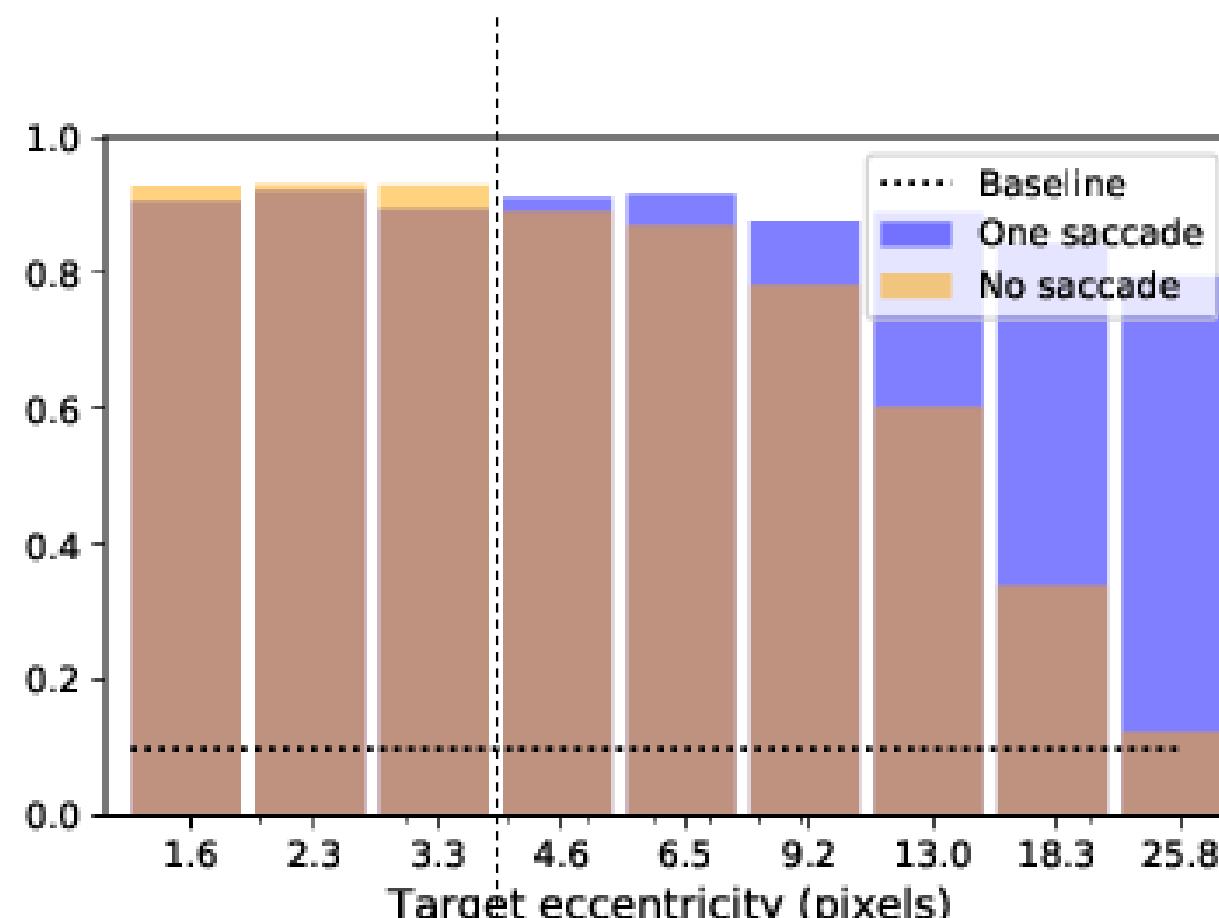
Results: role of contrast



Results: more saccades



IG-based selection of action



DECISION BOUNDARY

$$\log P(\hat{y}|x, u) - \log P(\hat{y})$$

Future Central
Accuracy
(after saccade)

Central Accuracy

Main results:

- A new interpretation of Information Gain in visuo-motor action selection :
 - Center-surround interpretation
 - An effective decoding scheme with strong bandwidth reduction
 - Information-gain based selection of action (saccade/pursuit)
- A sub-linear object detection for image processing:
 - A full log-polar processing pathway (from early vision toward action selection)
 - Sequential info gain converges to zero: in practice 2-3 saccades are enough
 - Ready for up-scaling
- Object identity-based monitoring of action
 - Dorsal = "actor" (where to look next?)
 - Ventral = "critic" (for what to see?)

Limits and Open questions

- Importance of centered objects:
 - Central object referential
 - log polar scale/rotation invariance
 - (feedback) prediction
- Information Gain-based décision :
 - Sequential info gain converges to zero: in practice 2-3 saccades are enough
 - Pursuit vs. saccade.
 - Maximizing info gain on multiple targets/ddls.
 - Illustration with z1, z2 axis
 - Overt/covert attention
 - Inhibition of return

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<https://laurentperrinet.github.io/talk/2019-07-15-cns>