Analysis of AMDX2011 aggregates in retinal images

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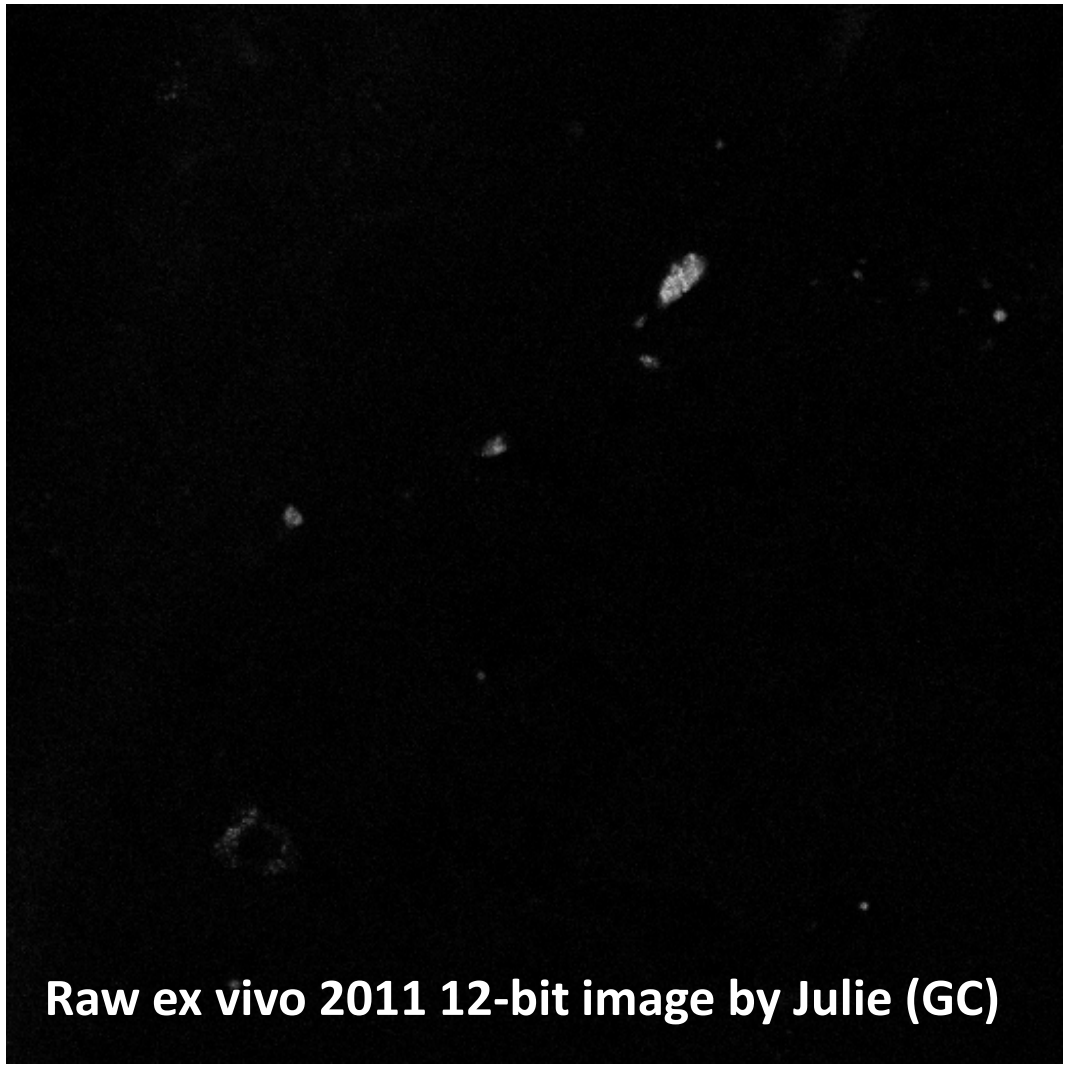
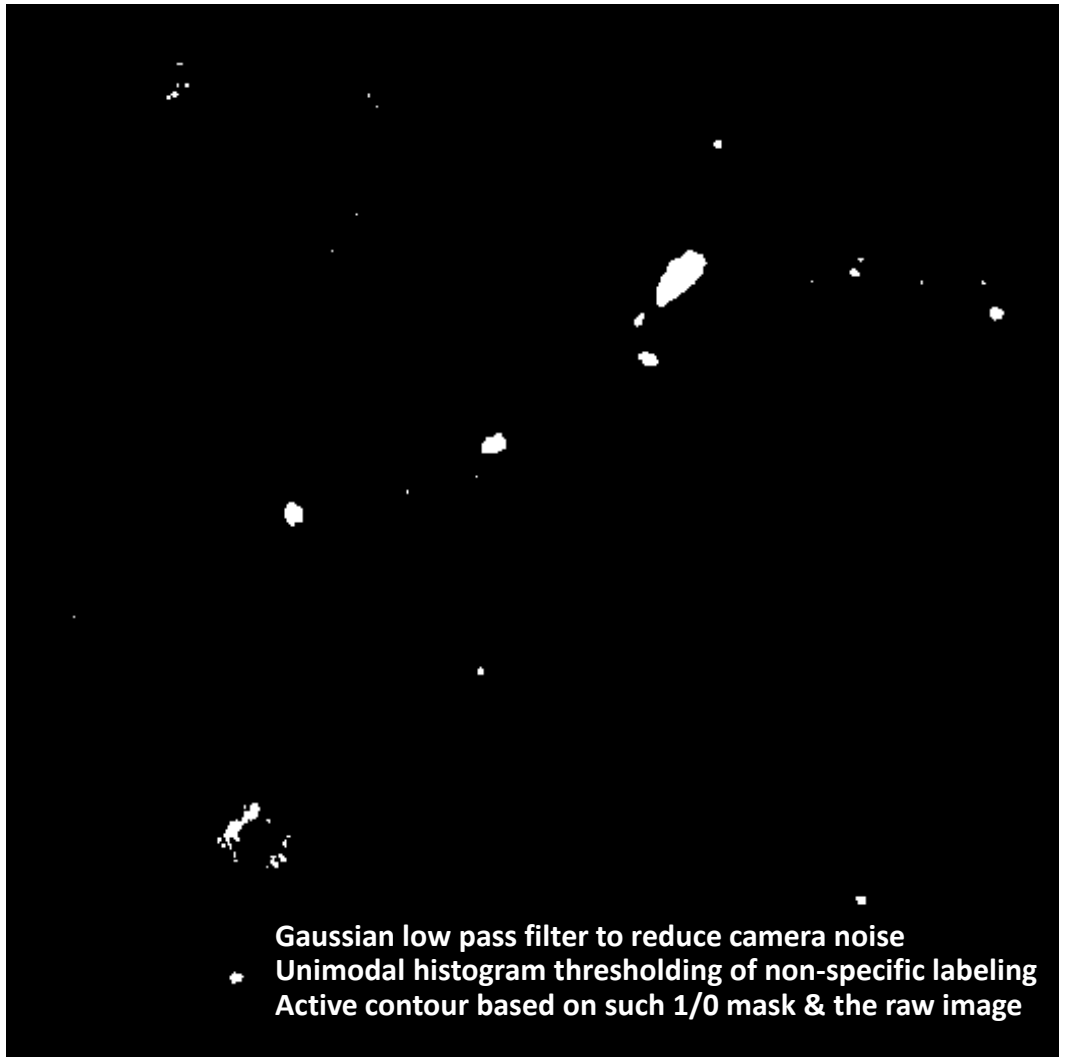
Image classification & disease detection

- Computer vision metrics (brightness, morphology, localization within the retina, etc.)
- Deep learning with neural networks (classification into different disease types/stages)
- Database image storage (rapid delivery of a searchable pool of informative analytics)

Preliminary analysis

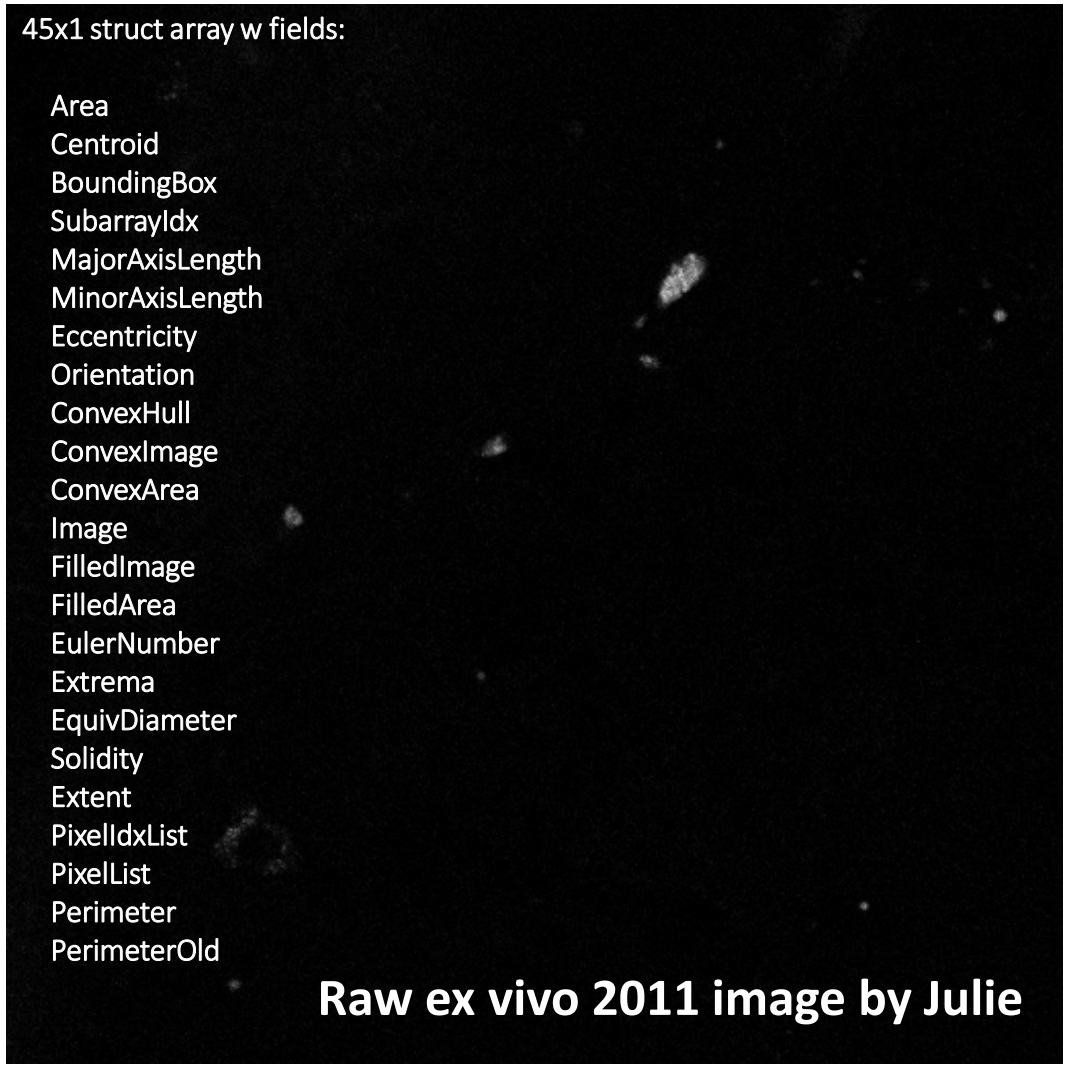


Raw ex vivo 2011 12-bit image by Julie (GC)

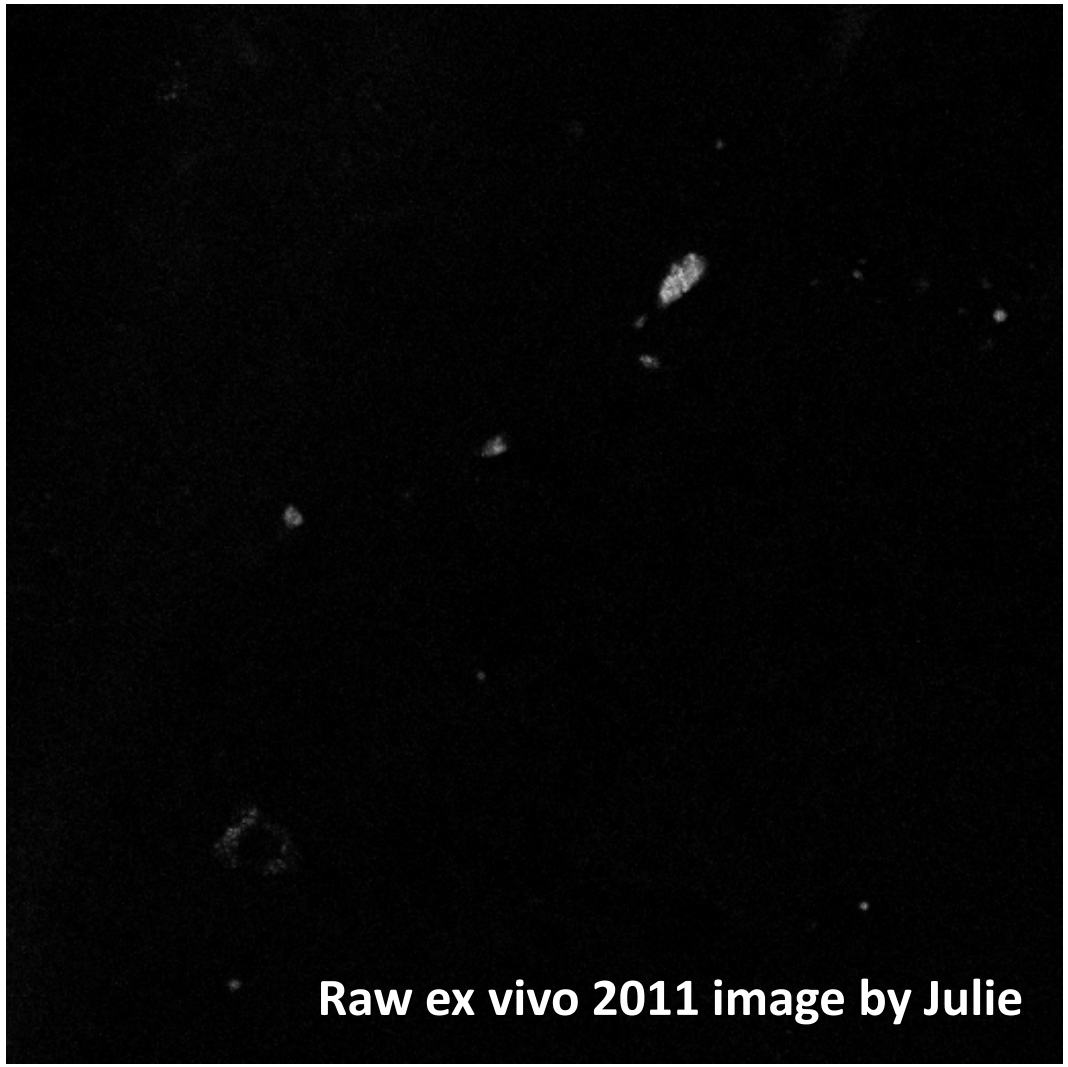


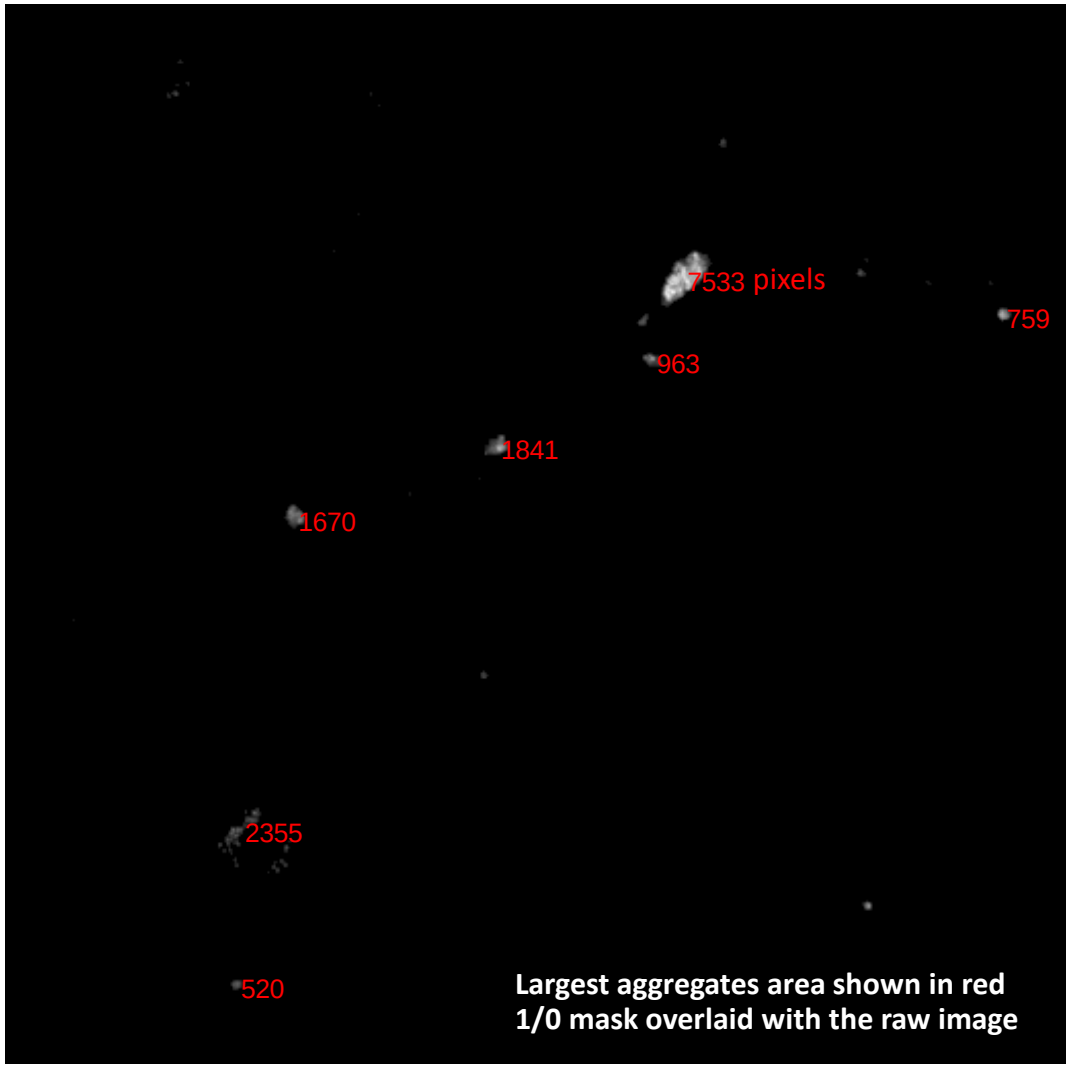
Gaussian low pass filter to reduce camera noise
Unimodal histogram thresholding of non-specific labeling
Active contour based on such 1/0 mask & the raw image

Preliminary analysis

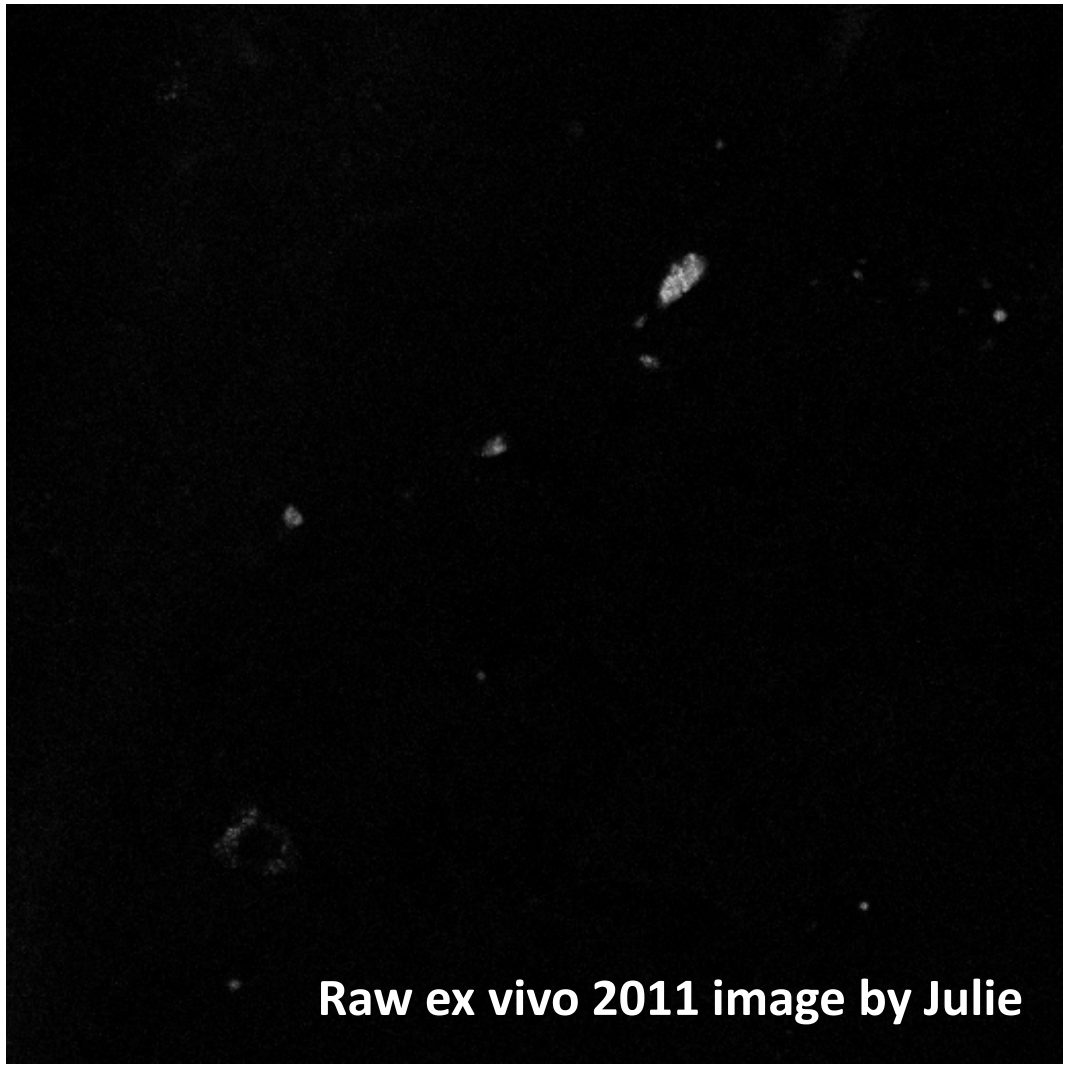


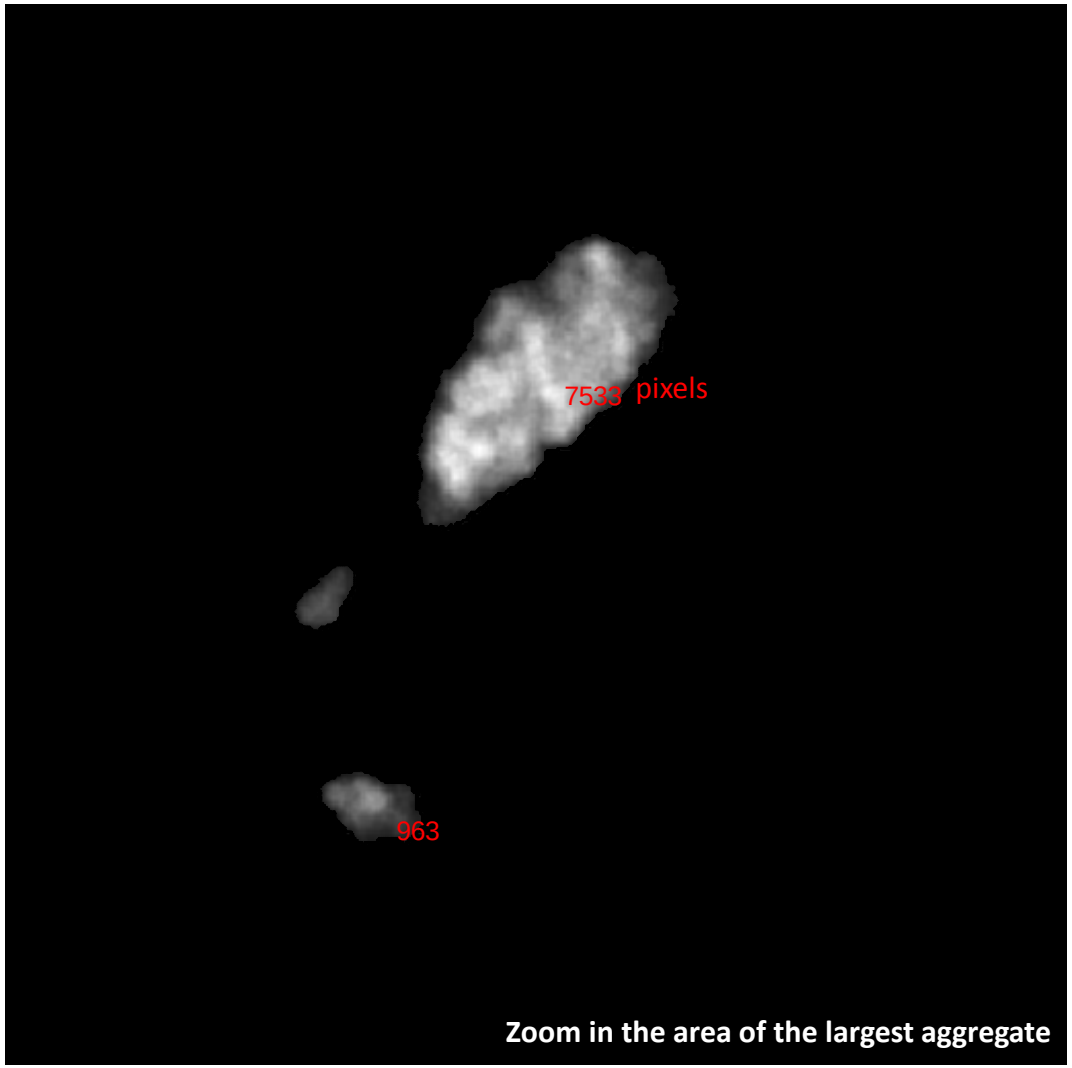
Preliminary analysis





Preliminary analysis





Examples of image metrics

SIZE AND DISTRIBUTION OF AGGREGATES

1) object: number – number of fluorescent aggregate in image

2) object: EurlerNumber - number of objects in the image minus the total number of holes in those objects – distinguishes reticular or mesh-like patterns vs more uniformly distributed aggregates

3) object_size:average - The average number of above-threshold pixels per object – captures information about the size of the aggregates

4) object_size:variance - The variance of the number of above-threshold pixels per object – quantifies the homogeneity of fluorescent objects in cells

5) object_size:ratio - The ratio of the size of the largest aggregate to the smallest within the retina – assessing the distribution of florescent aggregate sizes

6) object_distance: average – average aggregate distance to the optical nerve – provides information about how individual aggregate are distributed throughout the retina

7) object_distance: variance – variance of object distance to the optical nerve – captures information about the distribution of objects around a central point

8) Object_distance: ratio – ratio of largest to smallest distance to the optical nerve

AGGREGATES EDGE FEATURES

9) edges:area_fraction - fraction of the non-zero pixels in an aggregate that are along an edge – distinguishes protein that localizes along the aggregate edges

10) edges:homogeneity - Measure of edge intensity homogeneity - captures homogeneity of edge gradients, or 'are the edges primarily steep or more gradually sloping?'

11) edges:direction_maxmin_ratio - Measure of edge direction homogeneity 1 – captures homogeneity of edge direction, or are the edges primarily in one direction or are they more evenly distributed? images with patterns containing edges oriented predominantly along a particular direction result in edge gradient histograms

12) edges:direction_maxnextmax_ratio - Measure of edge direction homogeneity 2 – ratio of the largest to the next largest value in the histogram from above feature

13) edges:direction_difference - Measure of edge direction difference - this feature distinguish aggregate patterns in which there are parallel edges

SHAPE OF THE AGGREGATES

14) obj_skel_len - The average length of the morphological skeleton of the aggregates (or blood vessels in the eye)

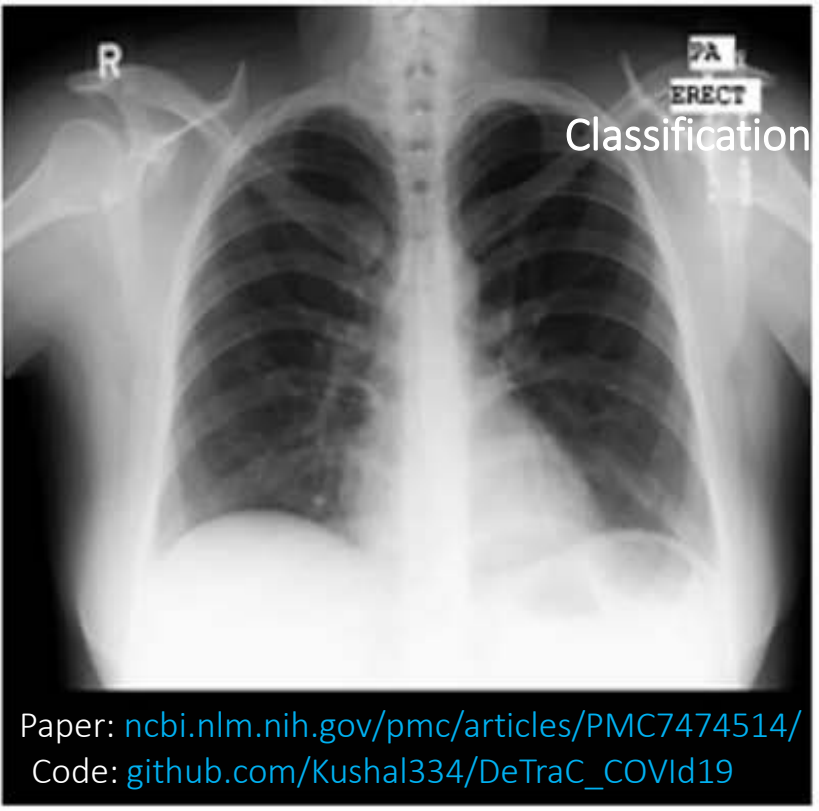
15) obj_skel_hull_area_ratio - The ratio of aggregate skeleton length to the area of the convex hull of the skeleton, averaged over all aggregates

16) obj_skel_branch_per_len - The ratio of the number of branch points in skeleton to length of the vascular skeleton

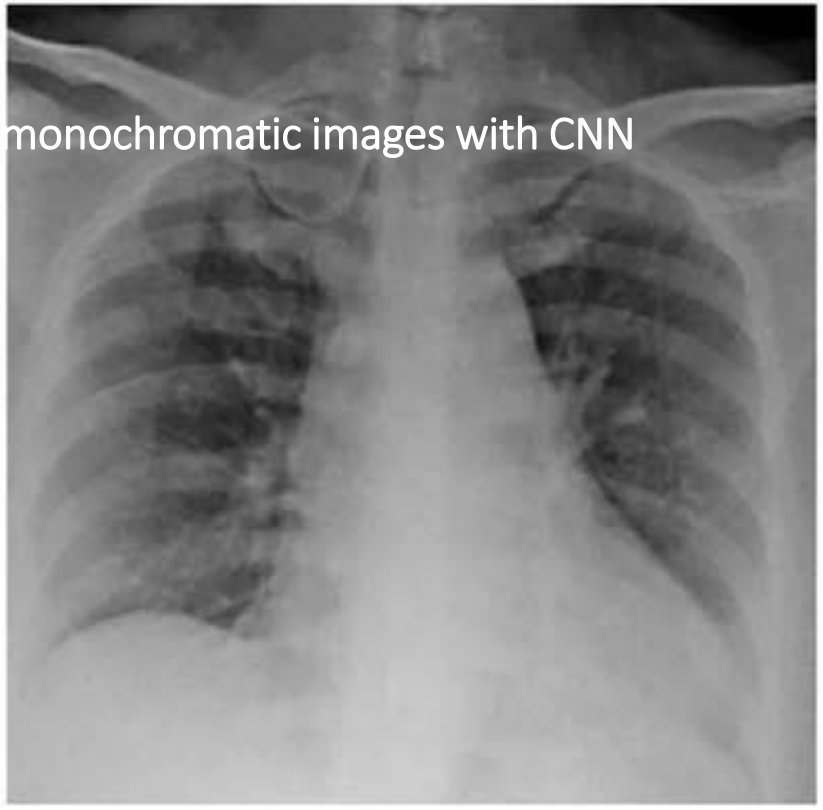
17) convex_hull: fraction of overlap - fraction of convex hull occupied by protein fluorescence (above-threshold pixels)

18) convex_hull: shape_factor

Classification of monochromatic images with CNN



Paper: ncbi.nlm.nih.gov/pmc/articles/PMC7474514/
Code: github.com/Kushal334/DeTraC_COVId19



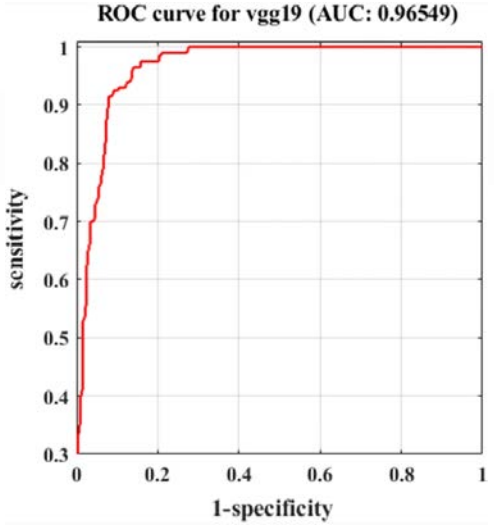
(a) (b)

Examples of **a**) normal, **b**) COVID-19, and **c**) SARS chest X-ray images

- 80 normal chest images (4,020 × 4,892 pixels)
- 105 COVID-19 images (4,248 × 3,480 pixels) 8-bit depth (max. intensity value 256)
- 11 SARS images (4,248 × 3,480 pixels)

ImageNet (15 million images)
pre-trained CNN networks:

- AlexNet
- VGG19 keras.io/api/applications/vgg
- ResNet
- GoogleNet
- SqueezeNet

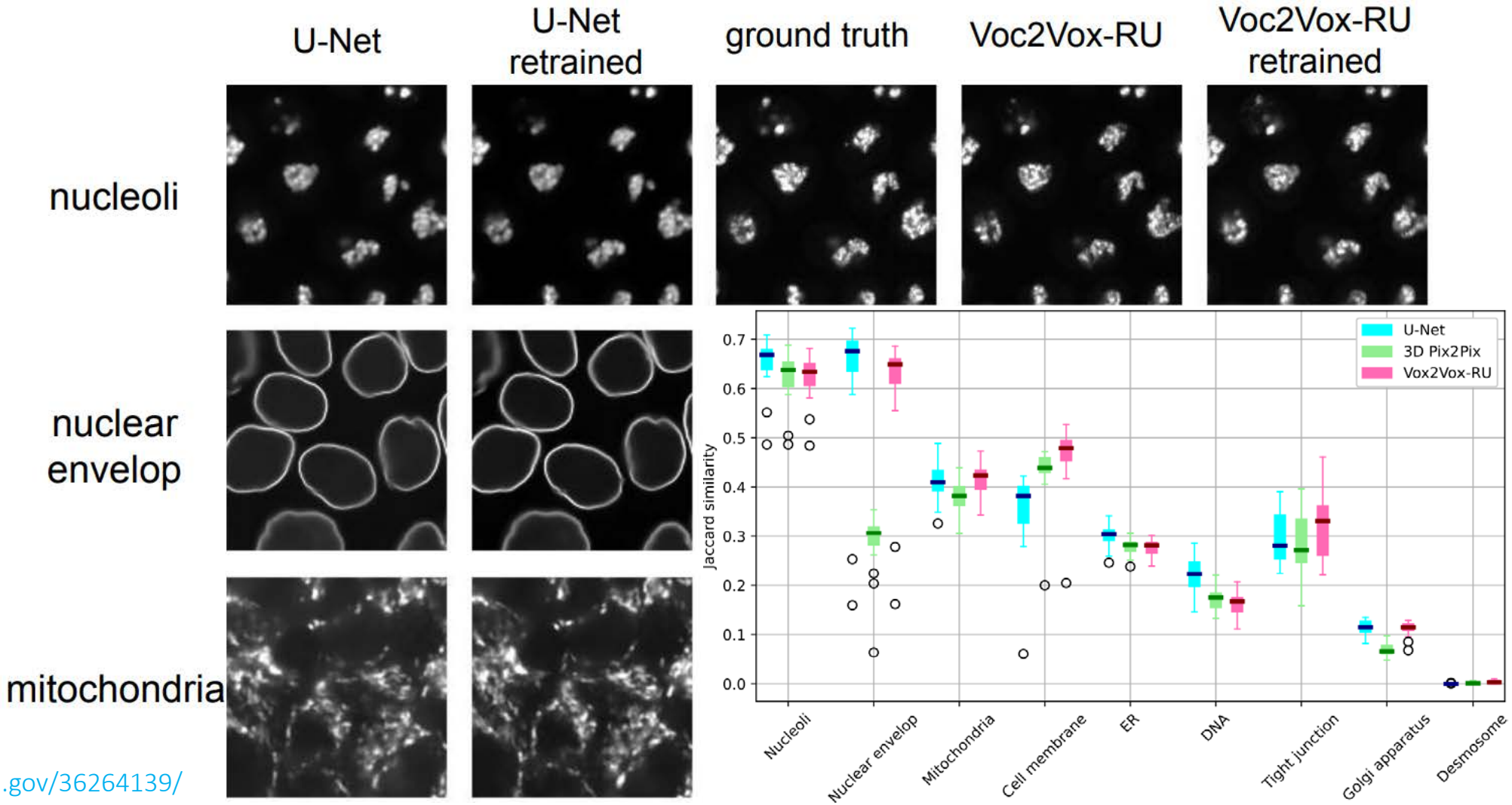


Transfer learning scenarios:

- "shallow tuning" adapts only the last classification layer & freezes the parameters of the remaining layers without training
- "deep tuning" retrains all parameters of the pre-trained network from end-to-end
- "fine-tuning" gradually trains more layers by tuning the learning parameters until a significant performance boost is achieved

Improving and evaluating deep learning models of cellular organization

similarity with AMDX-2011P aggregates



Paper: pubmed.ncbi.nlm.nih.gov/36264139/

Code: murphylab.cbd.cmu.edu/Software/2022_insilico/

Storage of image data & delivery of analytics

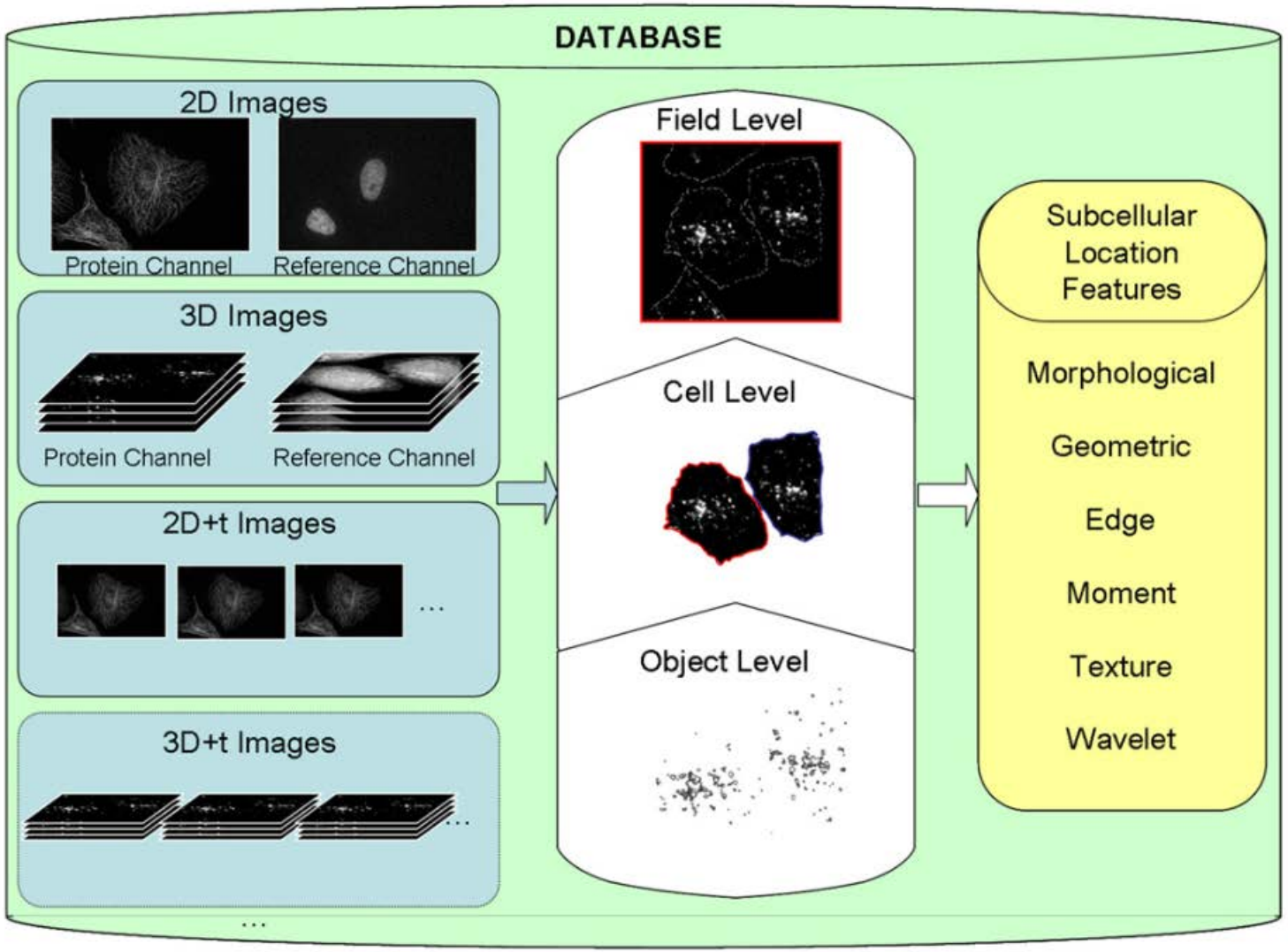


Figure 1. The Image Database Depicted Contains Images with Related Biological Protocol, Acquisition Parameters, and Subcellular Location Features

Murphy R. F. An active role for machine learning in drug development
Nature chemical biology 7 (6), 327-330