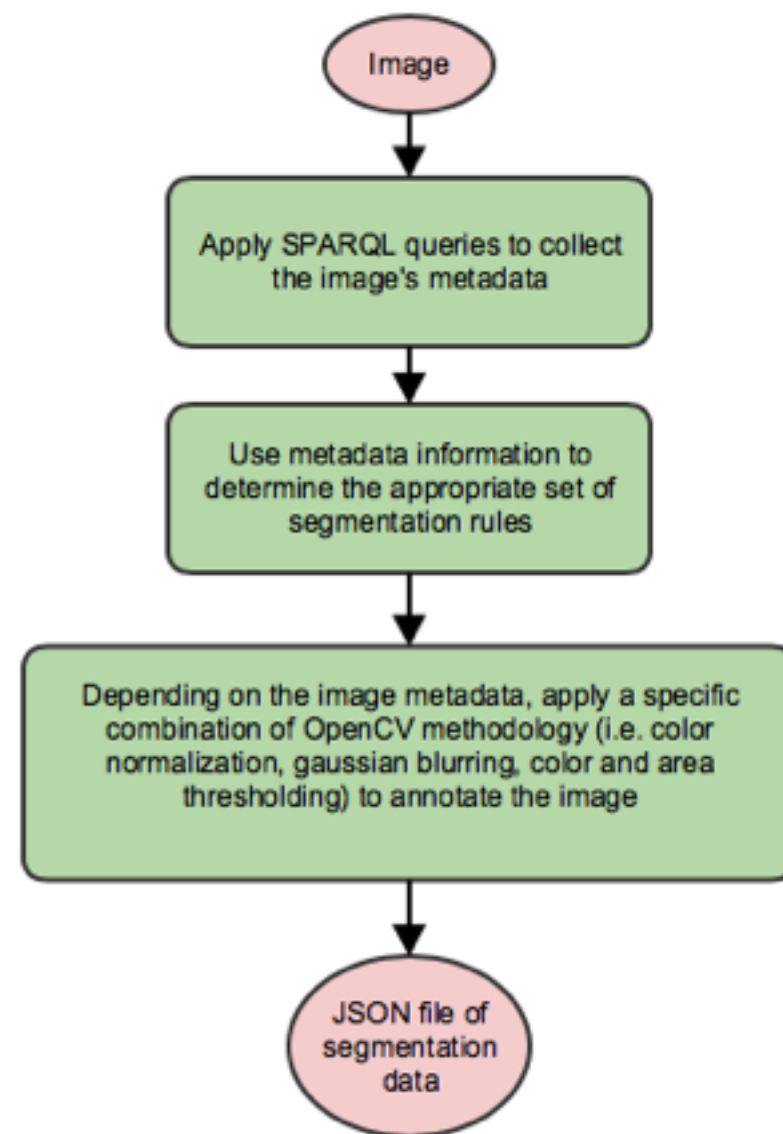


Purpose

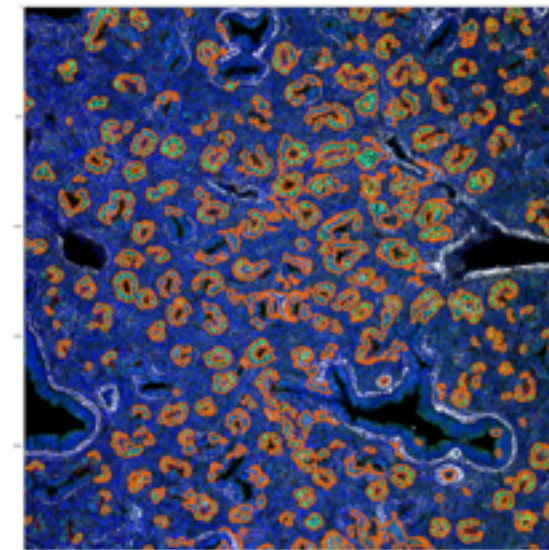
- Develop a pipeline to annotate IF images of developing lungs
- Motivations:
 - Educational - support investigations into regulation of lung development
 - Scientific - quantify changes in lung structure during fetal development

Strategy



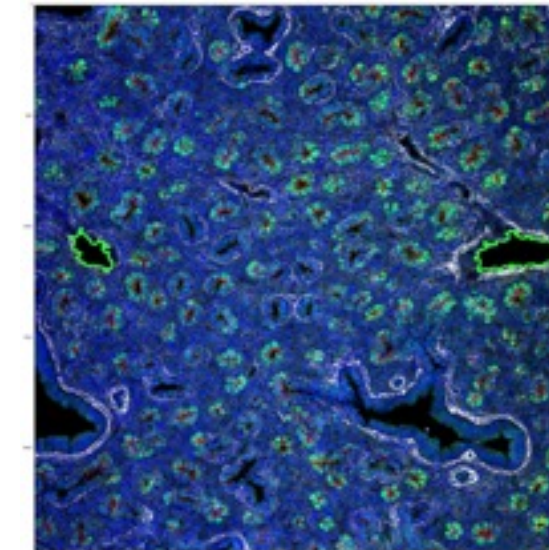
Segmentation

Anatomical Structure	Number of Images Containing this Structure
Acinar Tubules	85
Sox9 marked cells	46
Club cells	133
Bronchioles and Veins	495



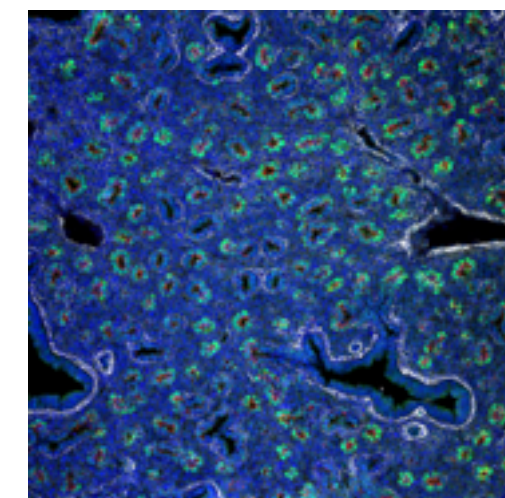
Acinar Tubules

Color Threshold: (0,55,40) - (60, 255, 255)
Area Threshold: 400 pixels
Gaussian Blur Kernel Size: (93, 93)
Normalization of Green (0, 255) -> (0, 175)

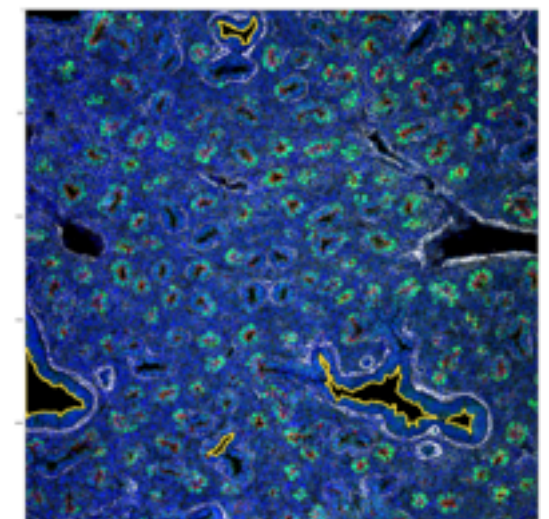


Veins and Arteries

Color Threshold: See Bronchiole Rules, additionally blue coloring must not exist within the white borders
Area Threshold: 3000 pixels

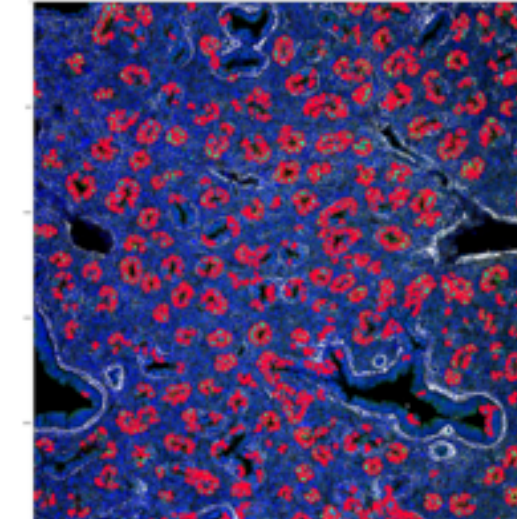


Original Image



Bronchioles

Color Threshold: (0, 0, 0) - (25, 25, 25)
Area Threshold: 3000 pixels
Gaussian Blur Kernel Size: (99, 99)



Sox9 marked cells

Color Threshold: (0,55,40) - (60, 255, 255)
Area Threshold: 100 pixels
Normalization of Green (0, 255) -> (0, 175)

```

thresh = cv2.inRange(im, np.array([0,0,0]), np.array([25,25,25]))
contours, hierarchy = cv2.findContours(thresh,cv2.RETR_CCOMP,cv2.CHAIN_APPROX_SIMPLE)
for i in range(0, len(contours)):
    a = cv2.contourArea(contours[i])
    if (a>minarea):
        finalcontours.append(contours[i])
    
```

Pipeline

Structures

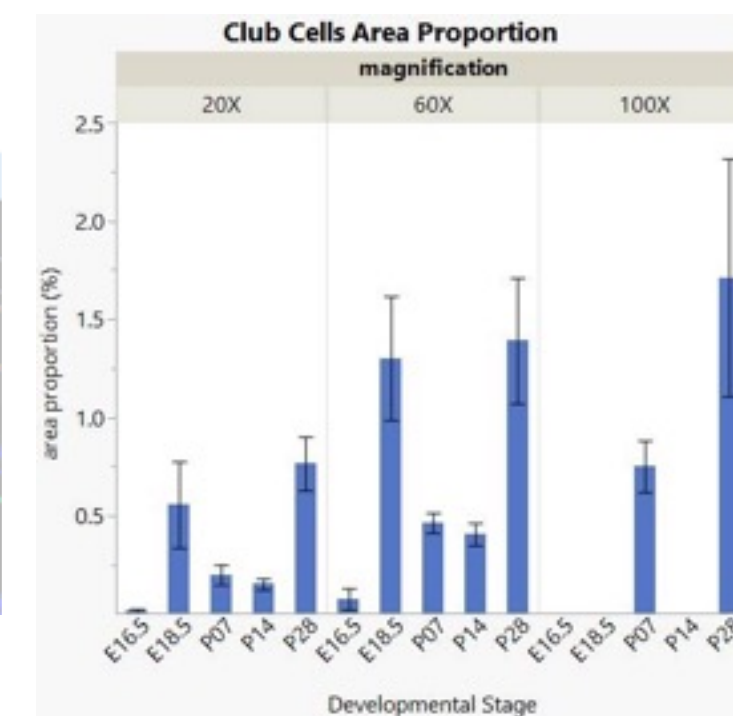
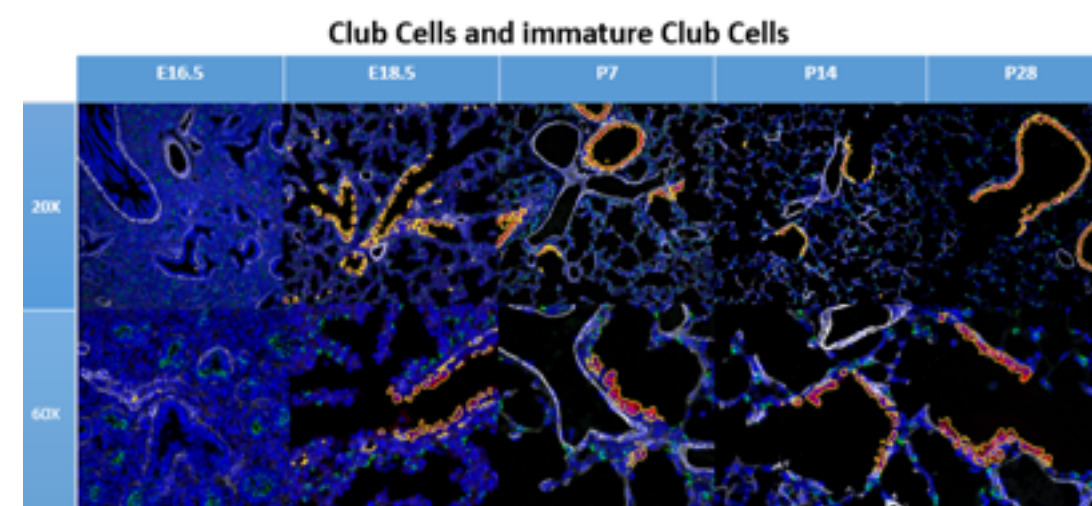
- Bronchioles
- Arteries, Veins
- Acinar Tubules

Cells

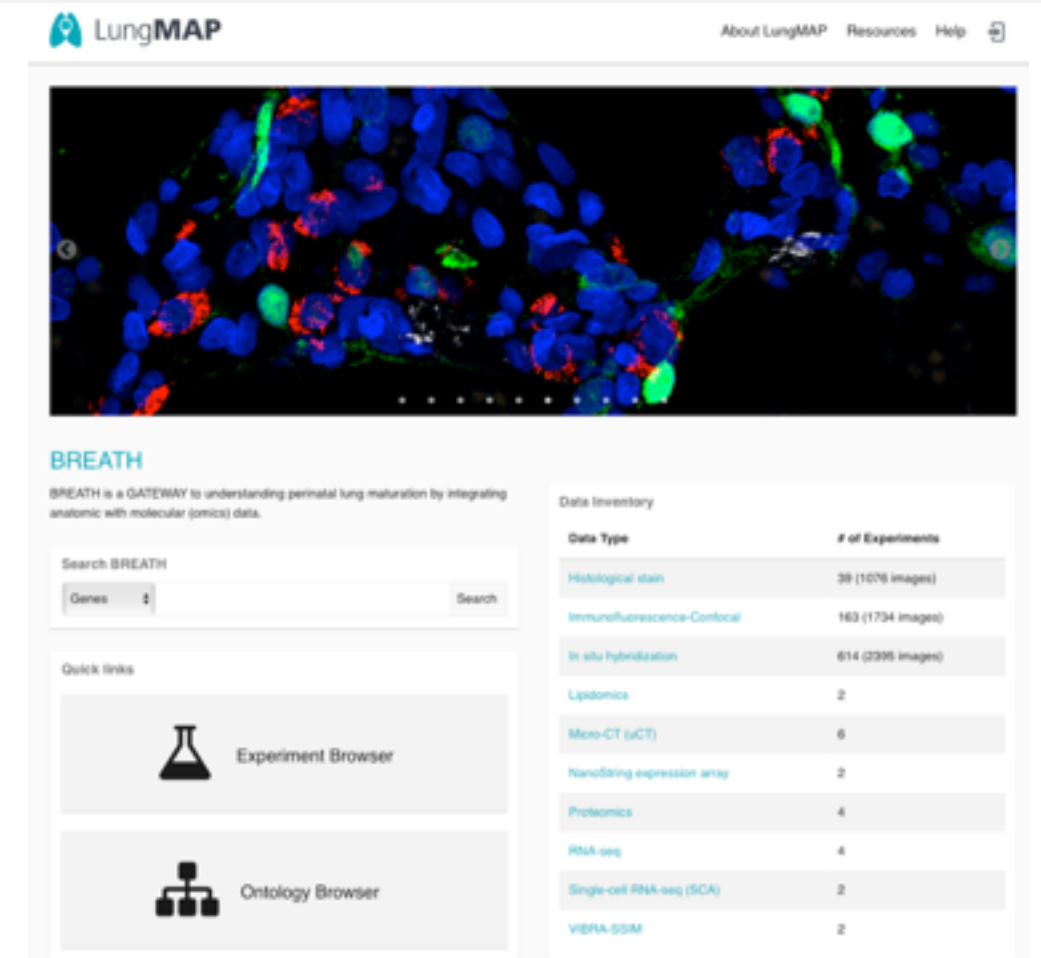
- Club Cells
- TTF-1 marked cells
 - acinar epithelial cells, ciliated cells, club cells, intermediate pneumocytes, type I pneumocytes, type II pneumocytes, alveolar epithelial cells, terminal saccule epithelial cells
- Sox9 marked Cells
 - chondrocytes, type II pneumocytes, fibroblasts, distal acinar tubule epithelial cells, terminal saccule epithelial cells

Species	Age	Number of Subjects	Number of Images	Total Images
Human	9 months old	1	99	427
	4 years old	2	328	
Mouse	E16.5	4	142	1000
	E18.5	7	162	
	P7	2	209	
	P14	2	296	
	P28	7	191	

Applications

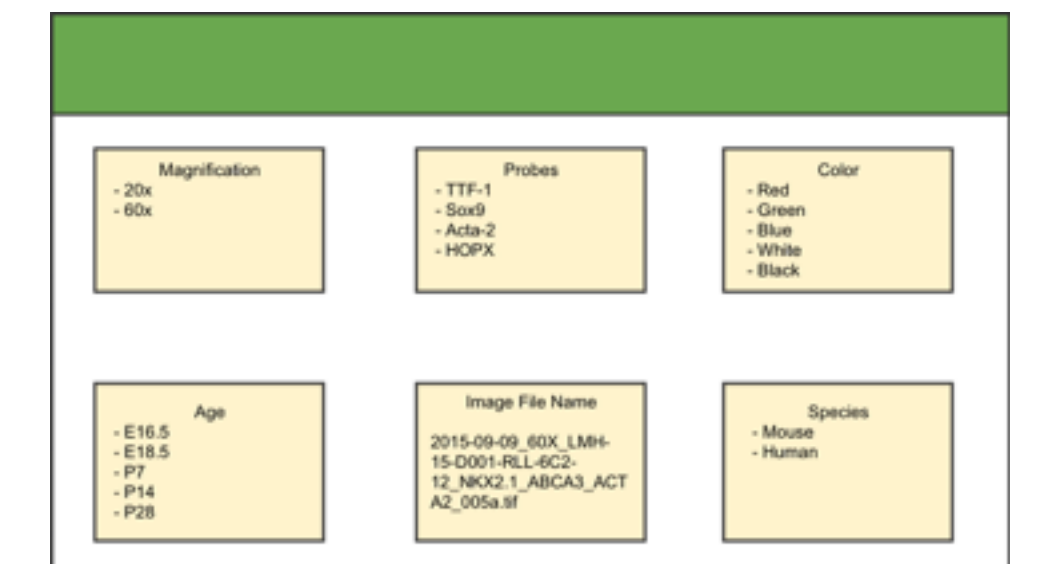


Metadata



Our final output depends on converting human-readable data into a file of machine-readable information

We used the SPARQL query language to collect image information on the LungMAP website



Future Plans

- Make segmentation rules more robust with better normalization and the use of different algorithms to detect more entity types
- Clean up code to make functions more flexible and generic
- Integrate pipeline and web visualization application into LungMAP website

Acknowledgements and Citations

Cliburn Chan, Megan Neely, Ben Neely, Rob Ravier
RTI and the LungMAP team
Paul Bendich, Ashlee Valente, Ariel Dawn, the Duke Data+ program

Citations

- Suzuki, Satoshi. "Topological structural analysis of digitized binary images by border following." Computer Vision, Graphics, and Image Processing 30.1 (1985): 32-46.
- <http://lungmap.net>