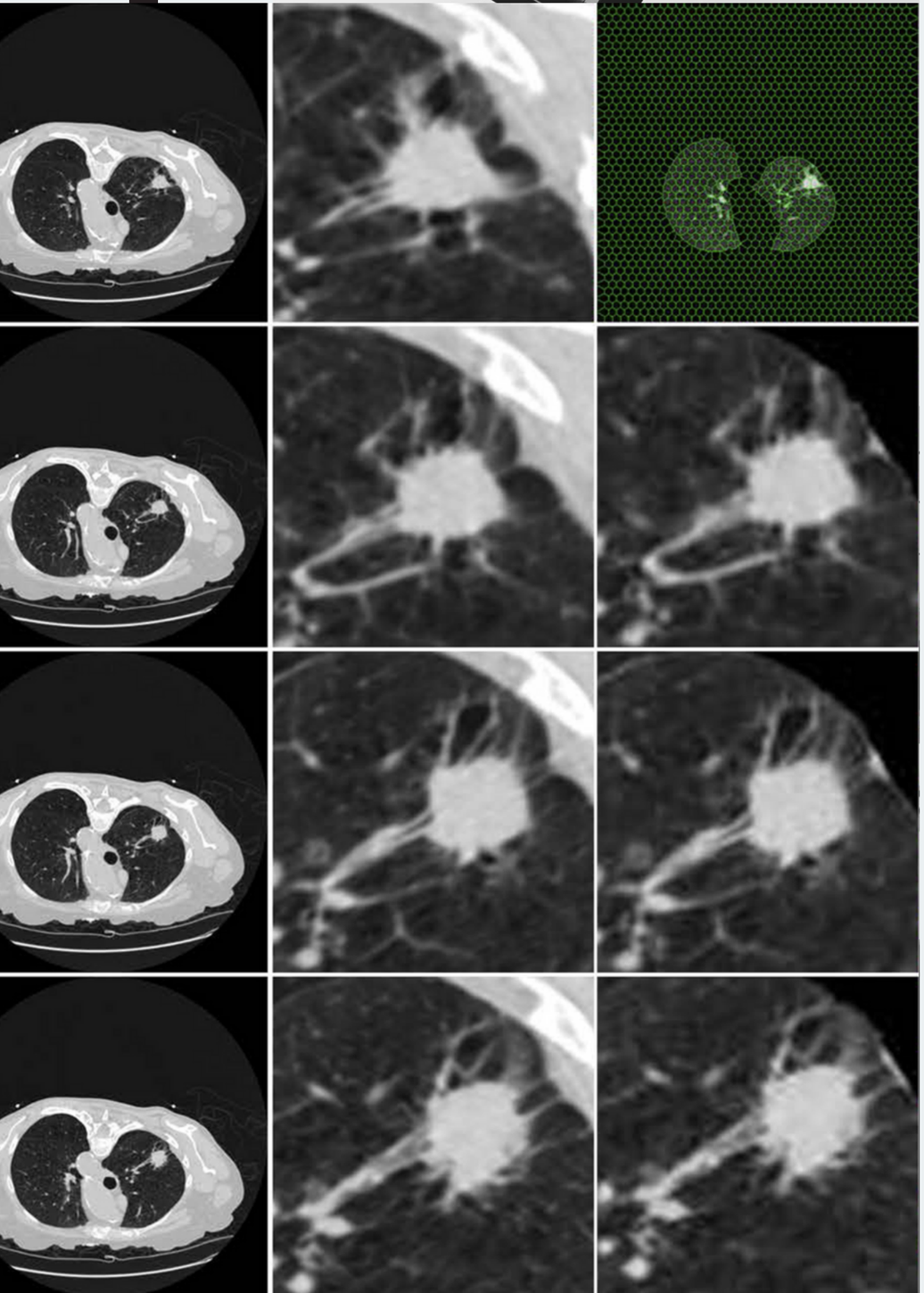


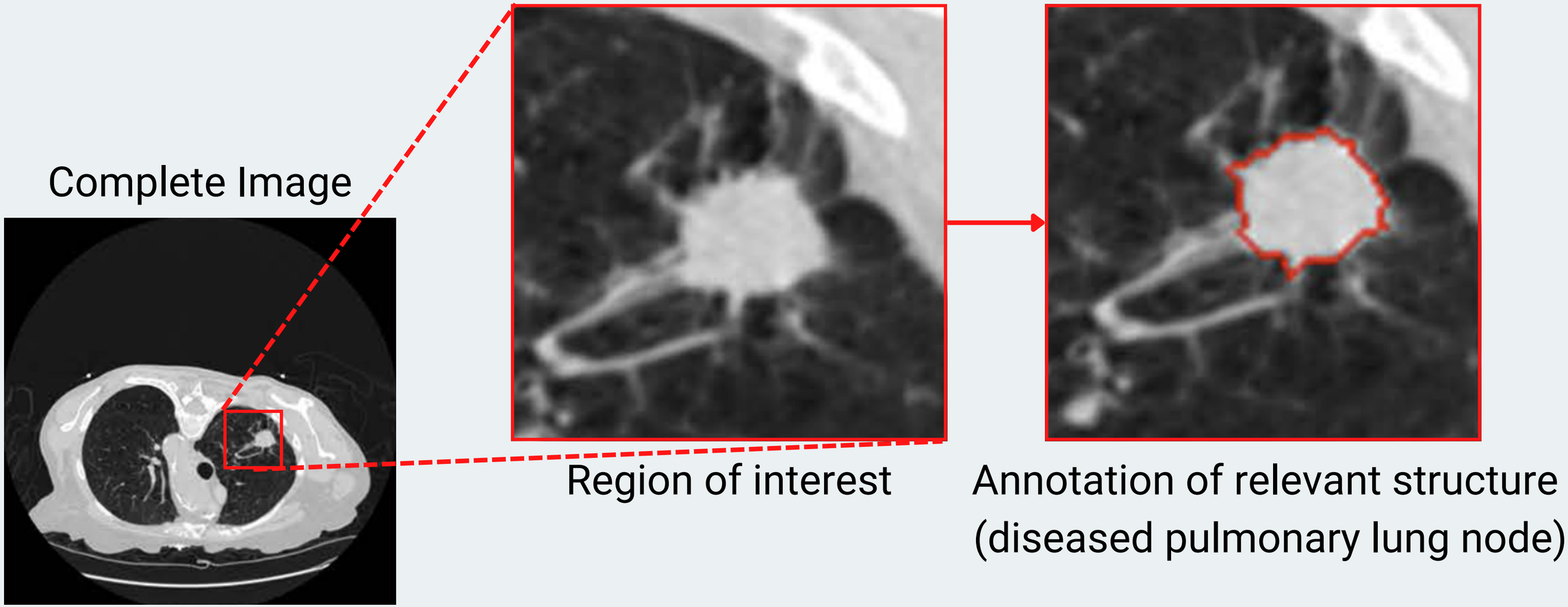
Medical Uncertainty Annotation

Andre Ye, June 2022

Deep Learning & Medical Imaging

- Medical imaging plays a critical role in detection and diagnosis of disease, damage, cell features, etc.
- **Semantic segmentation**: associate each pixel in an input with a class.
- To build robust & powerful medical deep learning computer vision models, we need highly accurate annotations/ground-truth labels.

Conventional Medical Annotation

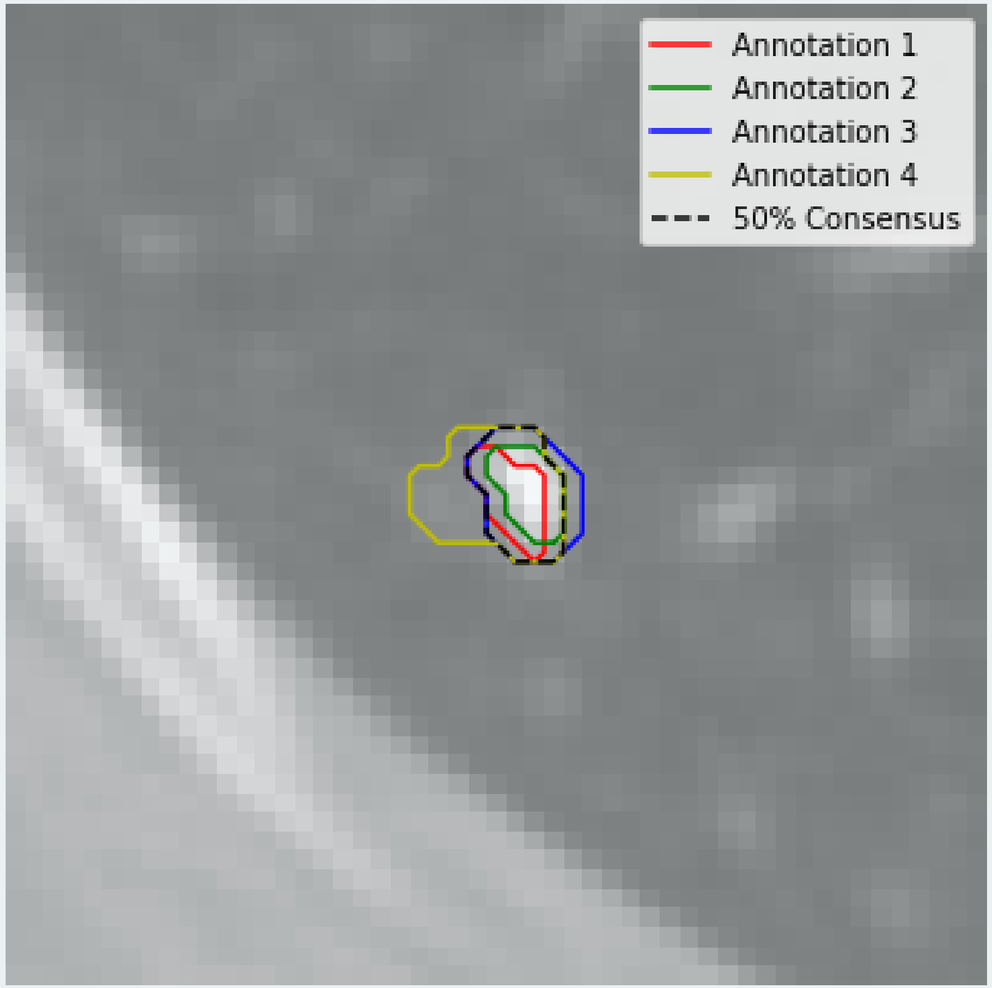


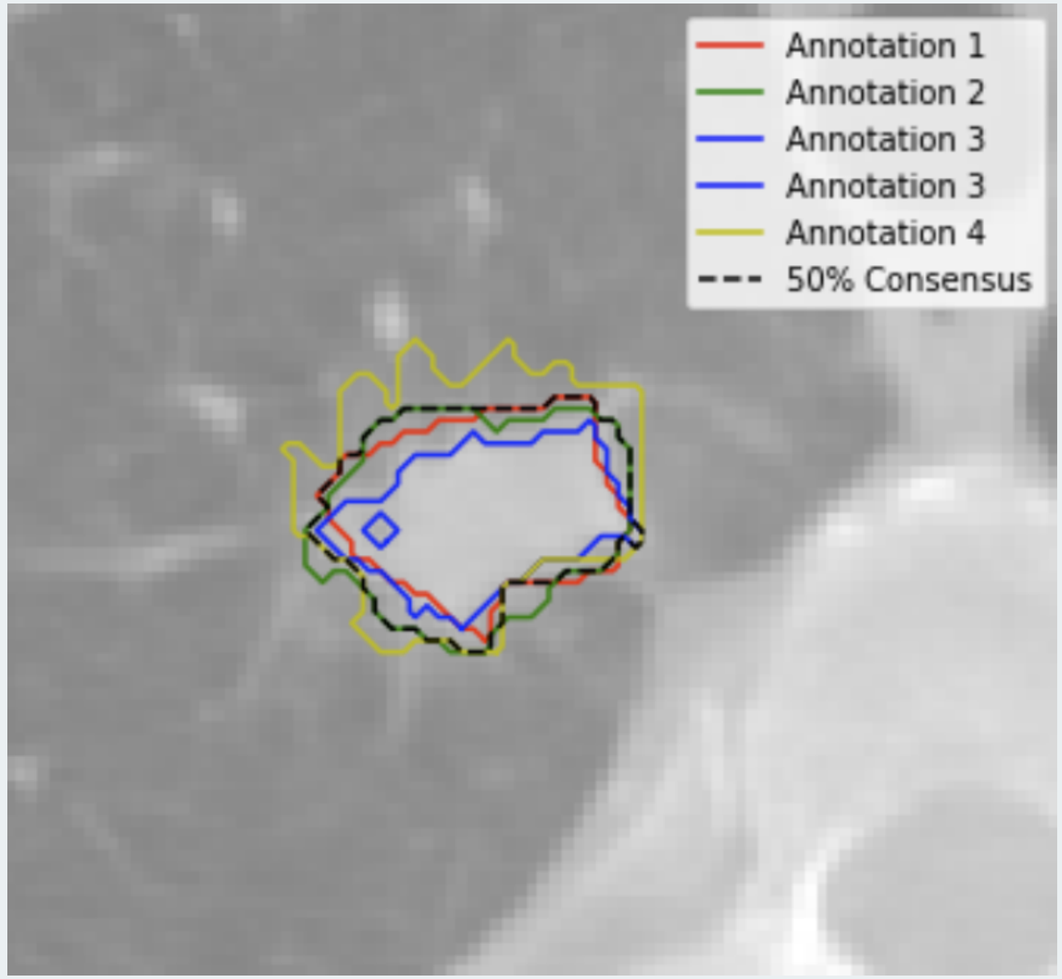
Conventional sem. seg. can't* handle uncertainty

- Semantic segmentation is deterministic
- Medical imaging often contains nondeterministic phenomena
  - Often, it is unclear exactly which class a structure falls into
- **Assertion:** inadequate tools in high-uncertainty contexts lead to high annotation disagreement.
  - Disagreement is a large inefficiency and source of non-robustness in the medical annotation process

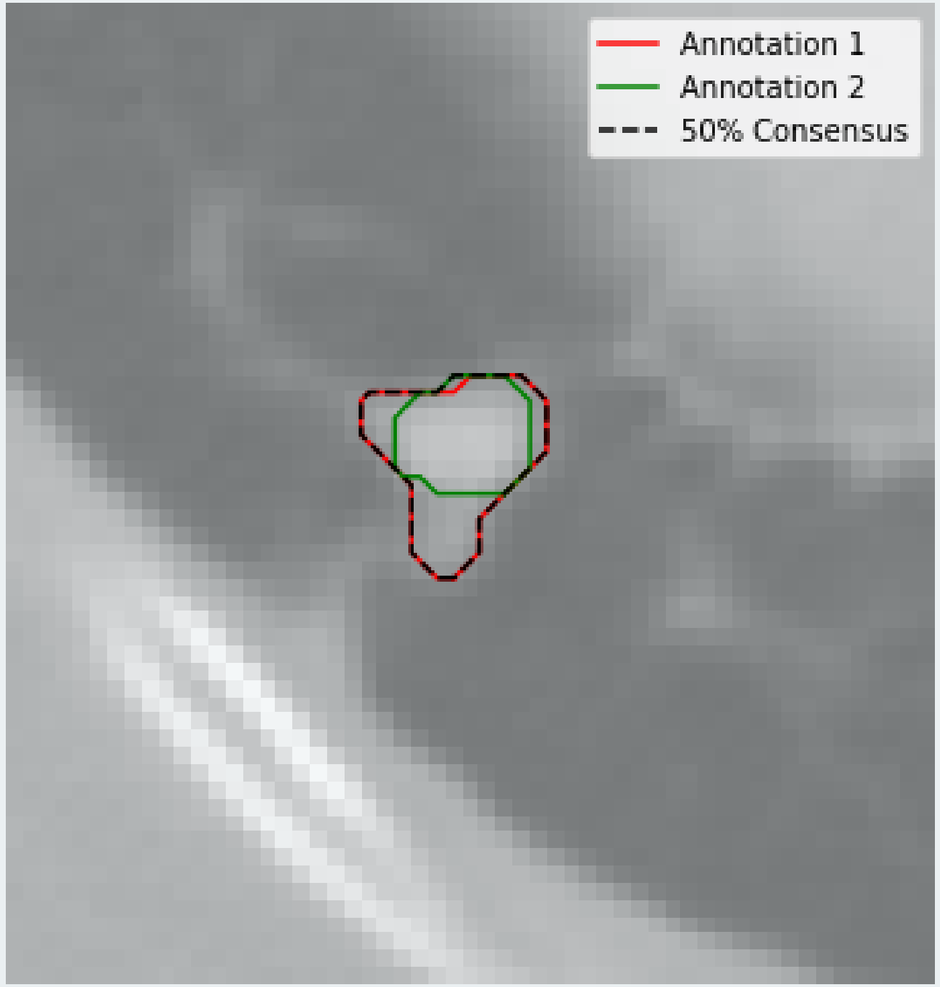
*natively

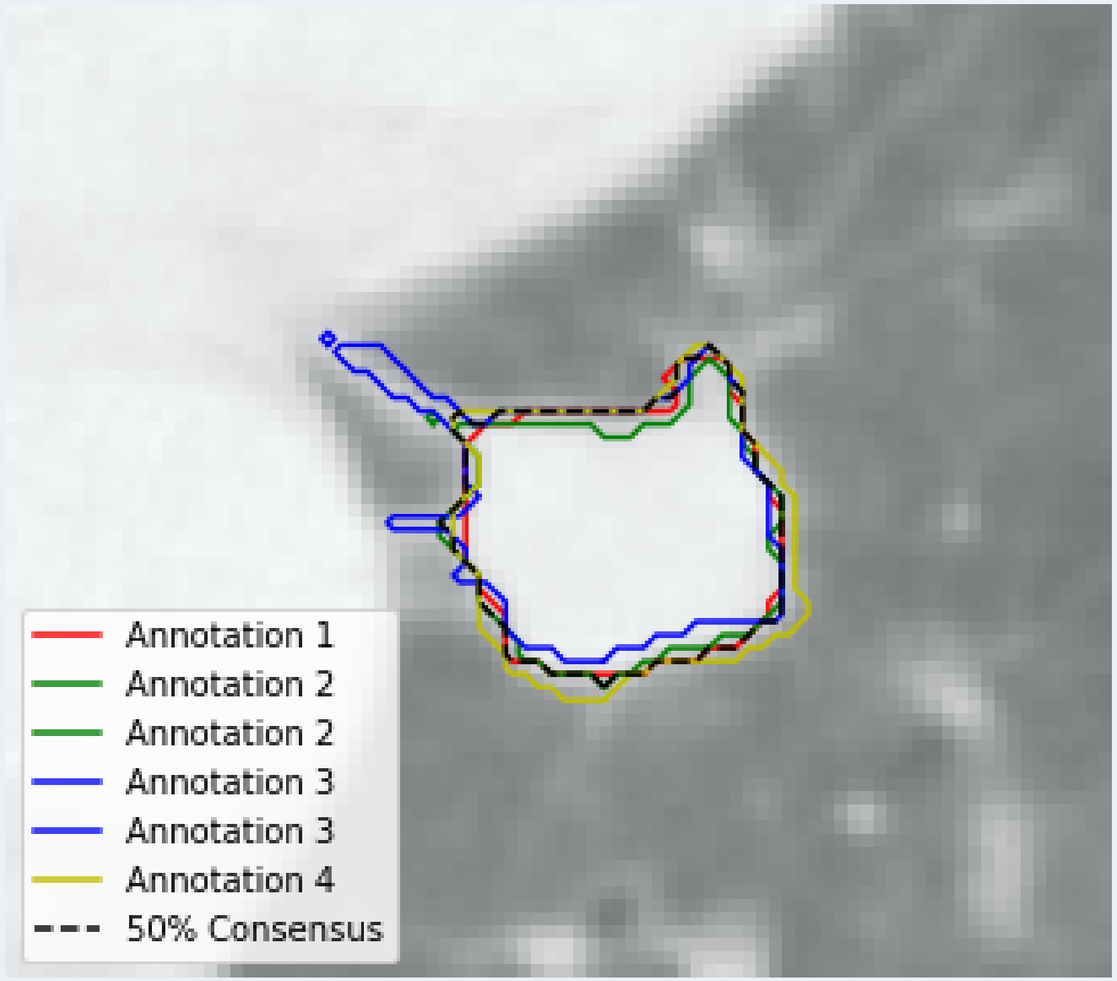
What does disagreement look like?





What does disagreement look like?





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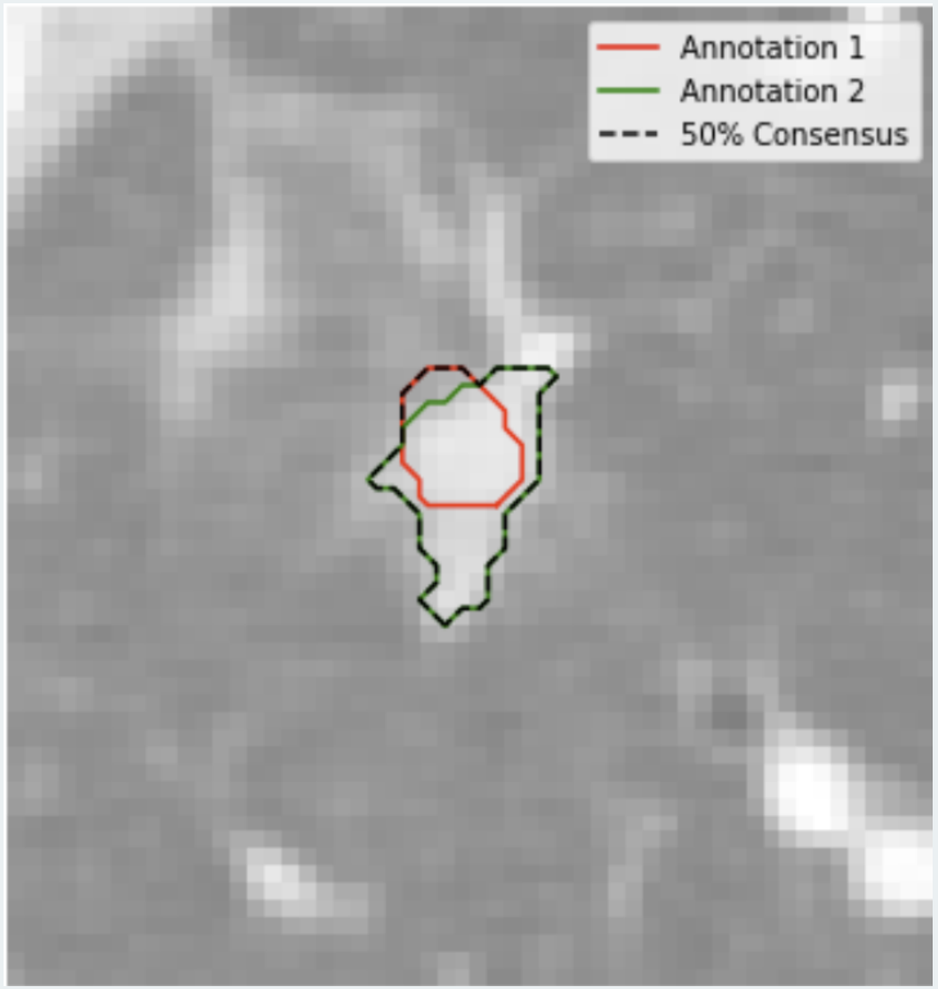

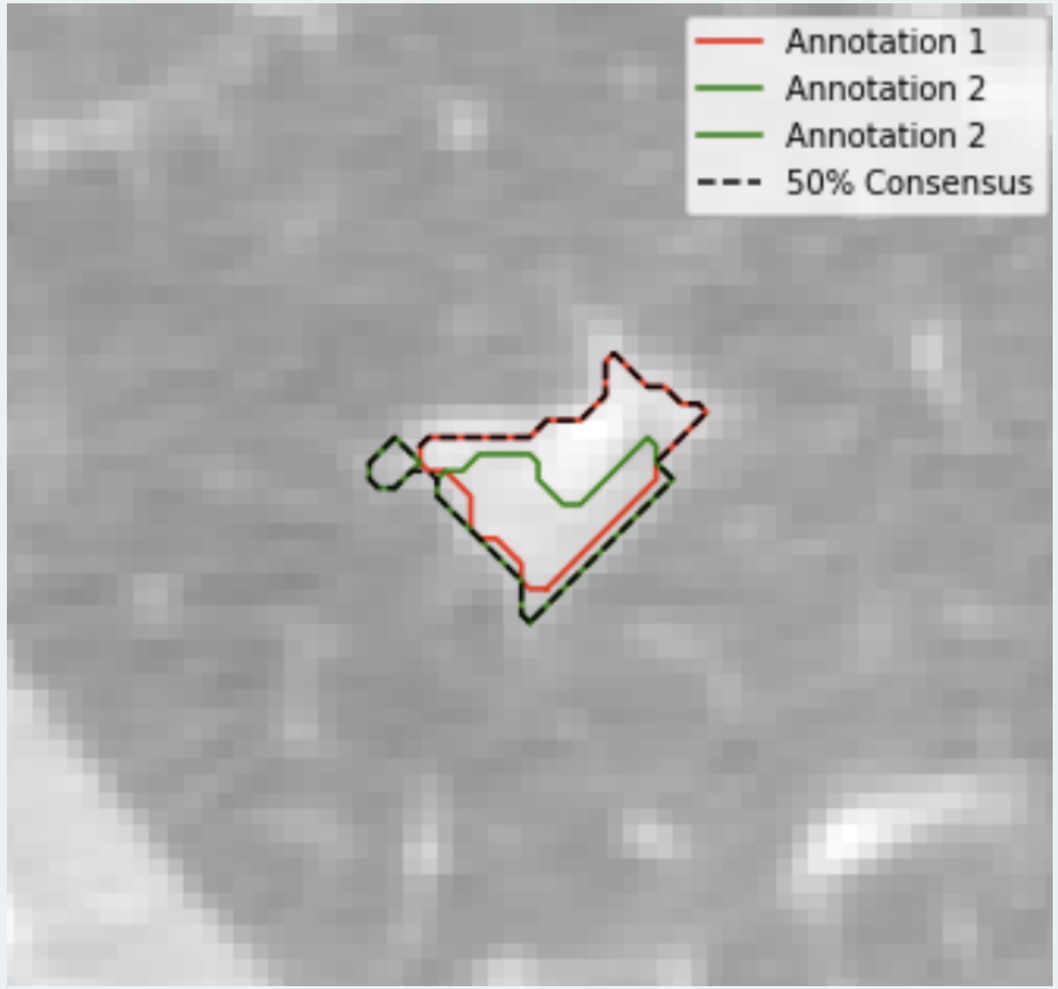

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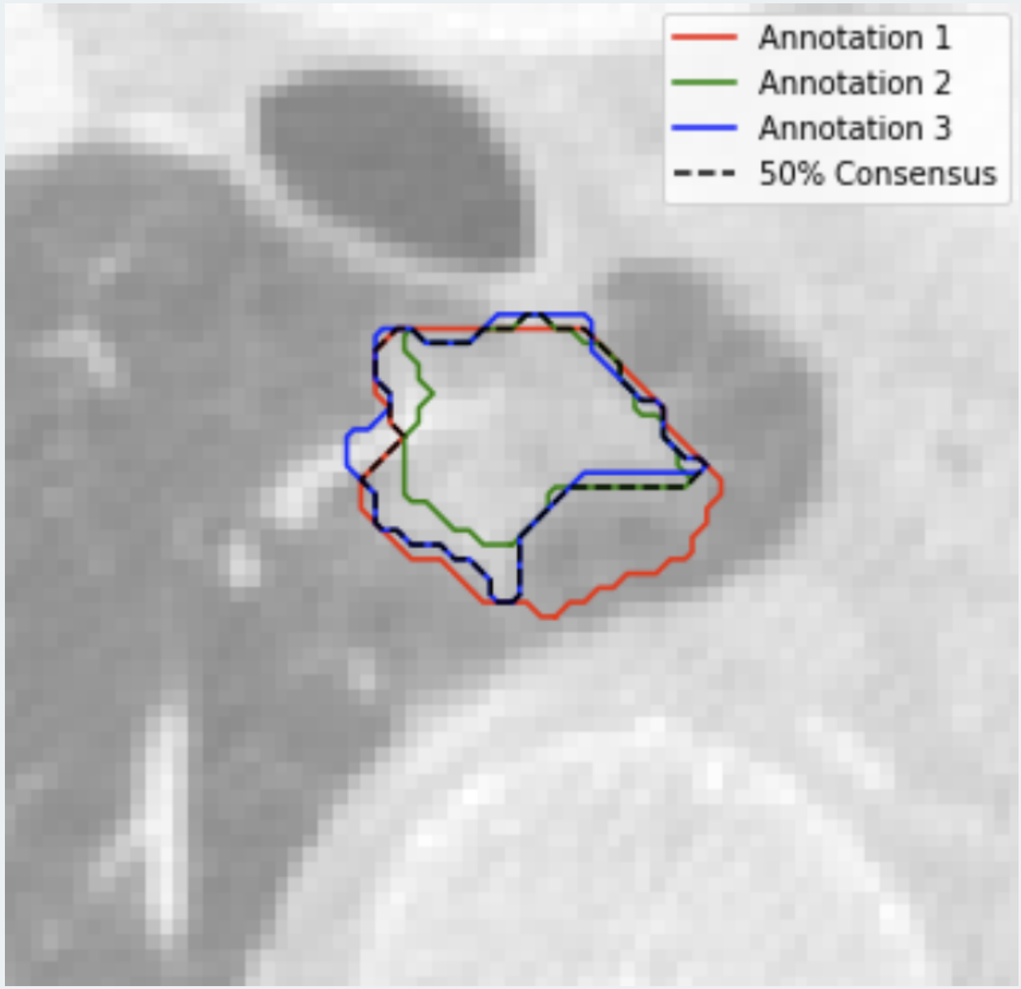
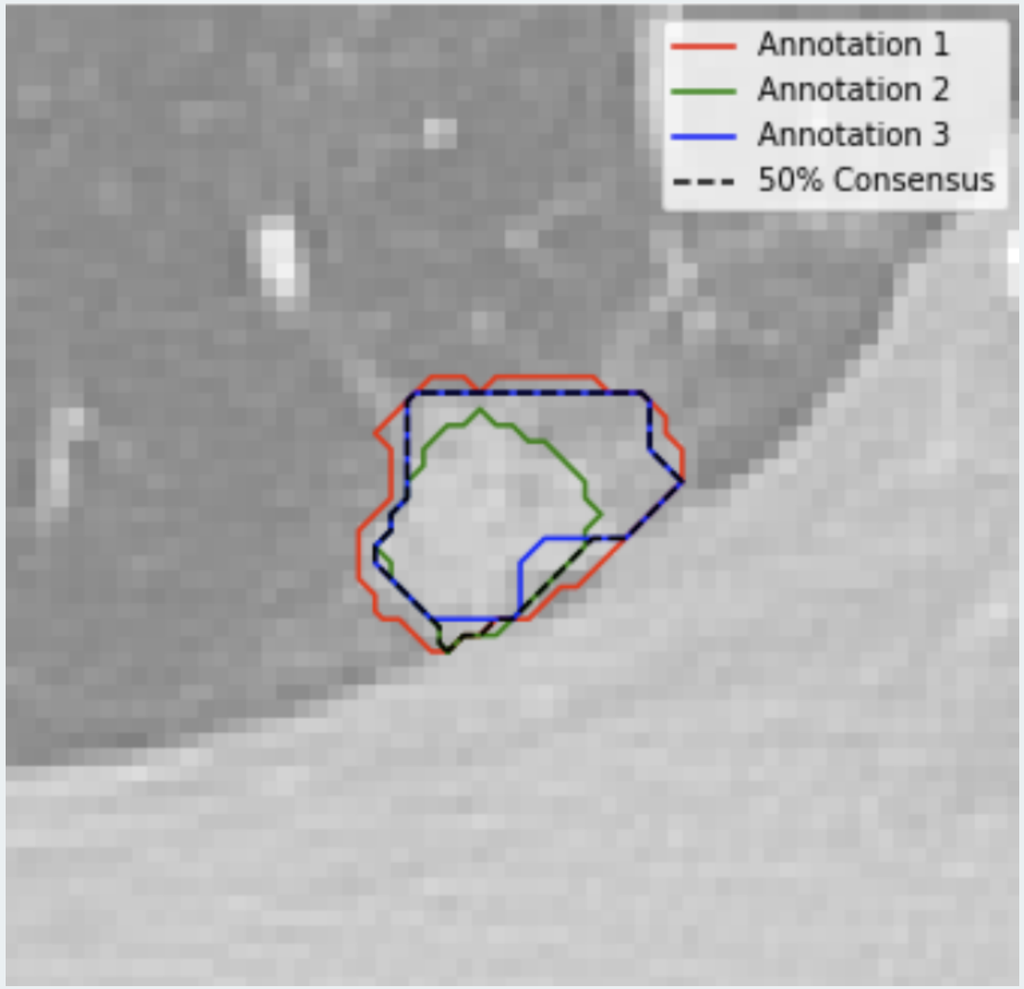


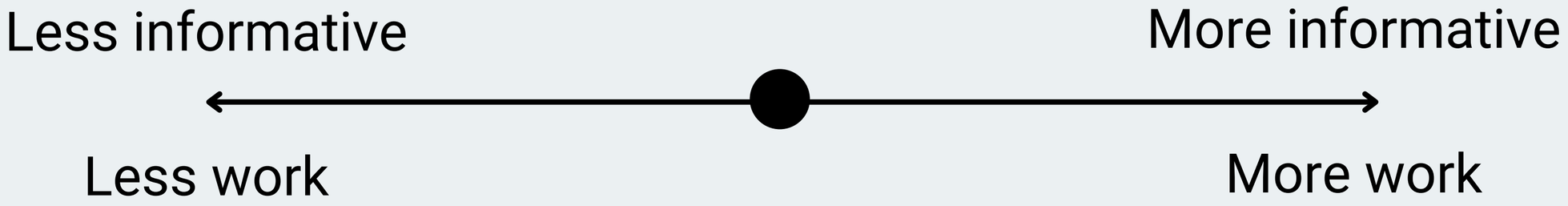


How to deal with uncertainty/disagreement?

- *Standard approach*: train on aggregate annotation
  - Often the mean annotation can be less accurate than any one annotation (Guan et al., 2017)
- *Popular approach in literature*: train on deterministic labels, then infer uncertainty probabilistically using fancy math
- *This idea*: Why not mark up uncertainty in the labels themselves?
  - Stronger and more direct uncertainty signal
  - Ubiqitous across many domains
  - Can be more work - potentially prohobitively so - to obtain

System Design Considerations: The Balance

- **Must meaningfully capture domain uncertainty**.
- **Must be efficient**. (Annotating images sucks and no one wants to expend a lot of effort on it.)
    - Dr. Linda Shapiro: "We are willing to accept inaccuracies if we can get more annotations completed faster." (paraphrased)



Idea: Min-Max Hypothesis Annotation

Two-step process:

1. We identify a 'min' structure which we are sure satisfies a class.
2. We identify additional parts of the structure which *might* satisfy the class and append to the structure as the 'max' hypothesis.

Max hypothesis defined in terms of appendages to the min hypothesis.

Simple prototype: mua.cs.washington.edu