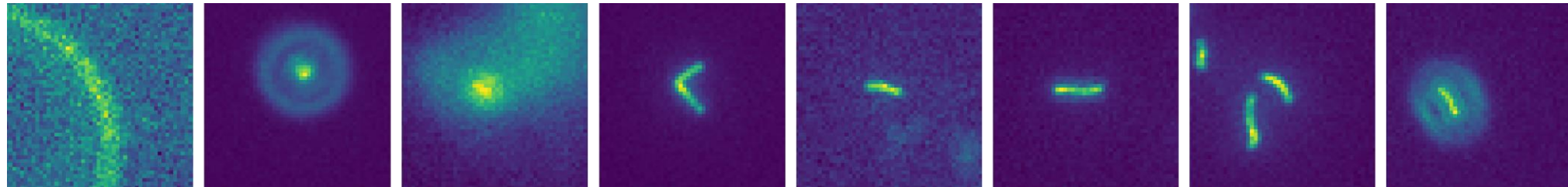
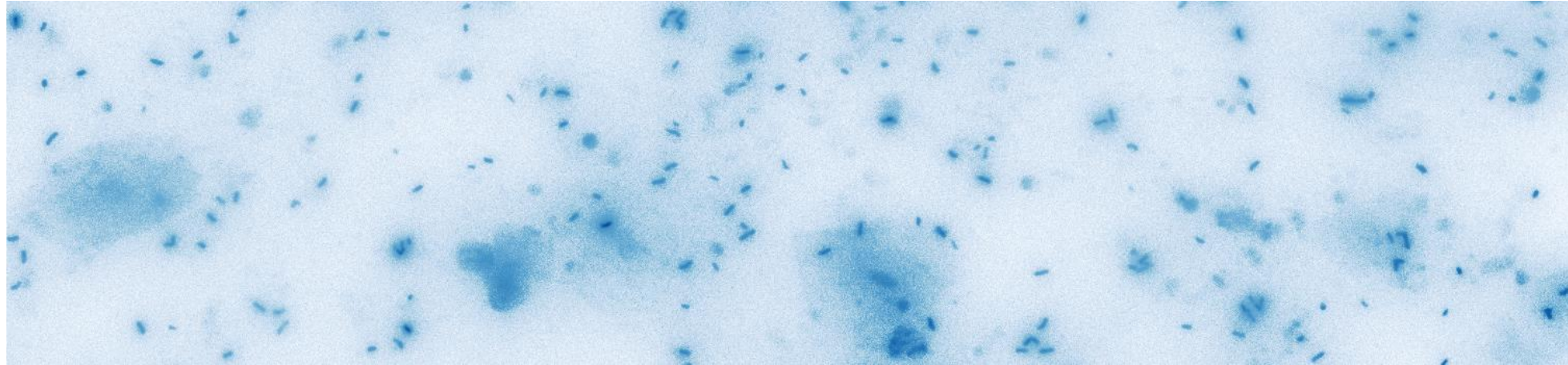


Automated Detection of Tuberculosis Bacilli in Stained Sputum Smears





Mission

Cheaper and more efficient sputum smear examination for tuberculosis detection.

Objective

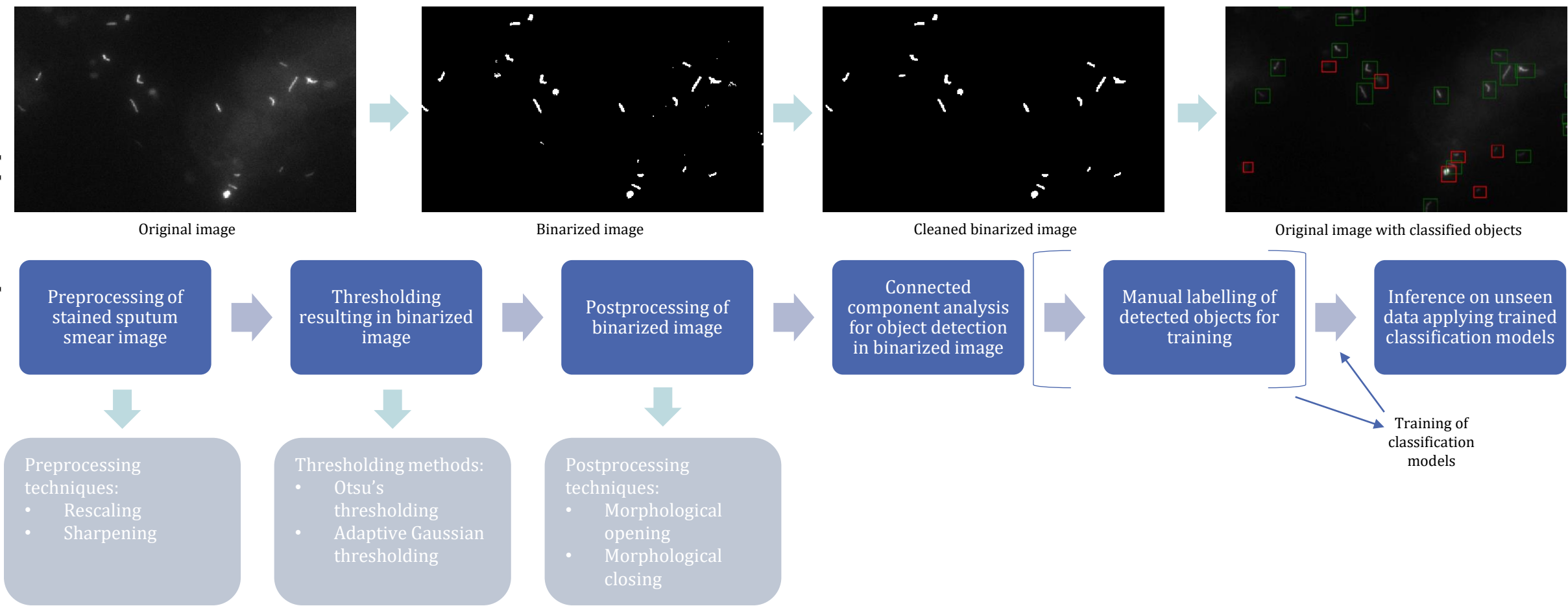
Pipeline to classify images of sputum smears using **CV techniques** and **CNN architectures**.

Data

86 whole-slide images of stained sputum smears graded on a scale from 0 to 4 for severity.

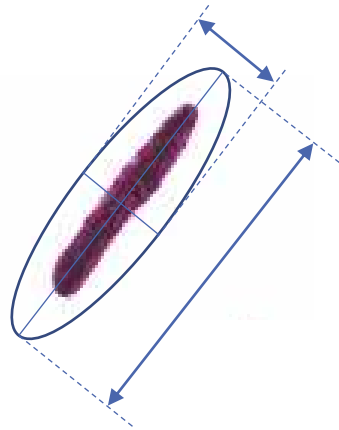
Computational Pipeline

Computational pipeline



Classification Models

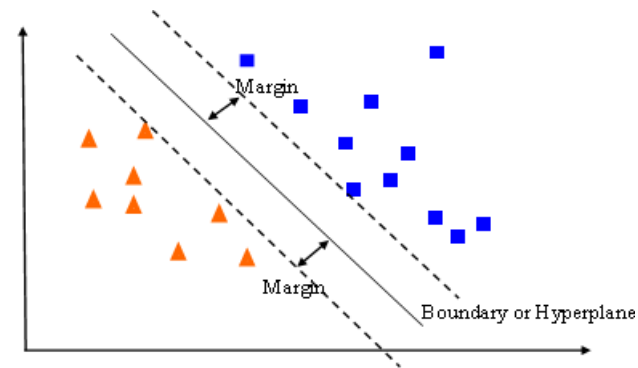
Baseline Model



Classification based on:

- size of area,
- ratio of lengths of major and minor axes of enclosing ellipse of detected objects.

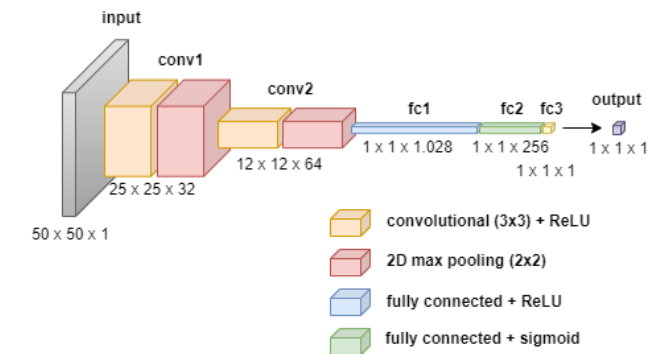
Support Vector Machine



Parameters passed to SVM:
geometric properties, i.e.,

- area,
- height/length of minor axis,
- width/length of major axis of detected objects.

Convolutional Neural Network

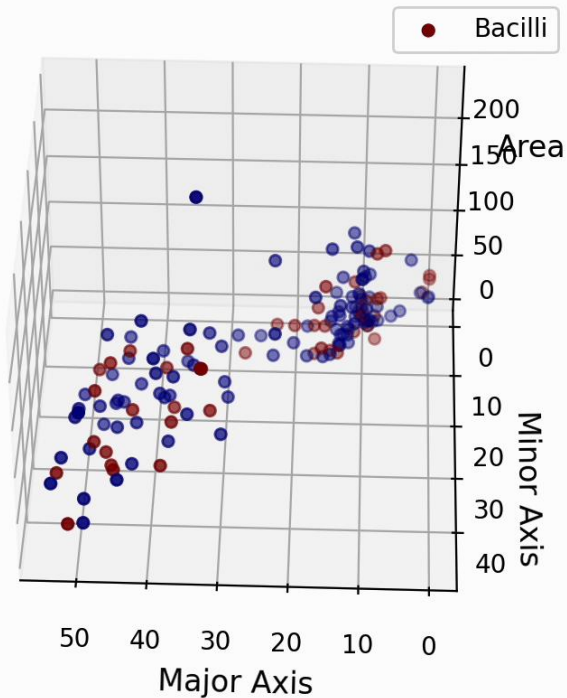


Model architecture:

- 2 blocks of convolutional and max-pooling layers,
- 3 fully connected layers,
- sigmoid neuron for final output.

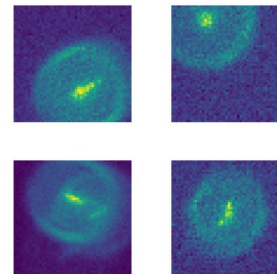
SVM: Results

- The plot suggests that bacilli and non-bacillus objects occupy the same region of space.
- But should bacilli not be identifiable by their elongated shape?

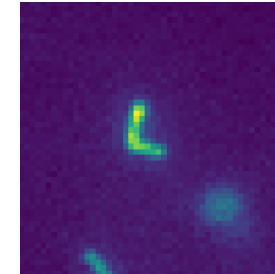


Possible issues might be:

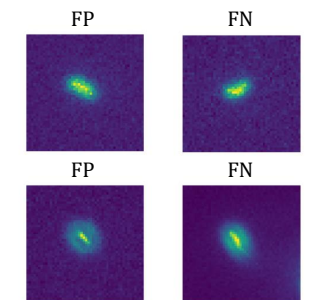
1. Round-like background noise



2. Bent or overlapping bacilli

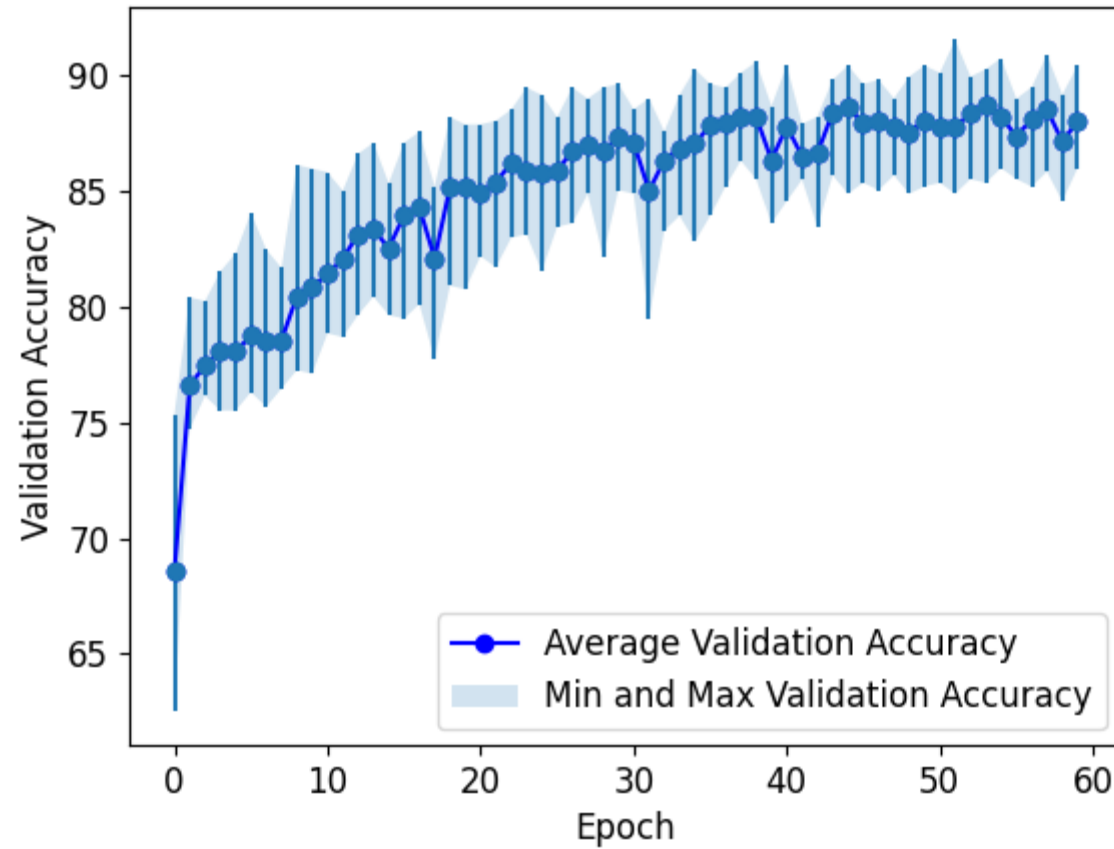


3. Inconsistent labelling

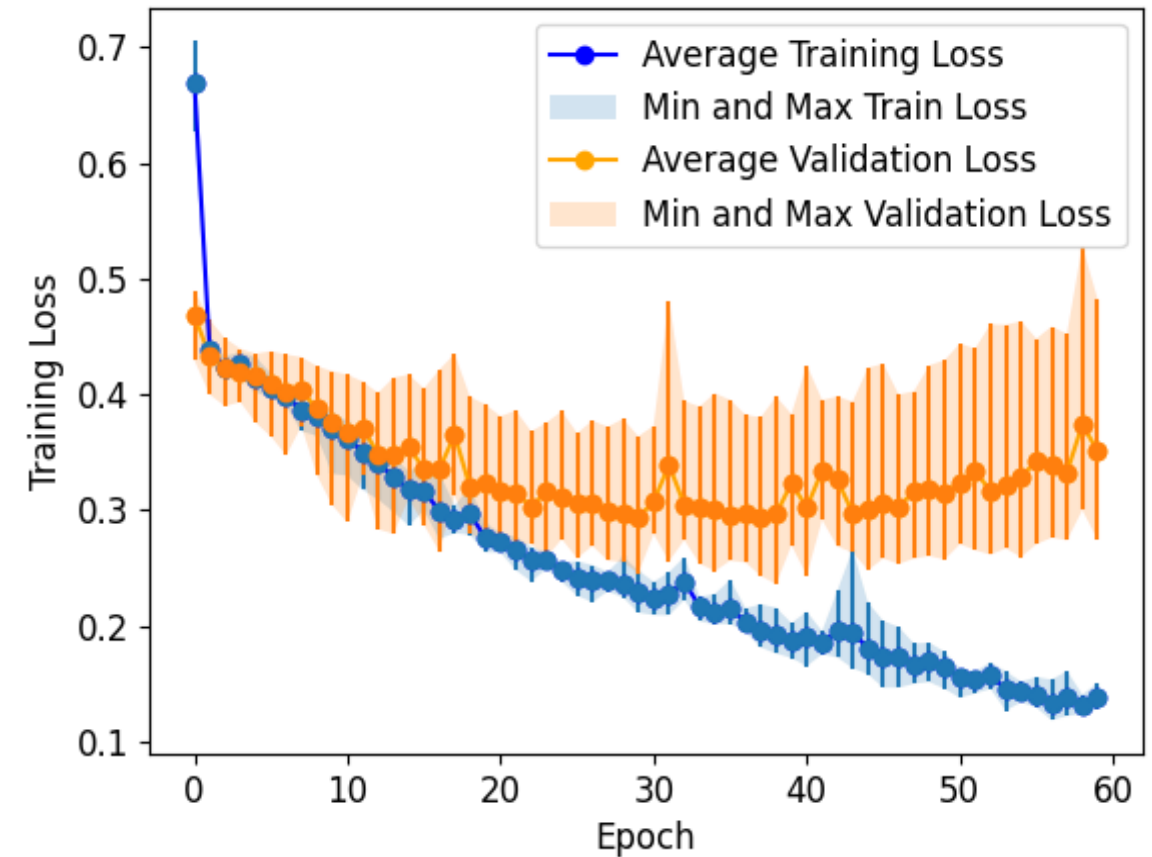


CNN: Results from 5-fold Cross-Validation

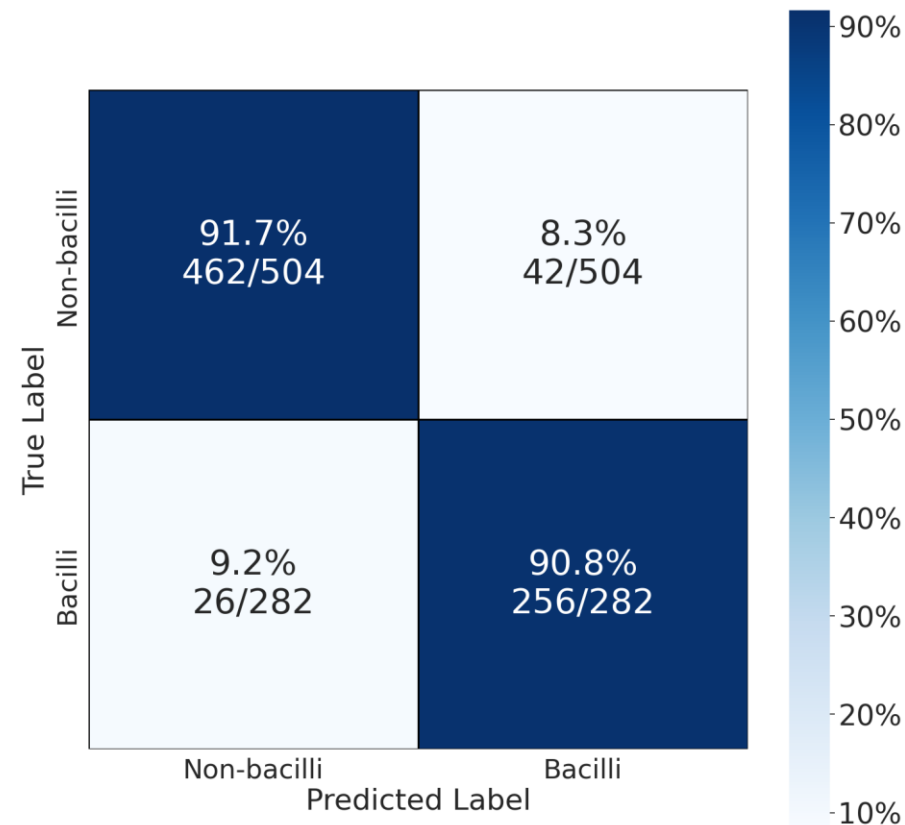
Validation Accuracy over Epochs



Train/Validation Loss



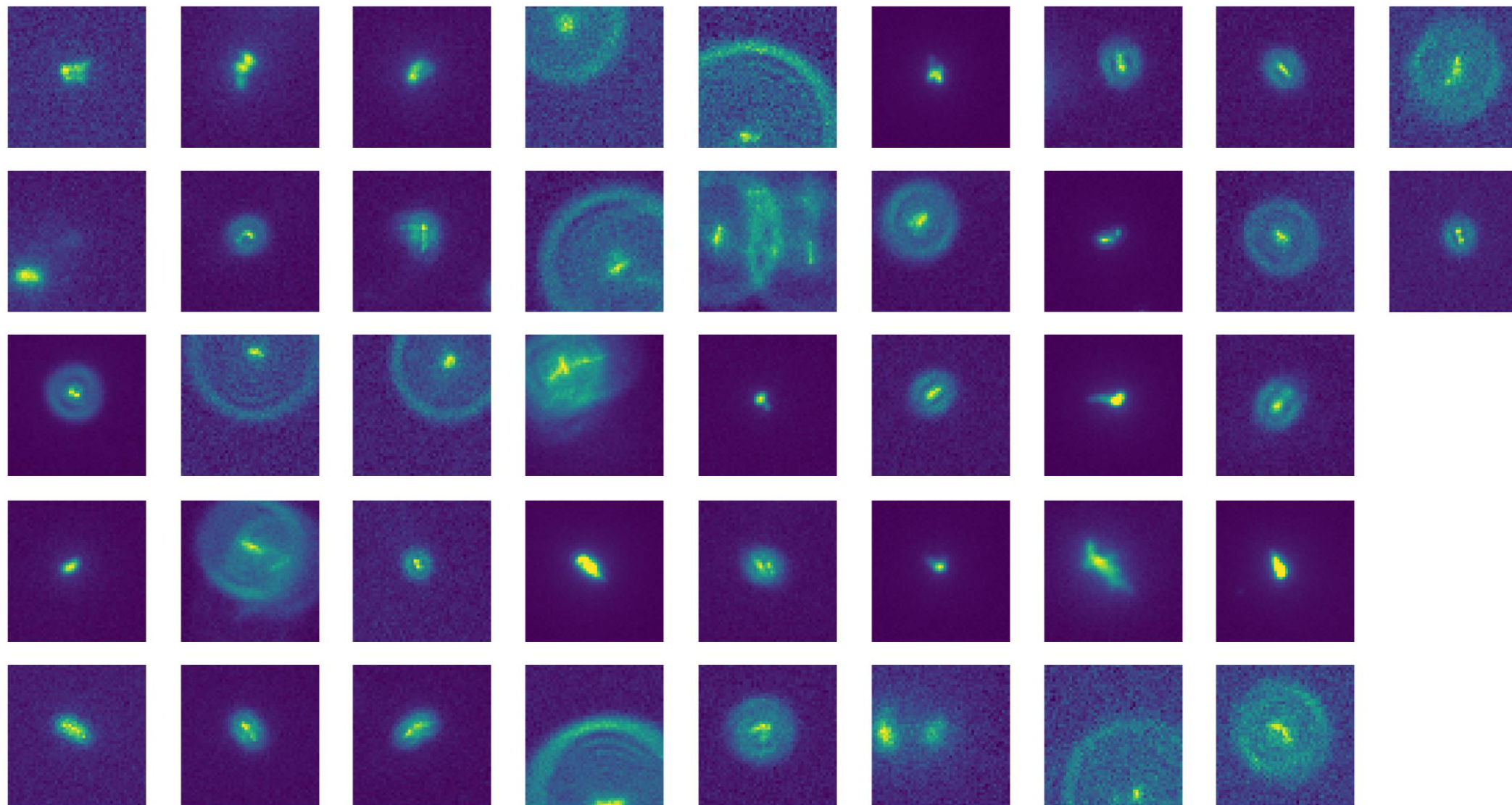
CNN: Test Results



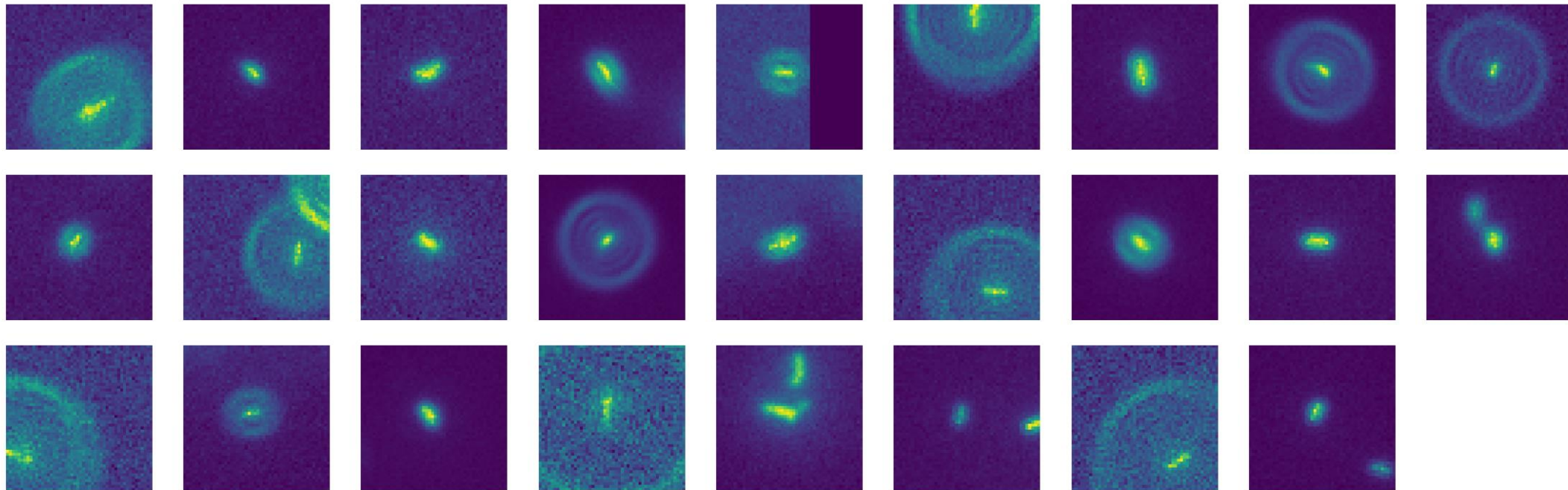
- The model identified 85% of all bacilli.
- Out of all objects classified as bacilli, 90% truly are bacilli.
- On which objects does the CNN model fail?

	Accuracy	Recall	Precision	F1
Model 1	0.91	0.86	0.90	0.88
Model 2	0.91	0.83	0.94	0.88
Model 3	0.91	0.87	0.87	0.87
Model 4	0.89	0.79	0.95	0.86
Model 5	0.89	0.88	0.81	0.85
Mean	0.90	0.85	0.90	0.87

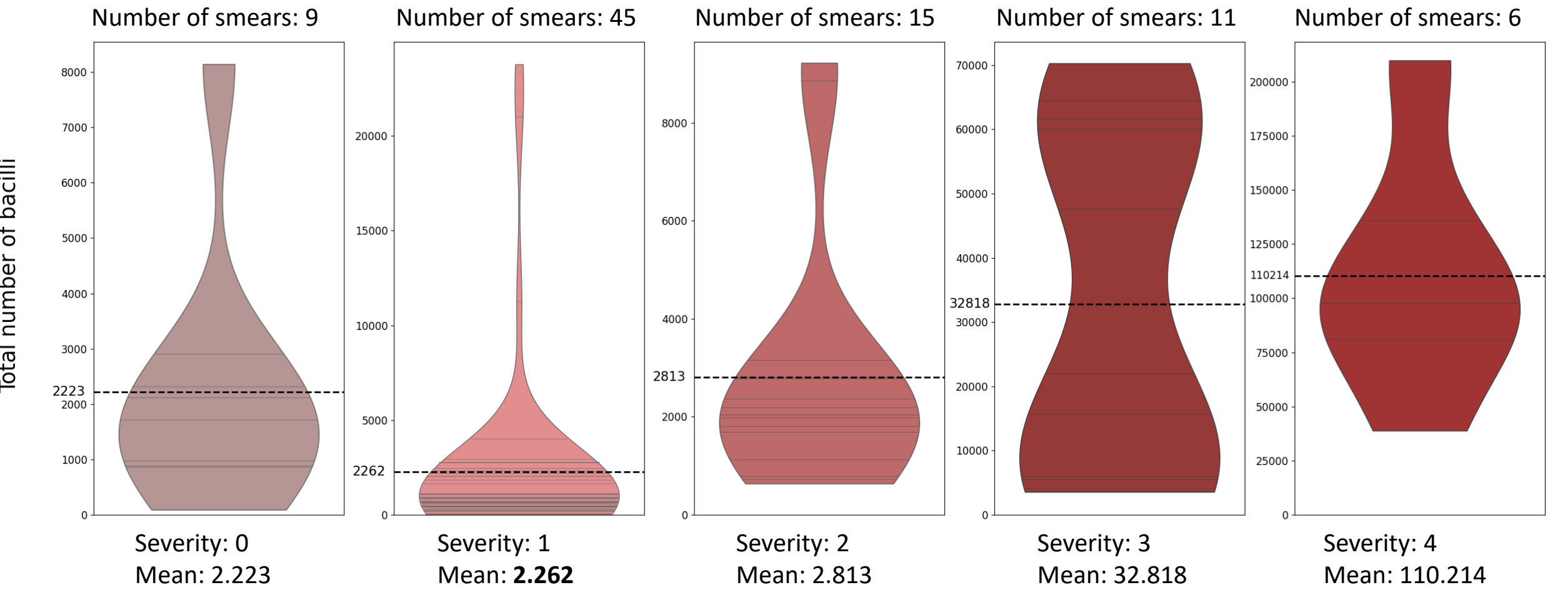
CNN Testing: False Positives



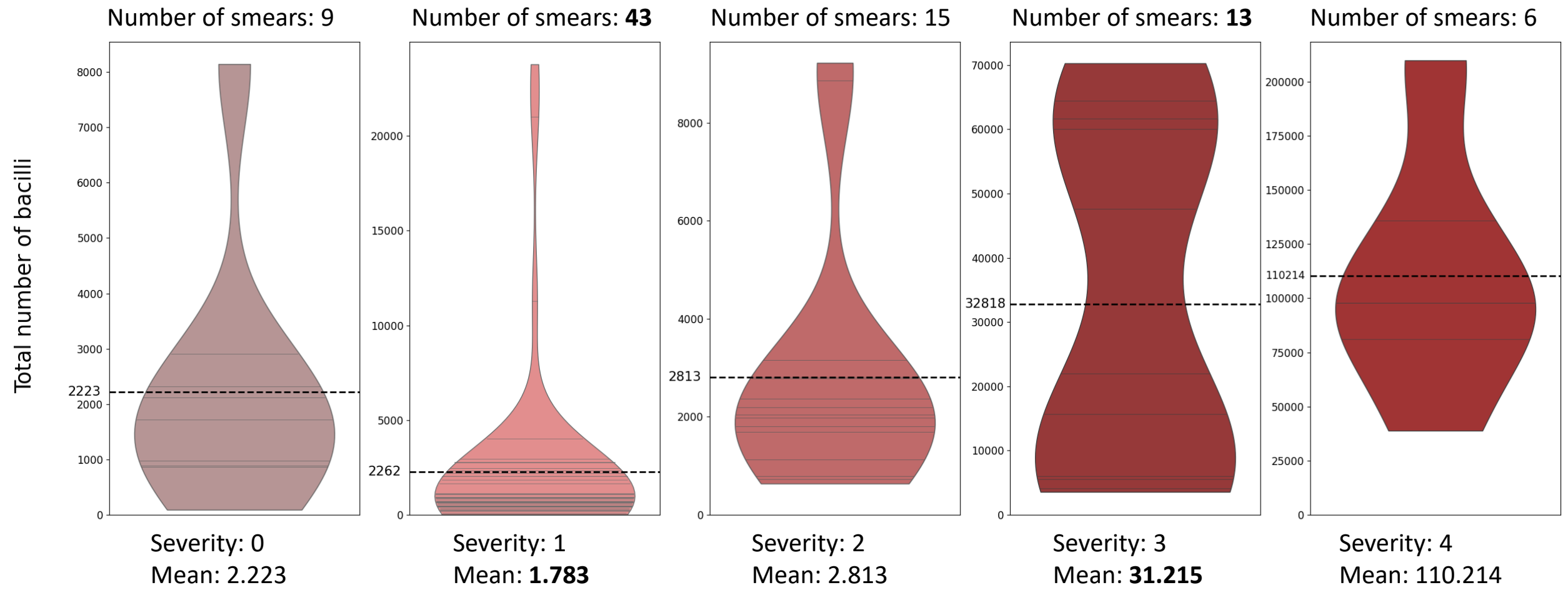
CNN Testing: False Negatives



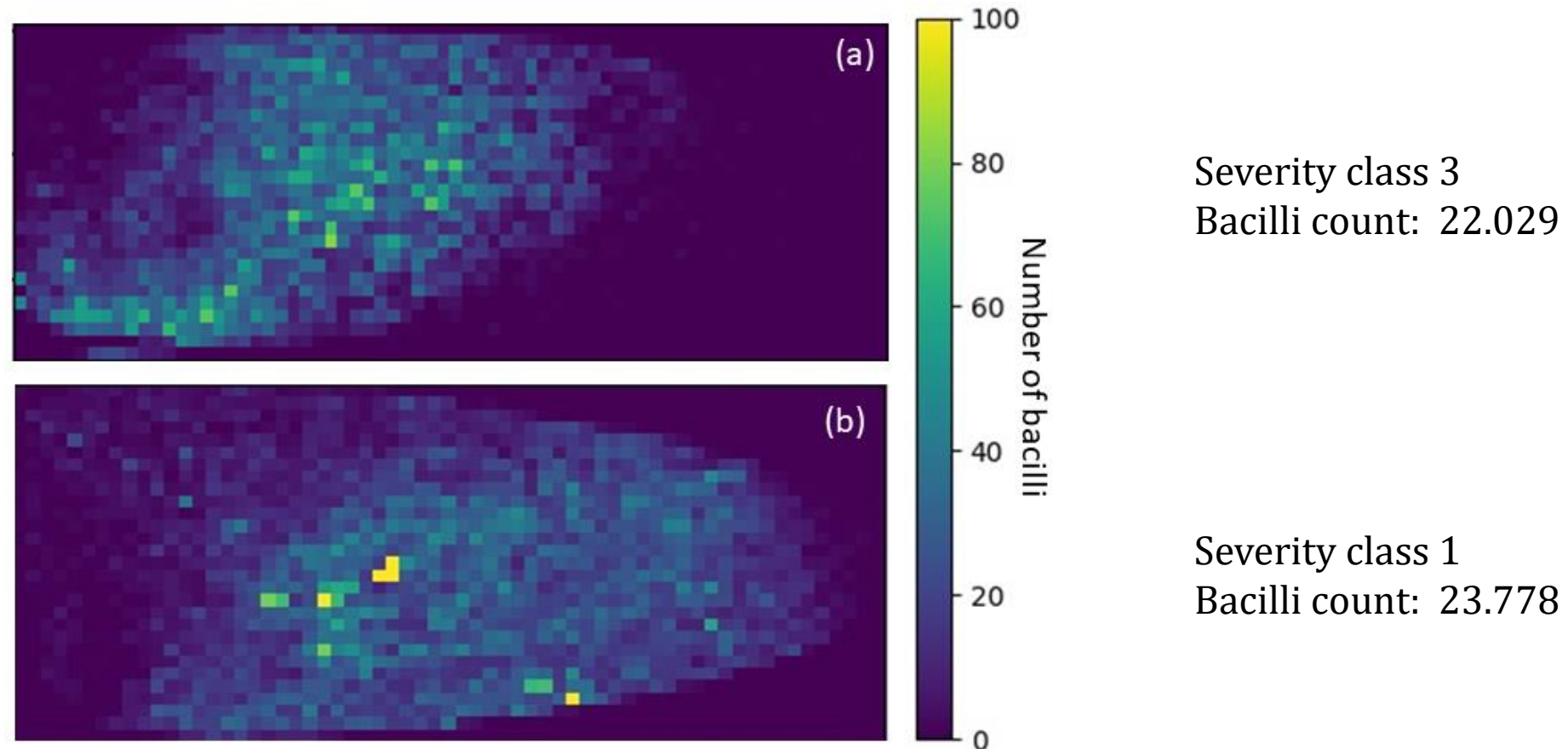
CNN Inference Results: Bacilli Counts vs. Severity Grade



CNN Inference Results: Correction for Outliers

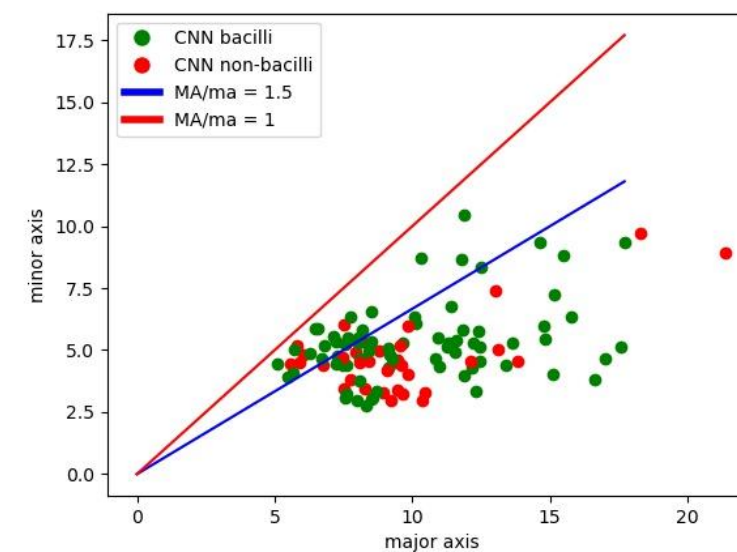
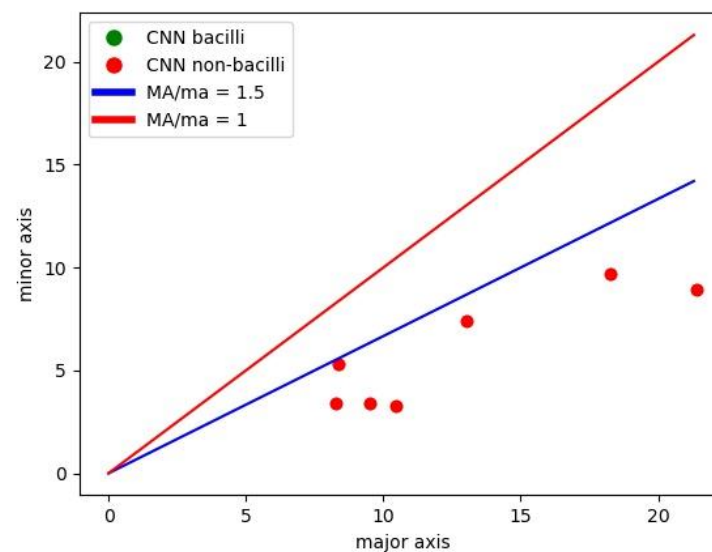
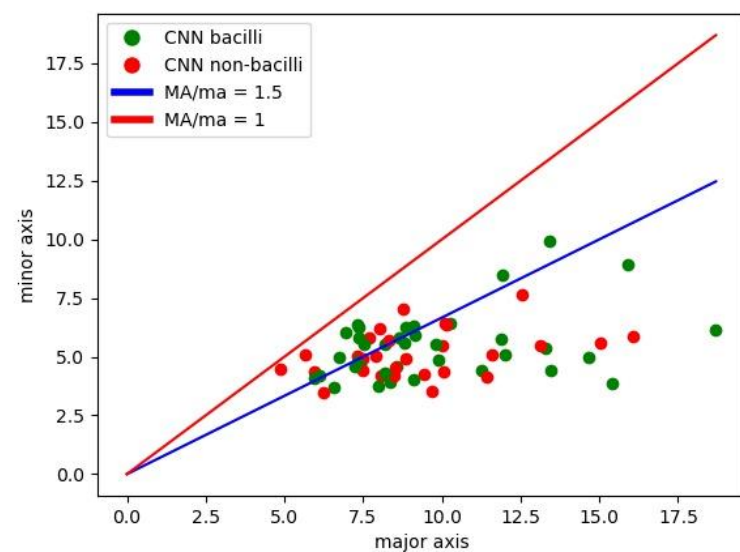


Misclassification: The Role of Bacilli Distribution

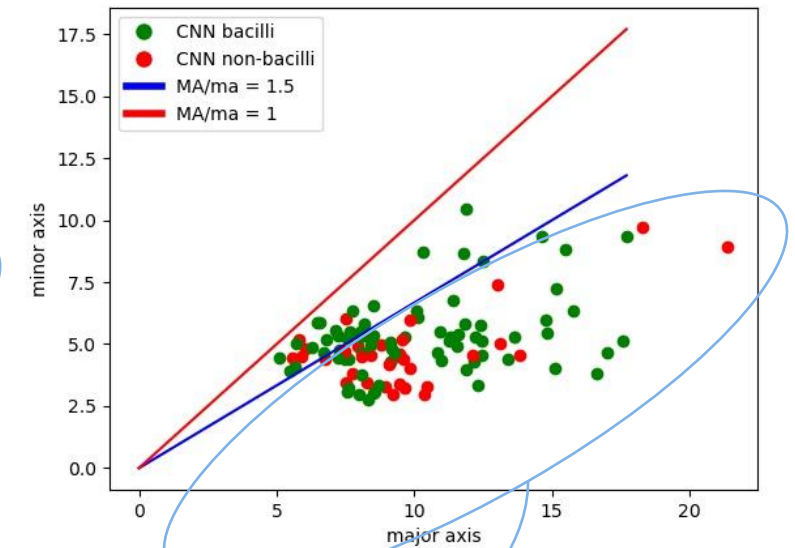
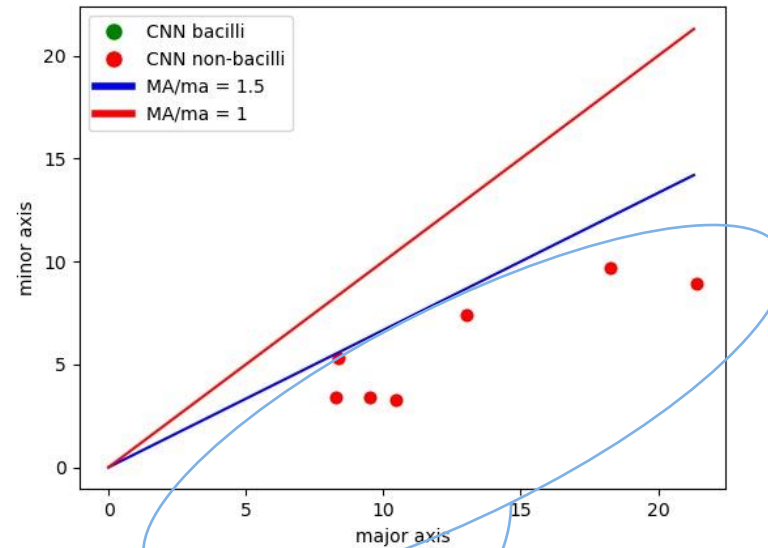
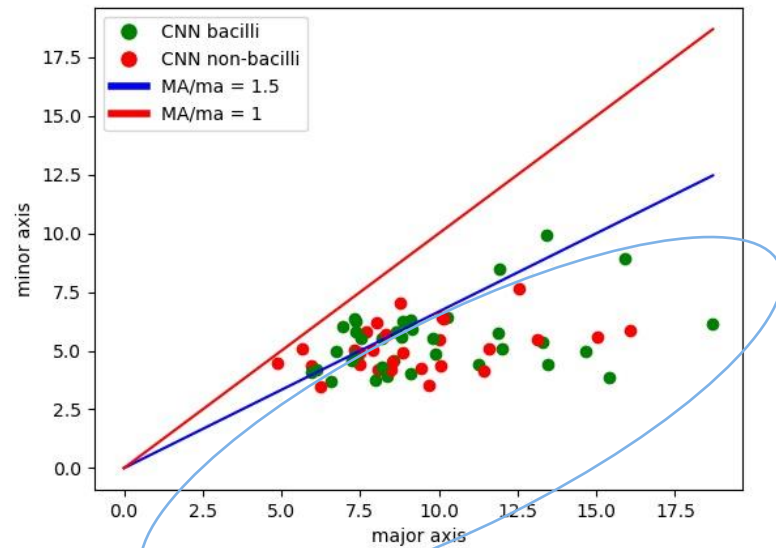


Thanks for your attention! Any questions?

Model Comparison: CNN and Baseline Model



Model Comparison: CNN and Baseline Model



Objects potentially classified as bacilli (depending on their area)