Computational Imaging Lab. (CIL)
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Improving RANSAC-Based Segmentation Through CNN Encapsulation

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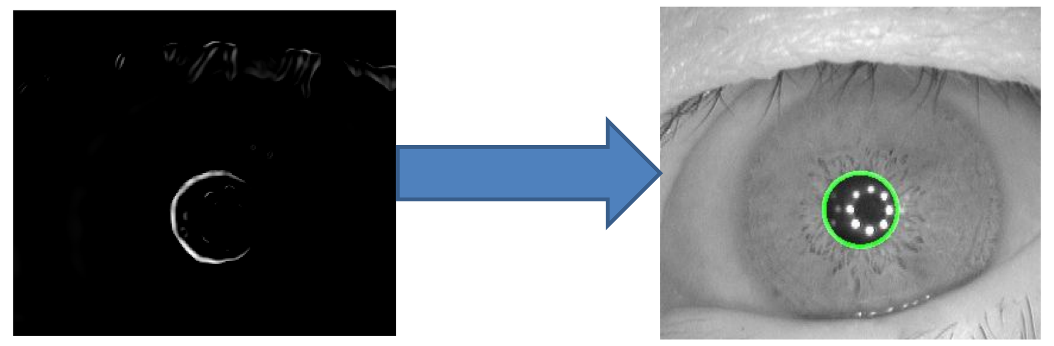
RANSAC as a CNN Output Layer

- Allows model specificity; Avoids need for nontrivial post-processing
- Example: pupil segmentation (known to be approximately circular)



RANSAC as a CNN Loss Layer

- Works by suppression of strongest impostor
- Additional loss term: $L_R = \log\left(\frac{1+S'}{1+S^*}\right)$, for true model score S^* and most convincing impostor score S'.
- Could in theory be applied to other problem domains as well.

Classical pre-RANSAC Methods as Utility Layers

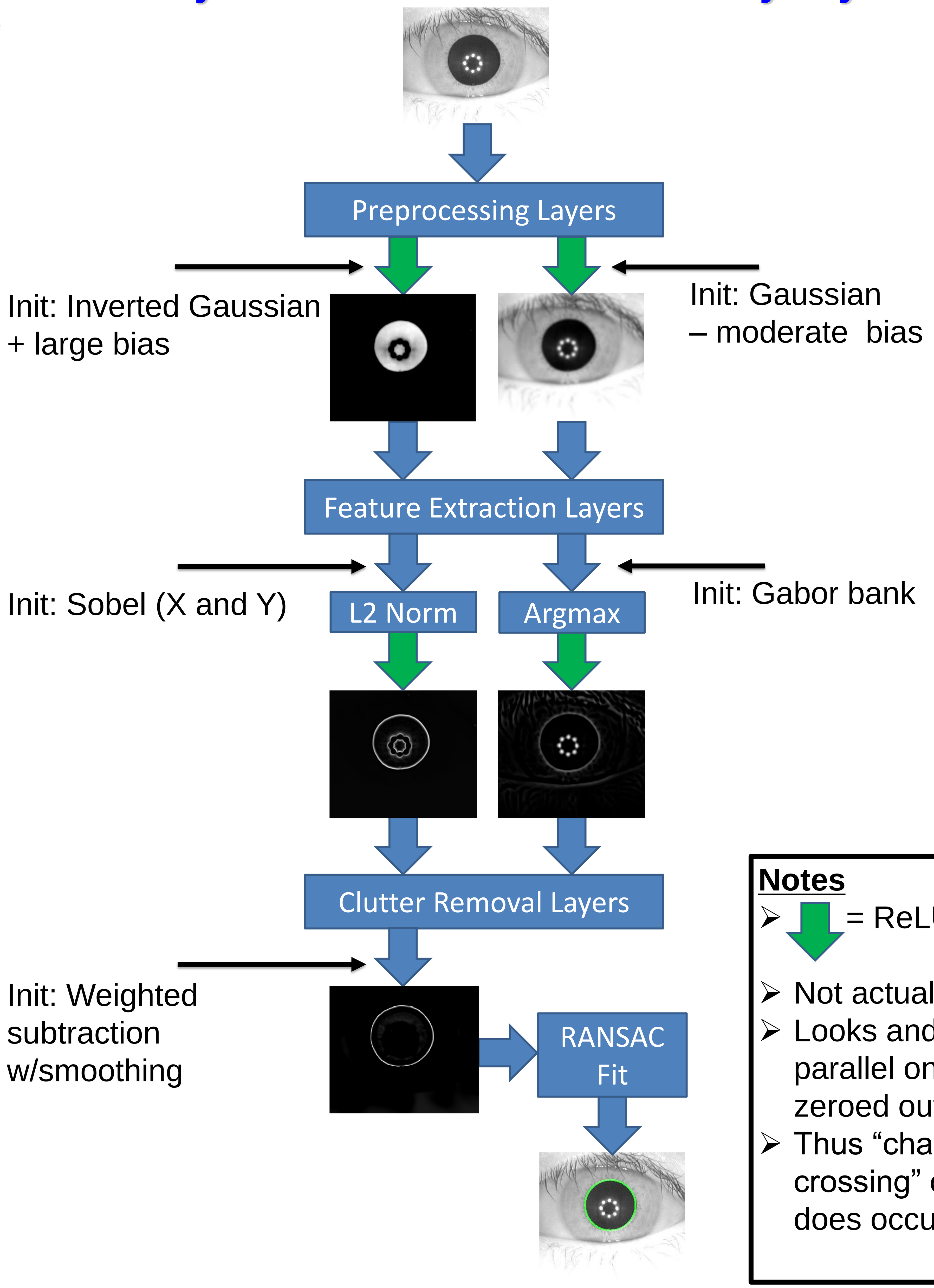
- Sensible for industrial migration
- Preserves mathematical structure of preexisting implementation, while providing optimizability of a CNN
- Example: L2-norm layer (think edge detection)

$$z = \sqrt{x_i^2 + x_j^2}$$

$$\frac{\partial L}{\partial x_i} = \frac{\partial L}{\partial z}\frac{\partial z}{\partial x_i} = \frac{\partial L}{\partial z}\frac{x_i}{z}$$

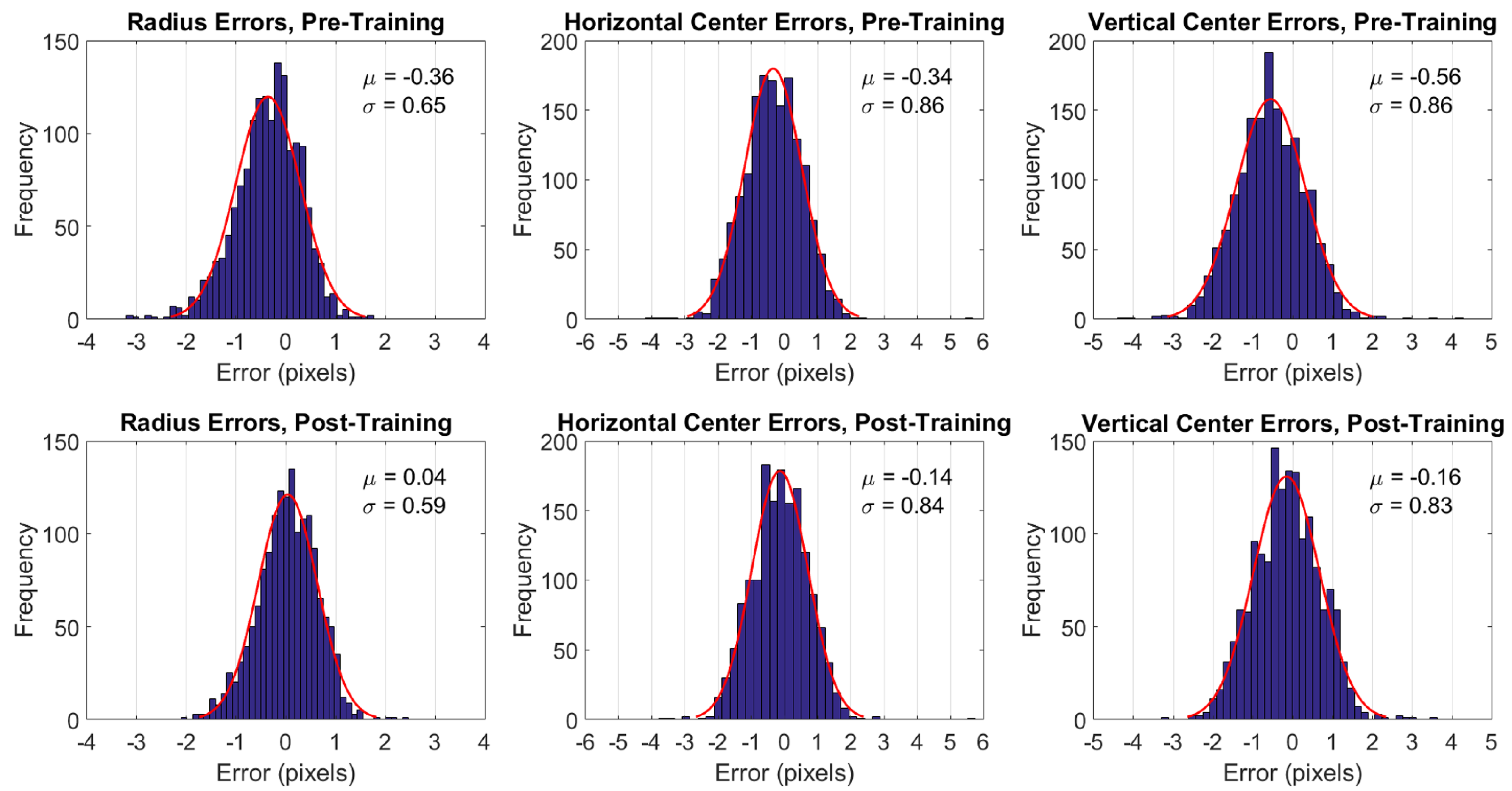
- The above ideas can be used to initialize a CNN to behave nearly identical to an existing high-performance RANSAC segmentation algorithm.
- Such a CNN can then in principle be fine-tuned to achieve even better performance.

Tiny CNN with RANSAC and Utility Layers



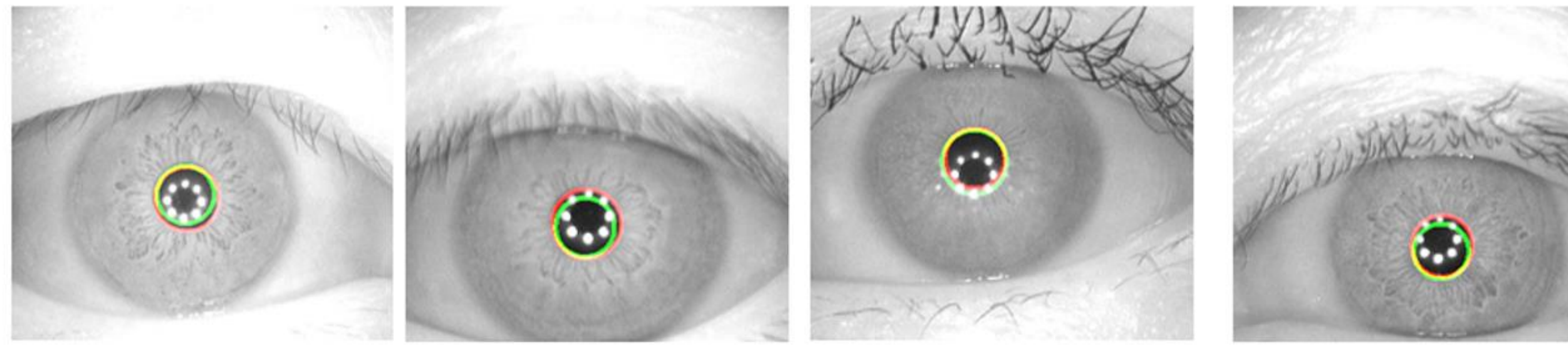
Notes
- = ReLU
- Not actually parallel
- Looks and behaves parallel on init due to zeroed out weights
- Thus "channel crossing" can and does occur in training

Statistical Results



- Statistically: biases significantly decreased; spread modestly decreased
- Pupil center absolute distance (pixels): **1.20 ± 0.69 → 1.06 ± 0.57**
- Pupil radius absolute error (pixels): **0.57 ± 0.48 → 0.47 ± 0.42**

Individual Results



- These images show multiple errors that occurred before fine-tuning, which no longer occur after fine-tuning.
- Erroneous segmentation occurs on only 1 out of 1500+ testing images after fine-tuning (similar error to above).