Stabilized Image Segmentation in the Presence of Noise

Jonas A. Actor (predoc)
Computational and Applied Mathematics
Rice University

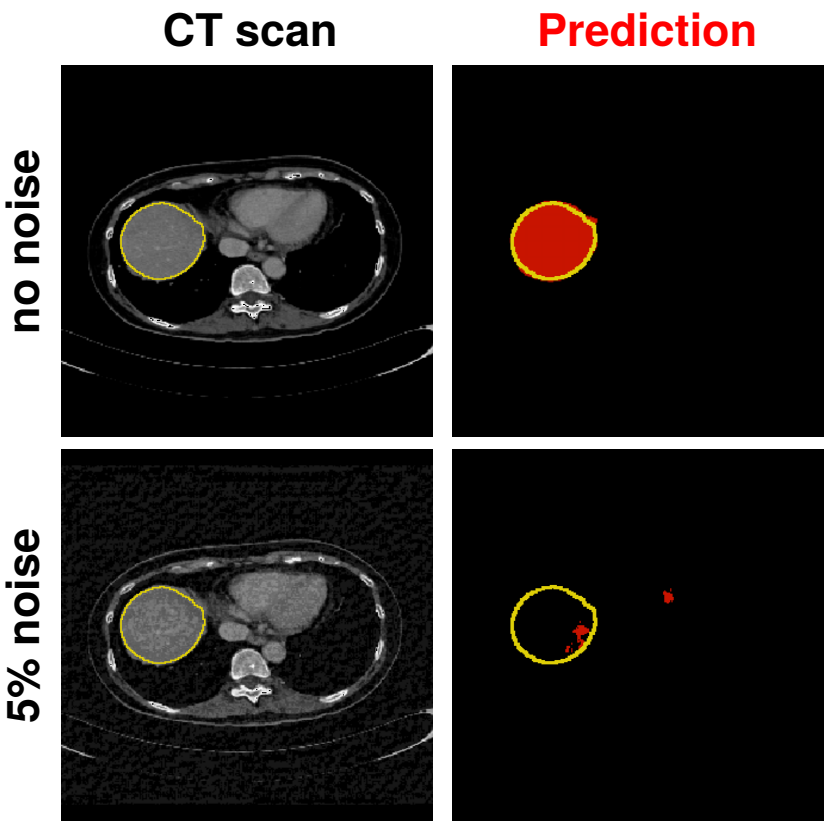
Stabilized Image Segmentation in the Presence of Noise

Jonas A. Actor (predoc)
Computational and Applied Mathematics
Rice University

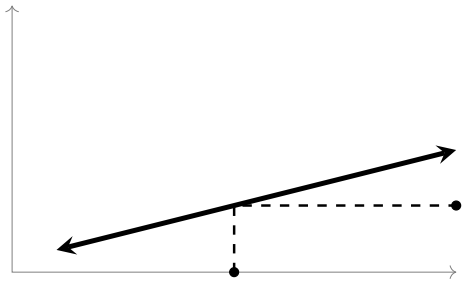
Medical image segmentation is corrupted by noise from:

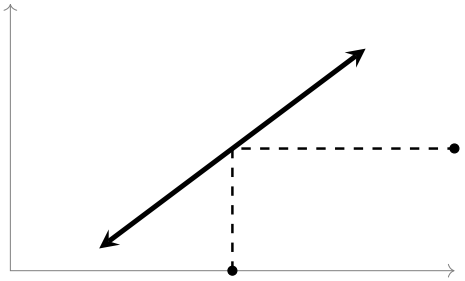
- acquisition artifacts
- image processing
- intrasite variability
- model uncertainty

Goal. good segmentation regardless of noise.

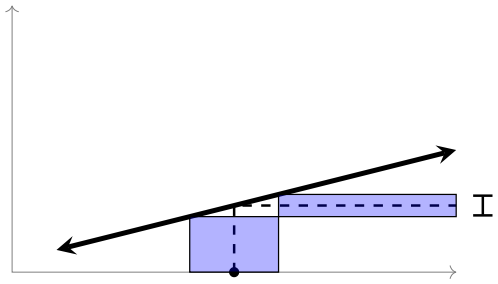


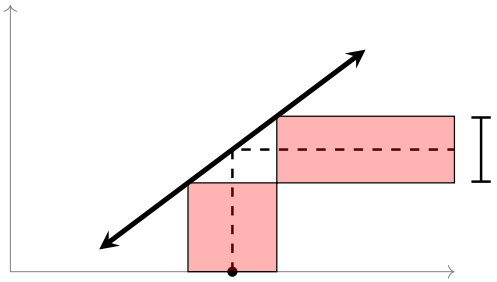
Observation: effect of noise depends on slope





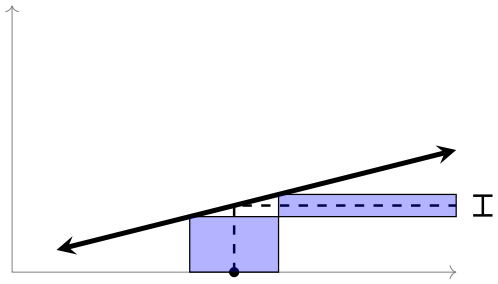
Observation: effect of noise depends on slope

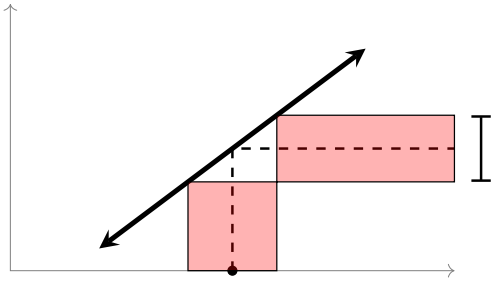




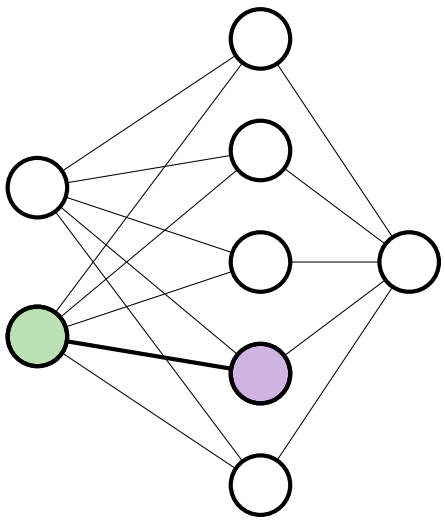
small slope,
small change from noise

Observation: effect of noise depends on slope





small slope,
small change from noise

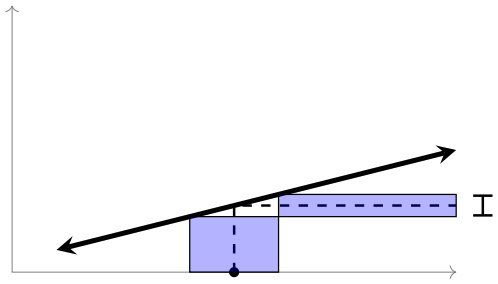


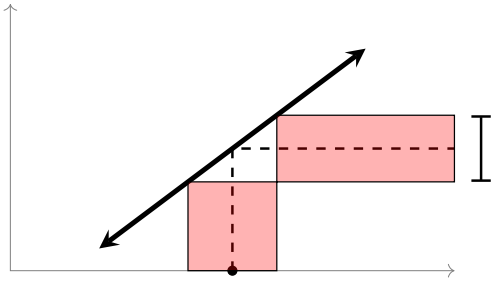
$$\begin{array}{ccc} x & \longmapsto & K * x \\ x & \longmapsto & A_{[K]}\, x \end{array}$$

K: 3×3

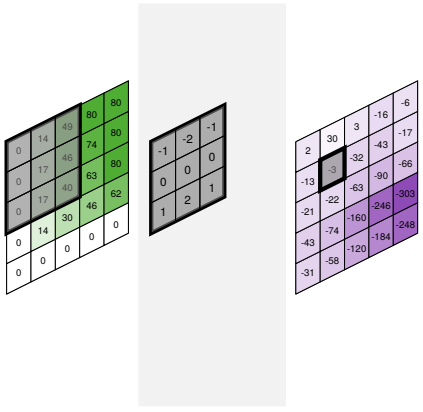
$A_{[K]}$: # pixels $\times$ # pixels

Observation: effect of noise depends on slope

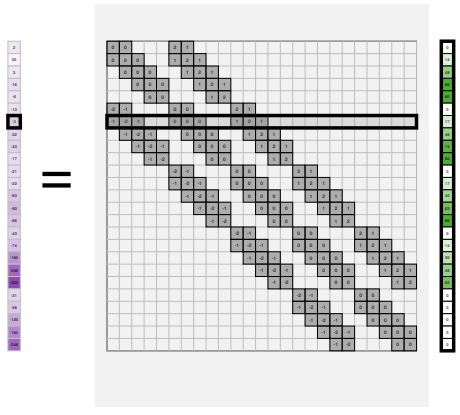




small slope,
small change from noise



kernel K



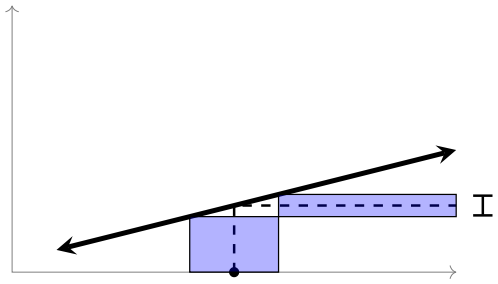
matrix $A_{[K]}$

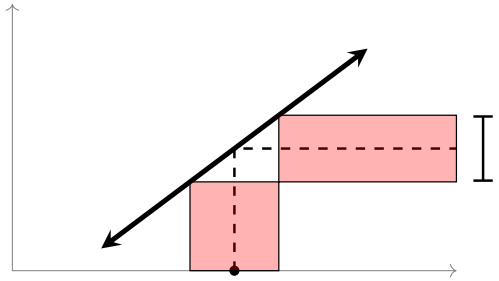
$$x \longmapsto K * x$$
$$x \longmapsto A_{[K]} x$$

K: 3×3

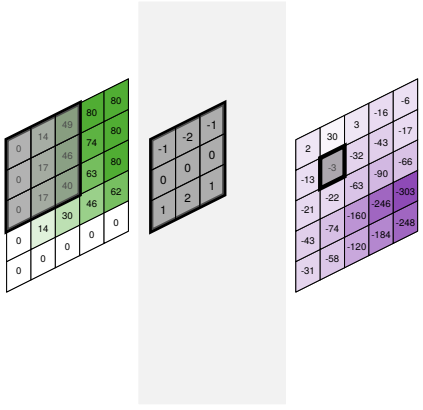
$A_{[K]}$: # pixels $\times$ # pixels

Observation: effect of noise depends on slope

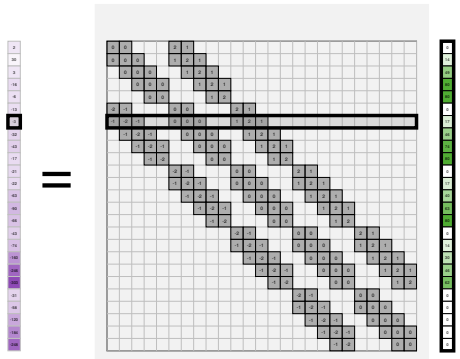




small slope,
small change from noise



kernel K



matrix $A_{[K]}$

small $\|A_{[K]}\|_2$,
small change from noise

Strategy: bound slope of $A_{[K]}$ using K

Reducing $\left\|A_{[K]}\right\|_2$ requires computing $\left\|A_{[K]}\right\|_2$...

...but $A_{[K]}$ is a **big** matrix of size $10^8 \times 10^8$.

Strategy: bound slope of $A_{[K]}$ using K

Reducing $\left\|A_{[K]}\right\|_2$ requires computing $\left\|A_{[K]}\right\|_2$...

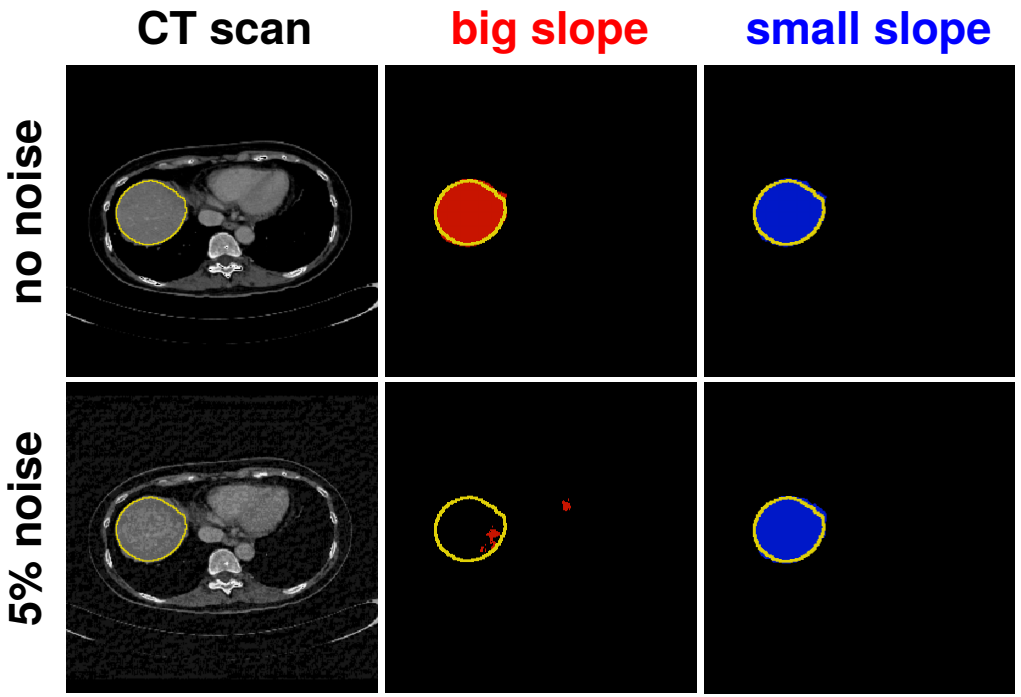
...but $A_{[K]}$ is a **big** matrix of size $10^8 \times 10^8$.

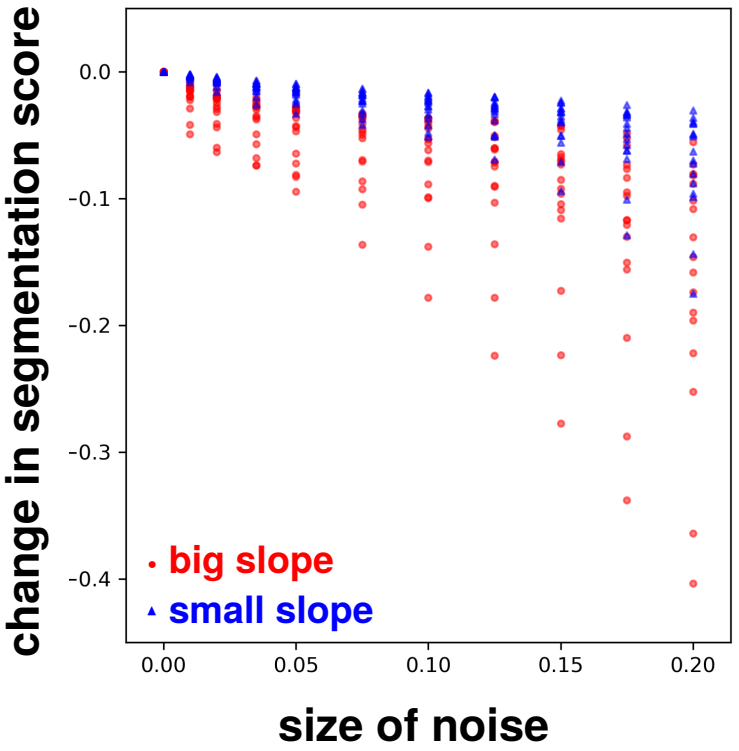
Bound $\left\|A_{[K]}\right\|_2$ instead of computing directly:

$$\left\|A_{[K]}\right\|_2 \leq \|K\|_1 \text{ (magnitude of convolution kernel)}$$

Reducing $\|K\|_1$ decreases effects of noise, and computing $\|K\|_1$ is cheap.

Result: protection against imaging noise





RICE
THE UNIVERSITY OF TEXAS MD Anderson Cancer Center Making Cancer History®
Gulf Coast Consortia QUANTITATIVE BIOMEDICAL SCIENCES
Supported by **NLM** Training Program in Biomedical Informatics and Data Science, T15LM007093.

github.com/jonasactor/livermask
jonasactor@rice.edu
jonasactor.github.io