TECHNION

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# A Model is Worth Tens of Thousands of Examples

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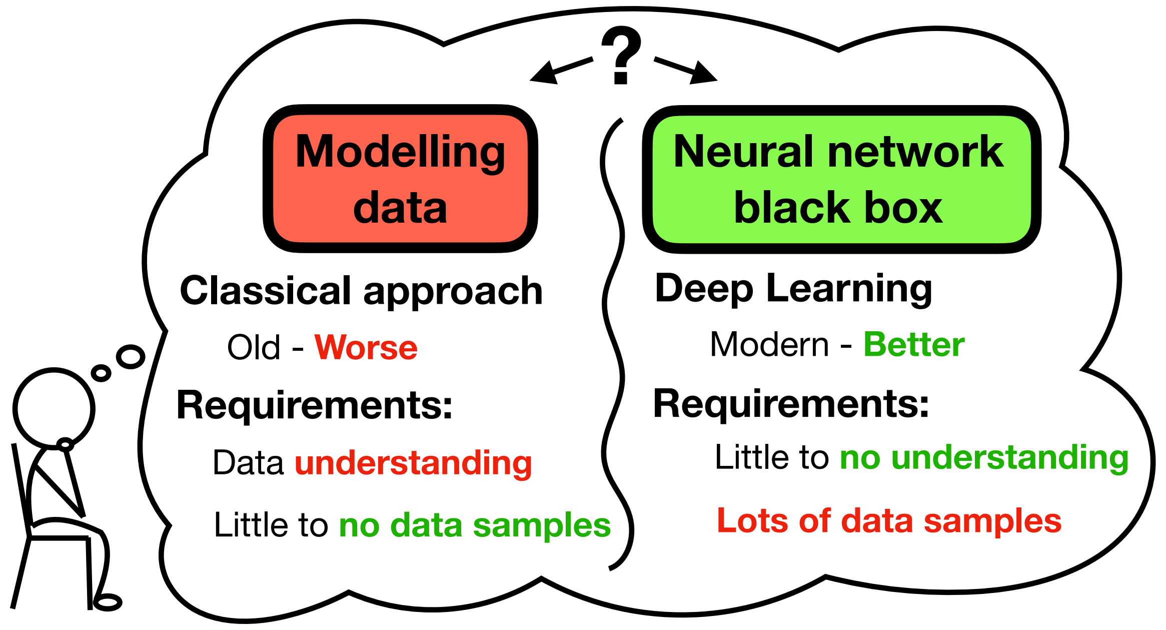
## Classical Data Model or NN?

### New estimation task:



?

Modelling data

Neural network black box

Classical approach

Old - Worse

Requirements:

Data understanding

Little to no data samples

Deep Learning

Modern - Better

Requirements:

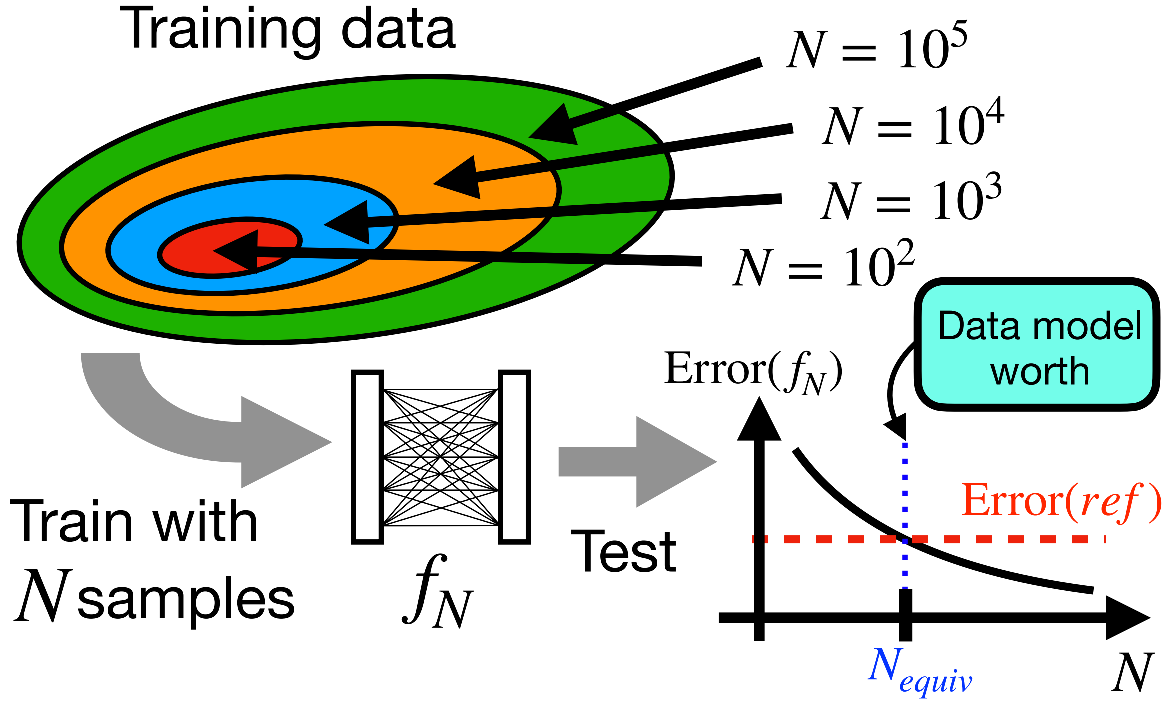
Little to no understanding

Lots of data samples

Data model $\Longleftrightarrow$ $N_{equiv}$ training samples ?

### Neural networks:

Training data



Train with $N$ samples

Test

Data model worth

## Take-home Message

- On toy examples:

Data model $\Longleftrightarrow$ $\geq 10^4$ training samples

- On real problems:

Greater complexity $\Longrightarrow$ More data needed

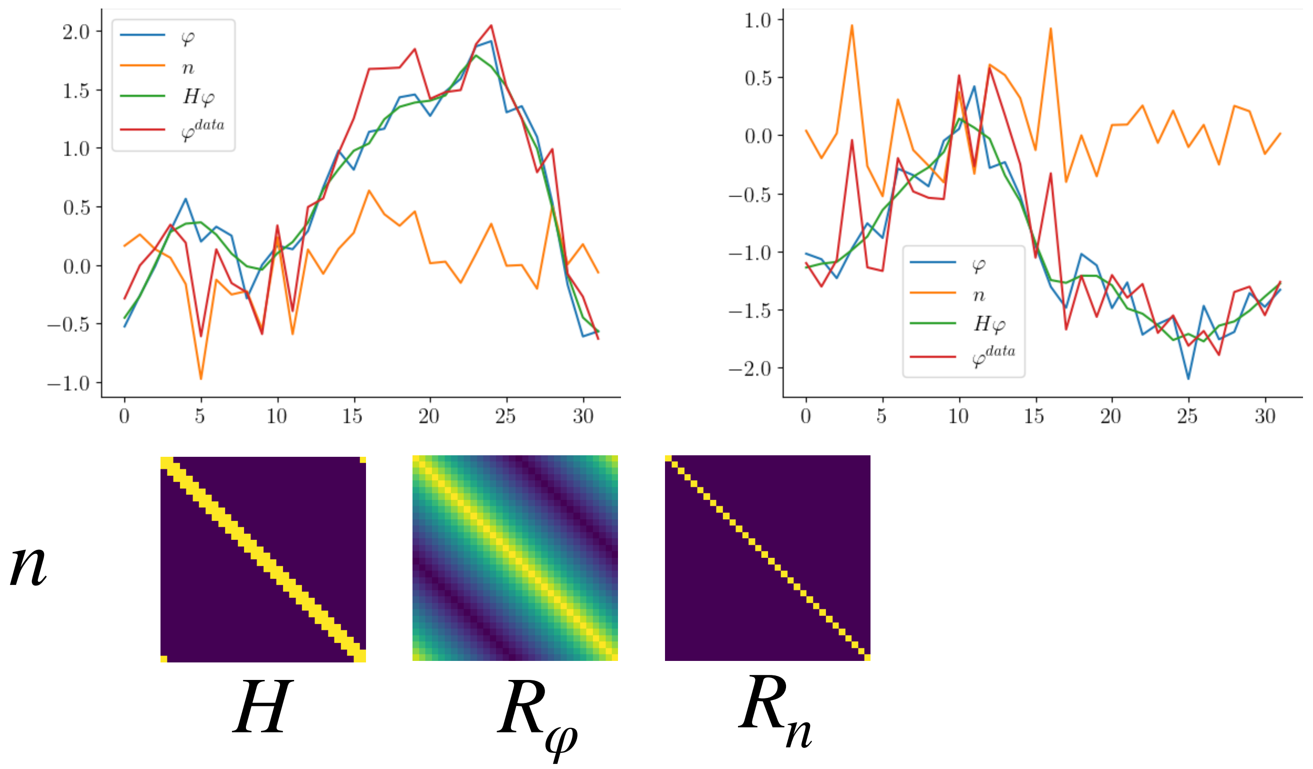
- Best practice (not studied):

Combine better of two worlds:

Data model/understanding + NN training

## 1D Gaussian Signals: Denoising and Deblurring

### Data model:

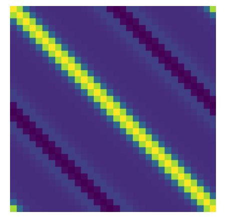


$$\varphi^{data} = H\varphi + n$$

### Goal:

$$\text{argmin} \quad \mathbb{E}(\|\hat{\varphi} - \varphi\|^2)$$

### Estimation:



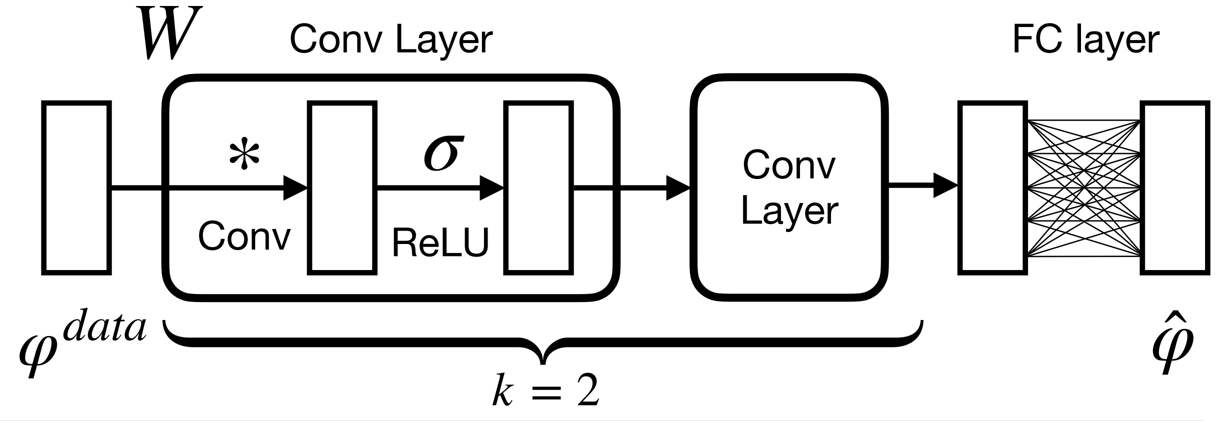
$W$

- $\hat{\varphi}^* = W \; \varphi^{data}$

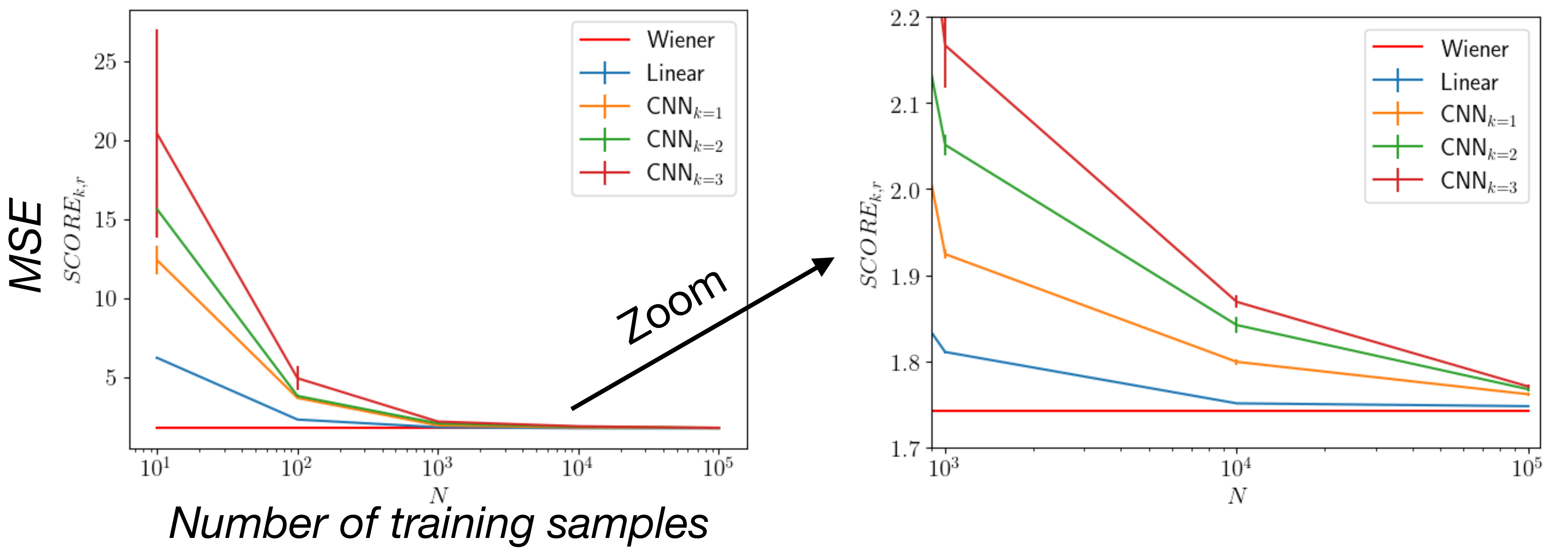
$$W = R_\varphi H^\top (H R_\varphi H^\top + R_n)^{-1}$$

Wiener filter (**optimal** $L^2$)

- $\hat{\varphi} = CNN_k \; (\varphi^{data})$

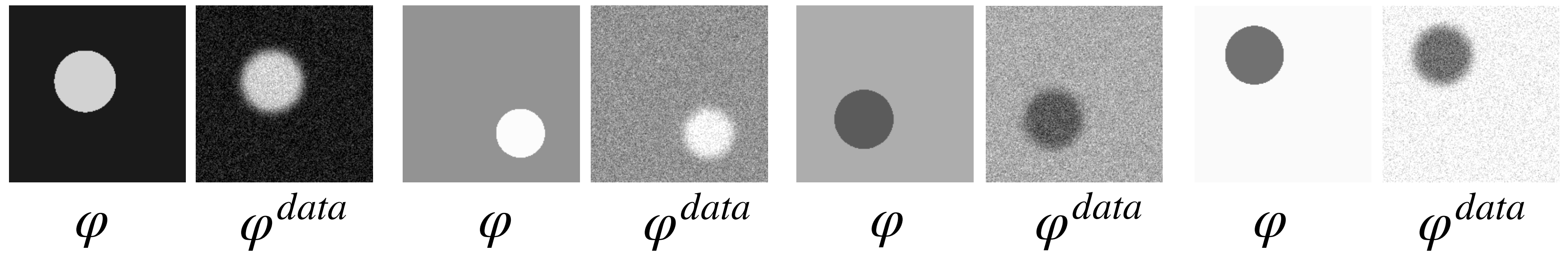


### Performance:



## 2D Disk image: Geometric Estimation

### Data model: $\varphi^{data} = H\varphi + n$



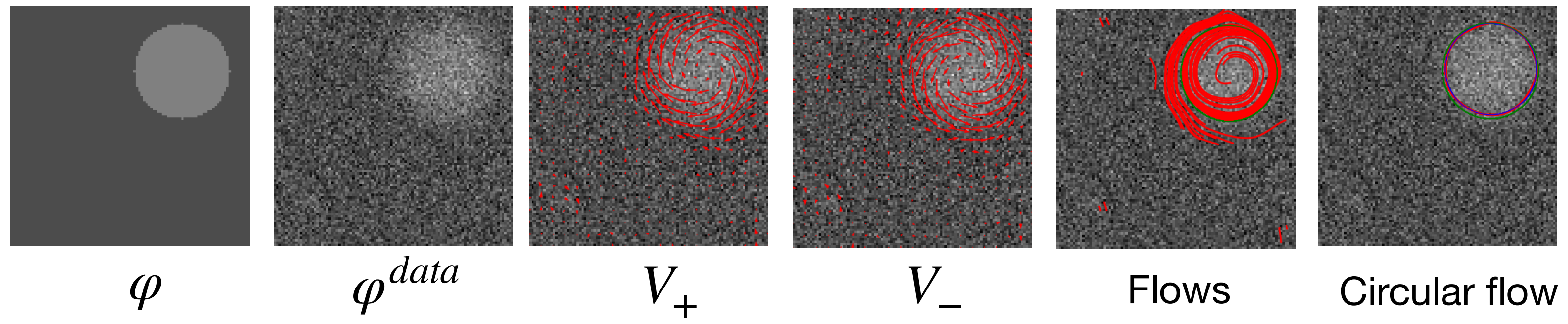
Random radius, centre, foreground, background intensities: $r, \; c, \; f, \; b$

### Goal: $\text{argmin} \quad \mathbb{E}(\|(\hat{\mathrm{r}}, \hat{\mathrm{c}}) - (\mathrm{r}, \mathrm{c})\|^2)$

### Estimation:

- **Pointflow** $V_\pm = \frac{1}{2}(\nabla \|\nabla I_b\| \pm \nabla I_b^\top)$ $\quad \frac{dP}{dt}(t) = V(P(t))$

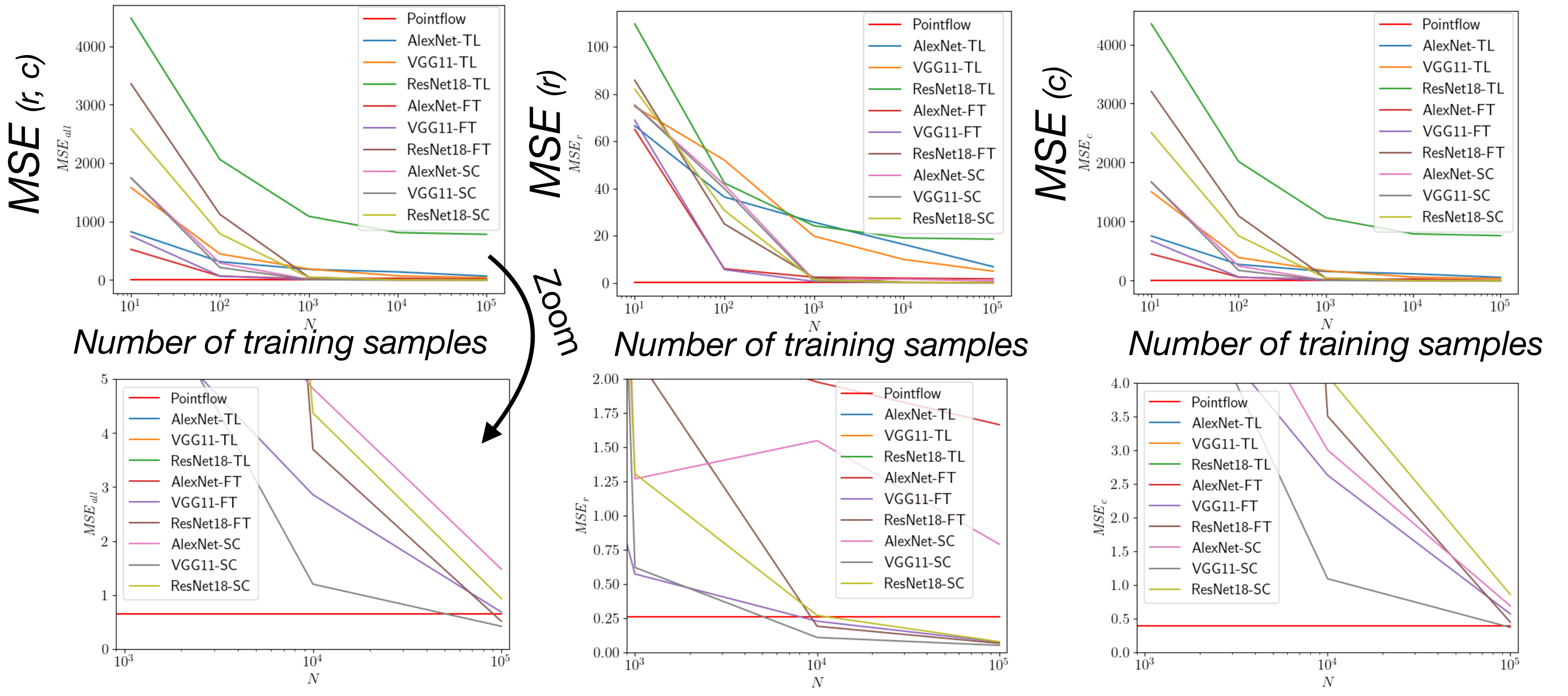
Yang, F., Cohen, L.D., Bruckstein, A.M.: A model for automatically tracing object boundaries, ICIP (2017)



- **CNN**: AlexNet, VGG11, ResNet18 *From standard Imagenet classification

Training: Transfer-learning* (**TL**), Finetuning* (**FT**), From Scratch (**SC**)

### Performance:



MSE (r, c)
$MSE_{all}$
MSE (r)
$MSE_r$
MSE (c)
$MSE_c$
Pointflow
AlexNet-TL
VGG11-TL
ResNet18-TL
AlexNet-FT
VGG11-FT
ResNet18-FT
AlexNet-SC
VGG11-SC
ResNet18-SC
Zoom
$N$
Number of training samples
Number of training samples
Number of training samples