General Guidance

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Framework of ML

Training data: $\{(\boldsymbol{x^1}, \hat{y}^1), (\boldsymbol{x^2}, \hat{y}^2), \ldots, (\boldsymbol{x^N}, \hat{y}^N)\}$

Testing data: $\{\boldsymbol{x^{N+1}}, \boldsymbol{x^{N+2}}, \ldots, \boldsymbol{x^{N+M}}\}$

Speech Recognition

$\boldsymbol{x}$:  $\hat{y}$: phoneme

Speaker Recognition

$\boldsymbol{x}$:  $\hat{y}$: John (speaker)

Image Recognition

$\boldsymbol{x}$:  $\hat{y}$: soup

Machine Translation

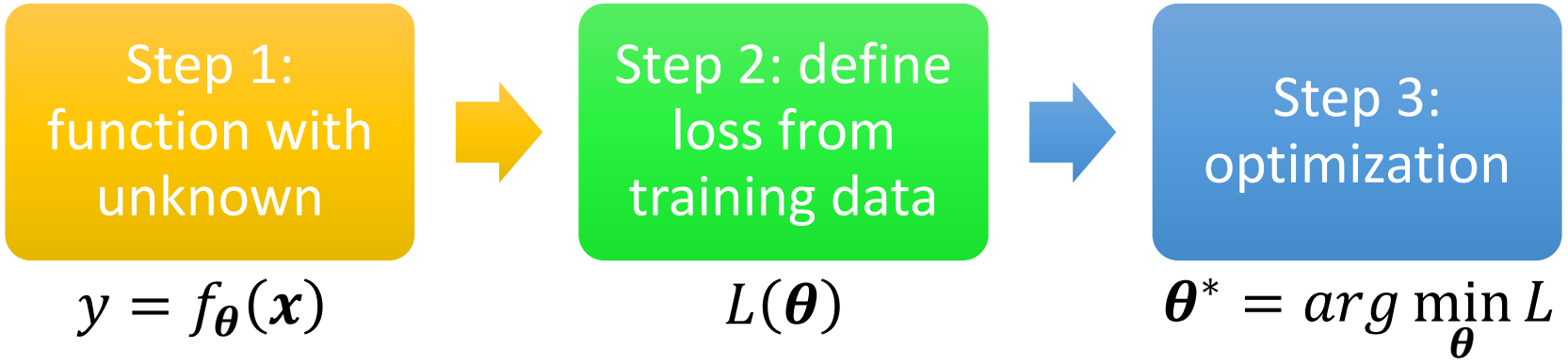
$\boldsymbol{x}$: 痛みを知れ

$\hat{y}$: 了解痛苦吧

Framework of ML

Training data: $\{(\boldsymbol{x^1}, \hat{y}^1), (\boldsymbol{x^2}, \hat{y}^2), \ldots, (\boldsymbol{x^N}, \hat{y}^N)\}$

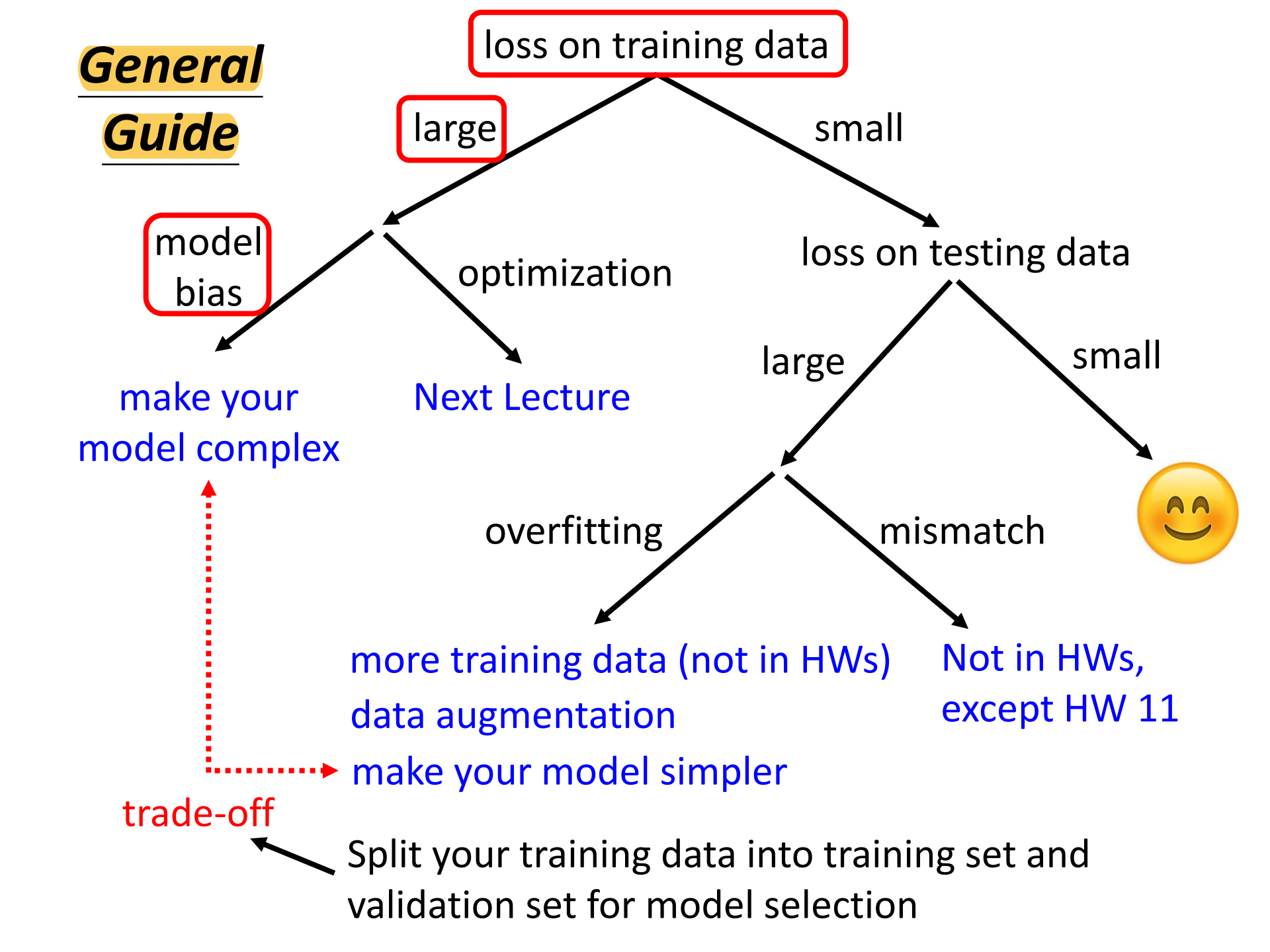
Training:



Testing data: $\{\boldsymbol{x^{N+1}}, \boldsymbol{x^{N+2}}, \ldots, \boldsymbol{x^{N+M}}\}$

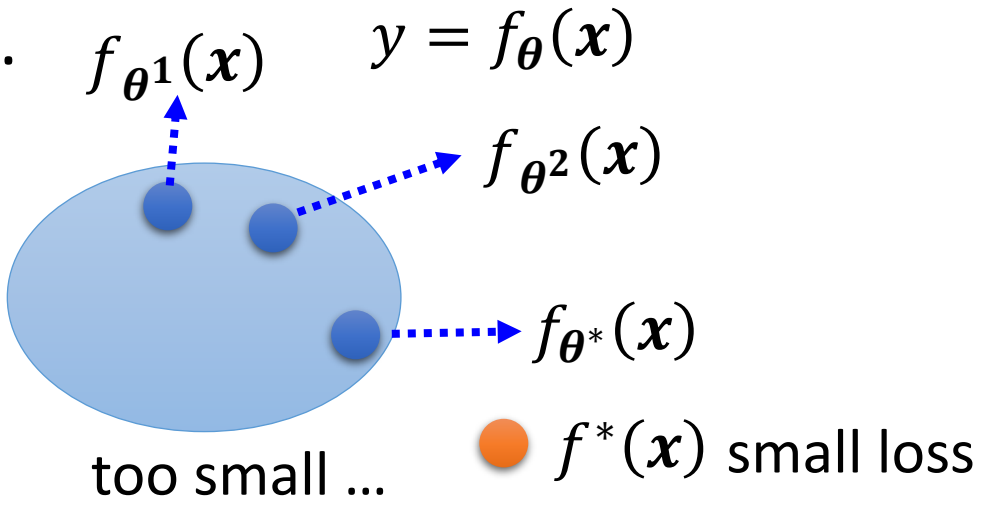
Use $y = f_{\boldsymbol{\theta}^*}(\boldsymbol{x})$ to label the testing data

$\{y^{N+1}, y^{N+2}, \ldots, y^{N+M}\}$ → Upload to Kaggle


General Guide
loss on training data
large
small
model bias
optimization
loss on testing data
make your model complex
Next Lecture
large
small
overfitting
mismatch
more training data (not in HWs)
data augmentation
Not in HWs, except HW 11
make your model simpler
trade-off
Split your training data into training set and validation set for model selection

Model Bias

- The model is too simple.



find a needle in a haystack …

… but there is no needle

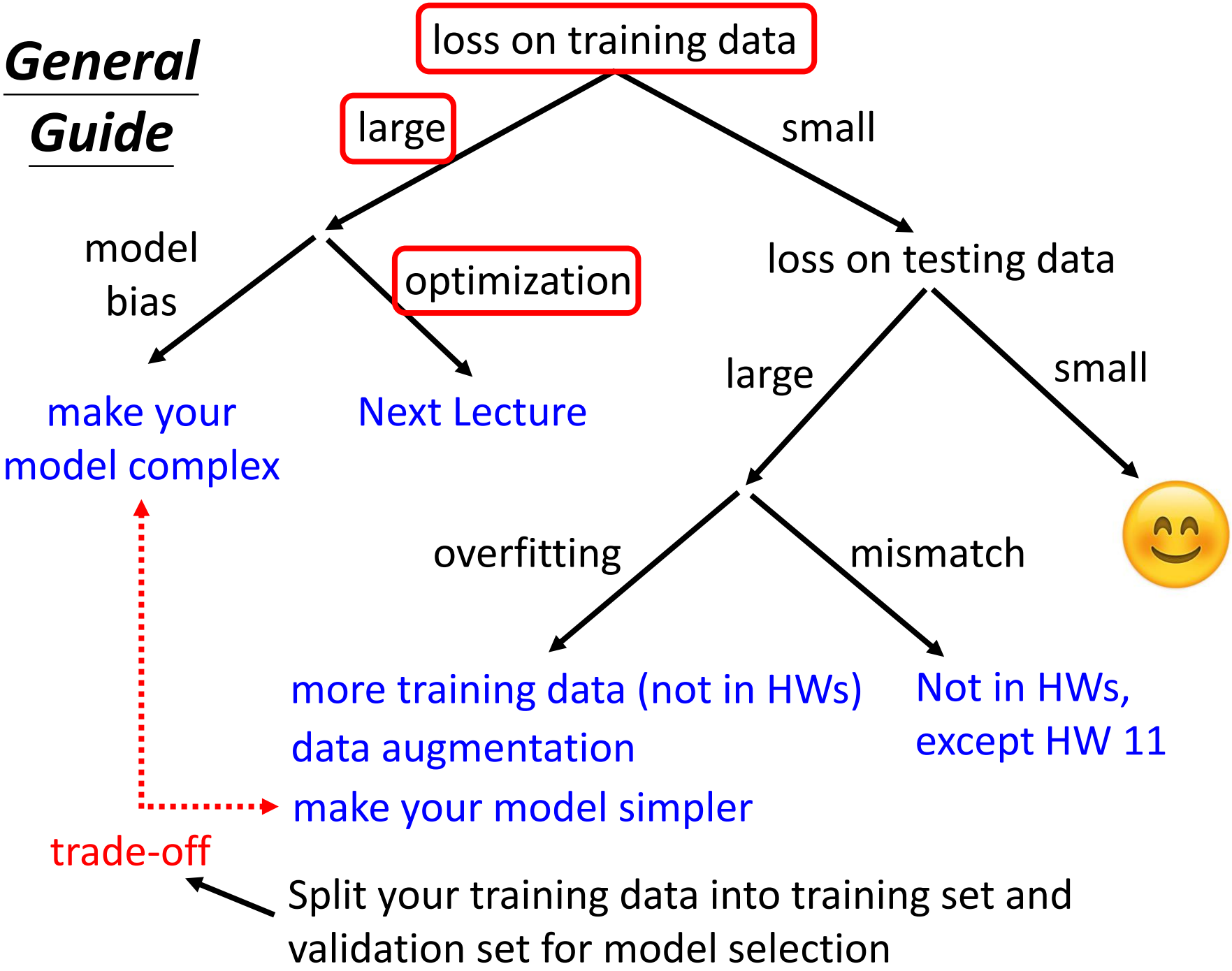
- Solution: redesign your model to make it more flexible

$$y = b + wx_1 \xrightarrow{\text{More features}} y = b + \sum_{j=1}^{56} w_j x_j$$

Deep Learning
(more neurons, layers)

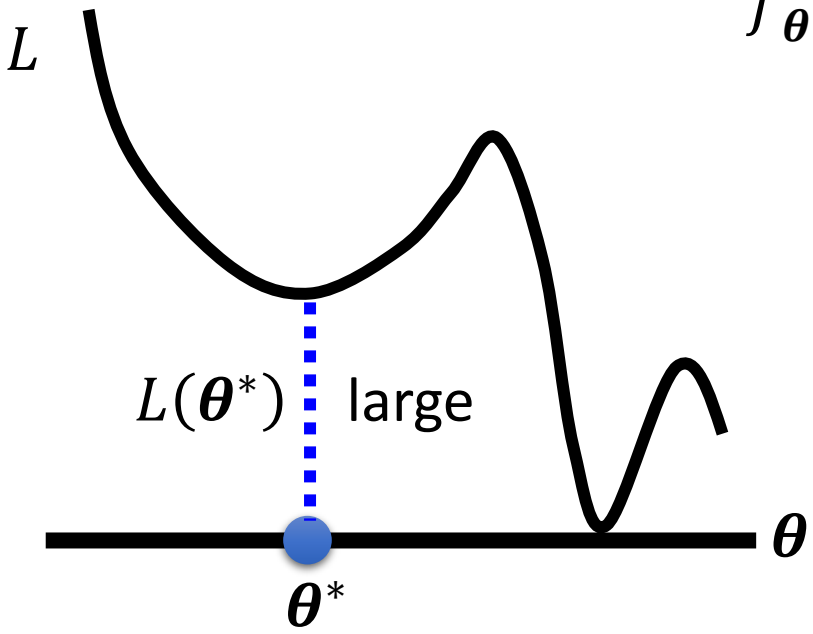
$$y = b + \sum_i c_i \, sigmoid\left(b_i + \sum_j w_{ij} x_j\right)$$

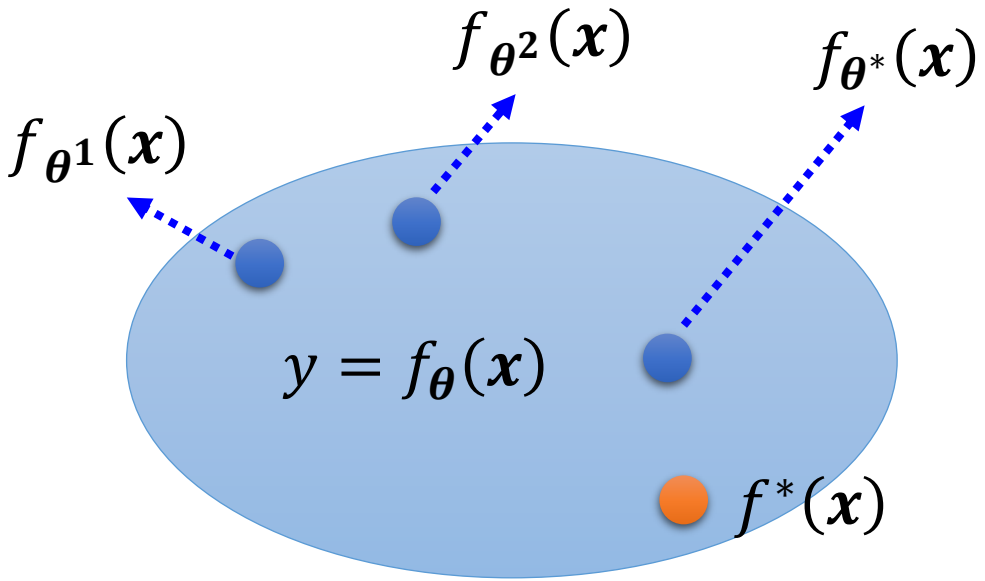
General Guide



Optimization Issue

- Large loss not always imply model bias. There is another possibility …





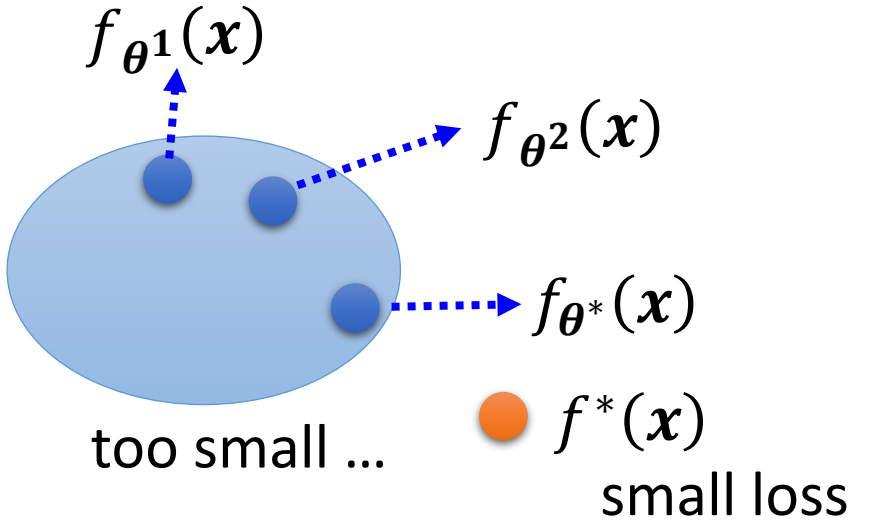
A needle is in a haystack …

… Just cannot find it.

Model Bias

find a needle in a haystack …

… but there is no needle

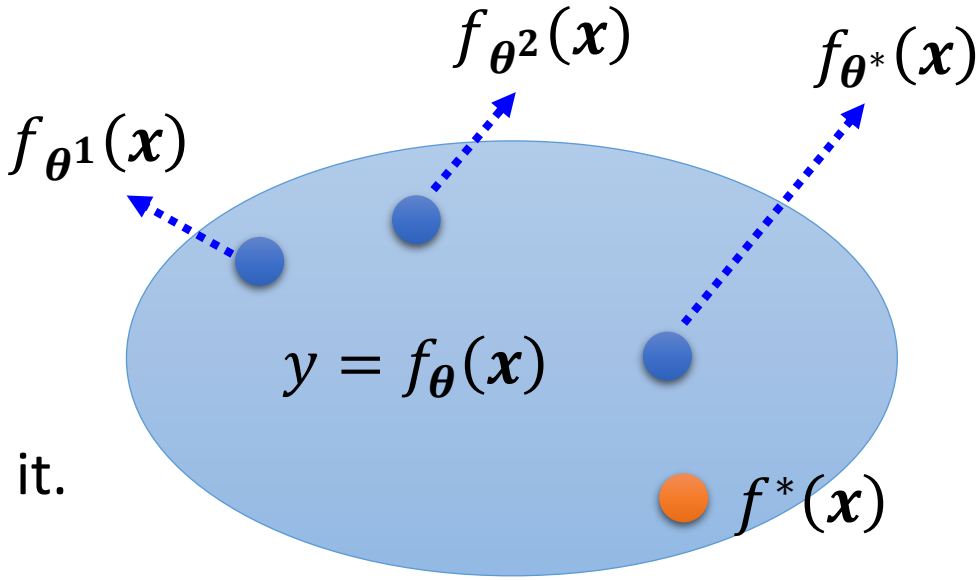


Which one???

Optimization Issue

A needle is in a haystack …

… Just cannot find it.



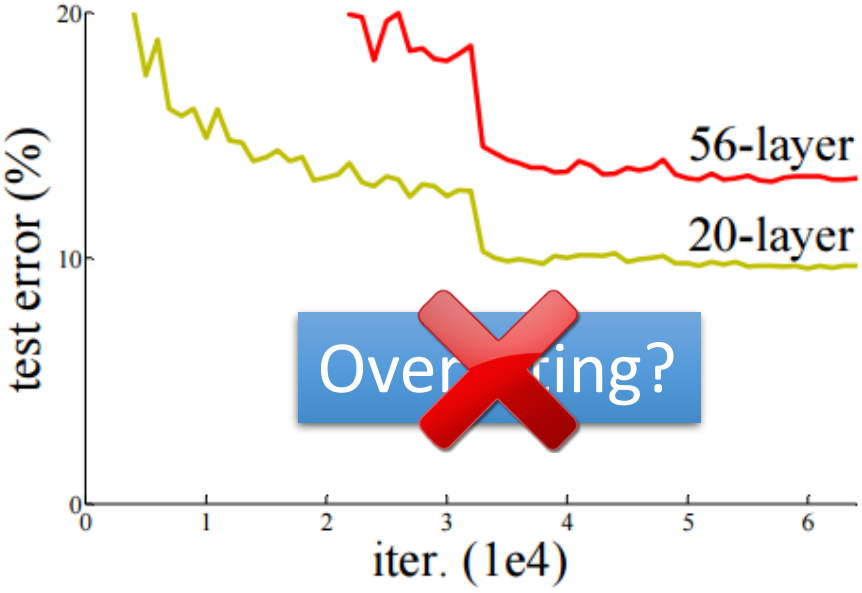
Ref: http://arxiv.org/abs/1512.03385

Model Bias v.s. Optimization Issue

- Gaining the insights from comparison

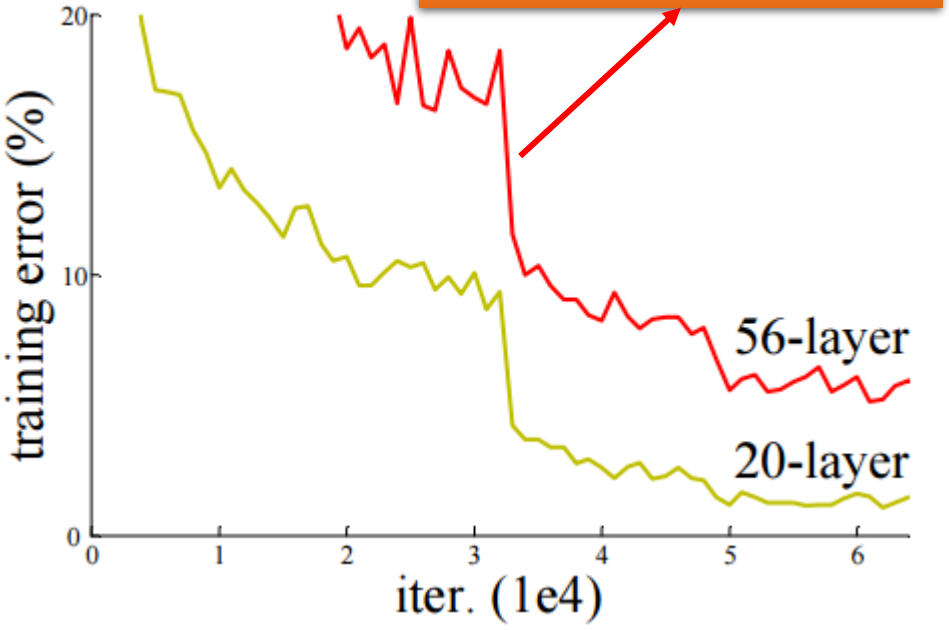
這裡的問題會是optimization問題
因為56層應包含20層
因此不會是model bias

要training data比較好
testing data比較差
才算overfitting



Testing Data

Optimization issue



Training Data

Ref: http://arxiv.org/abs/1512.03385

Optimization Issue

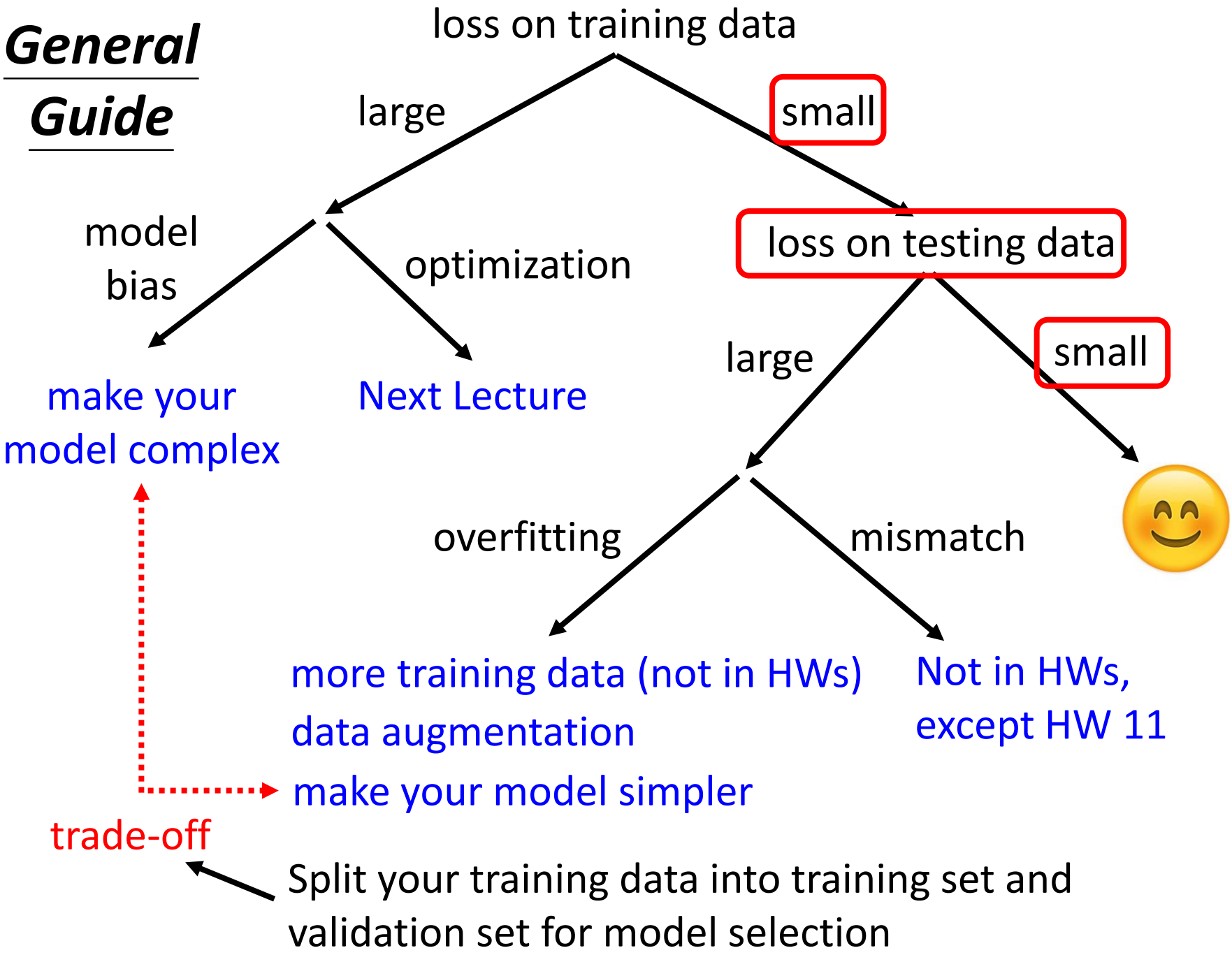
怎麼判斷optimization有沒有做好？

- Gaining the insights from comparison
- Start from shallower networks (or other models), which are easier to optimize.
- If deeper networks do not obtain smaller loss on **training data**, then there is optimization issue.

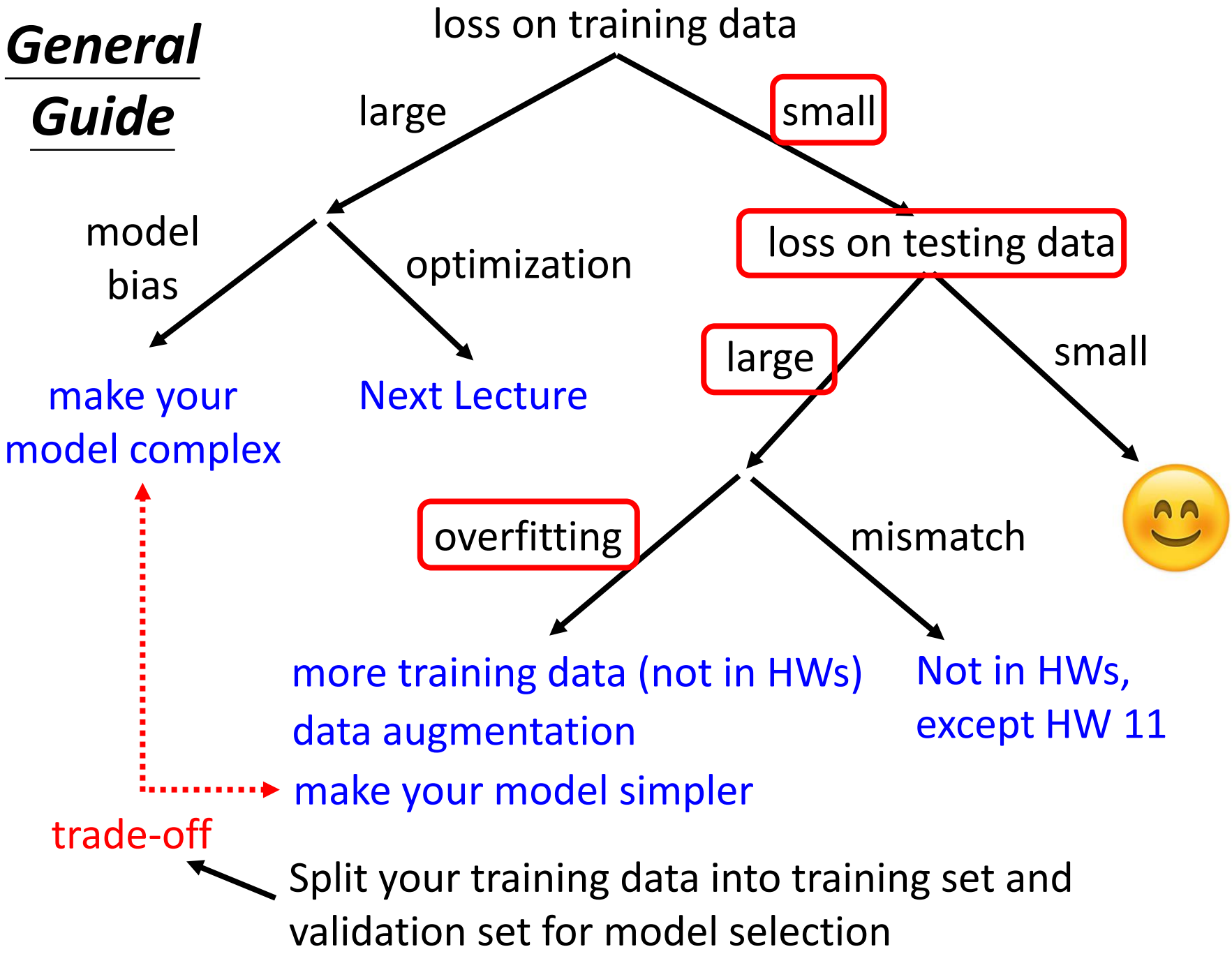
	1 layer	2 layer	3 layer	4 layer	5 layer
2017 – 2020	0.28k	0.18k	0.14k	0.10k	0.34k

- Solution: More powerful optimization technology (next lecture)

General Guide



General Guide



Overfitting

- Small loss on training data, large loss on testing data. Why?

An extreme example

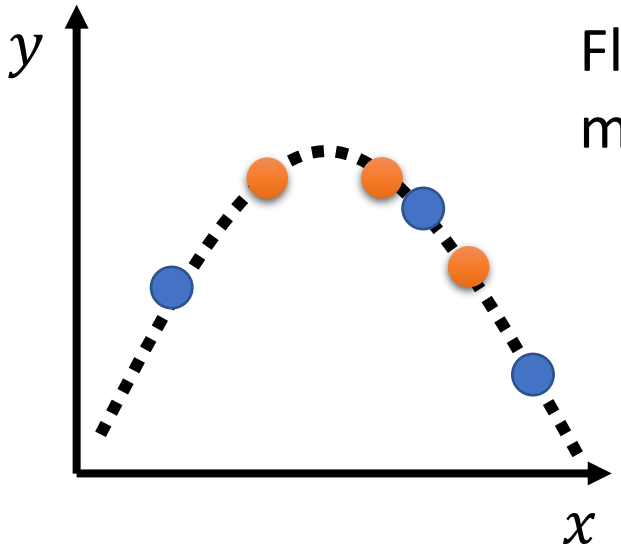
Training data: $\left\{\left(\boldsymbol{x^1}, \hat{y}^1\right), \left(\boldsymbol{x^2}, \hat{y}^2\right), \ldots, \left(\boldsymbol{x^N}, \hat{y}^N\right)\right\}$

$$f(\boldsymbol{x}) = \begin{cases} \hat{y}^i & \exists \boldsymbol{x^i} = \boldsymbol{x} \\ random & otherwise \end{cases}$$

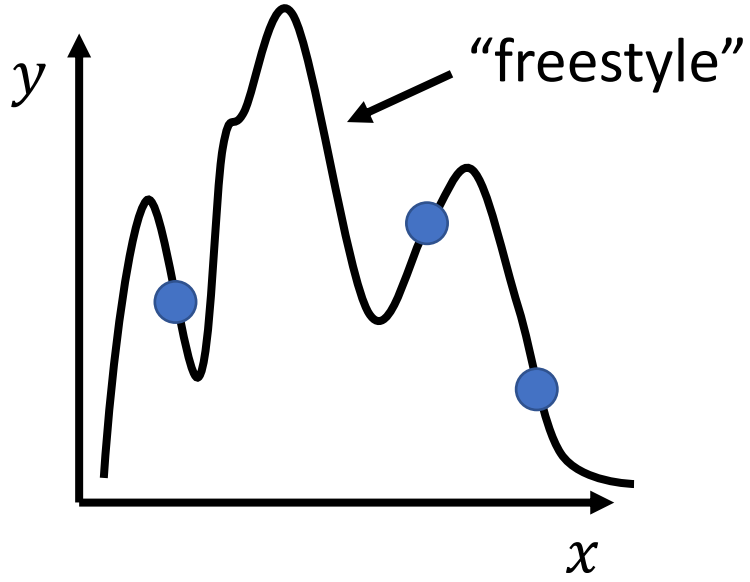
Less than useless …

This function obtains **zero training loss**, but **large testing loss**.

Overfitting



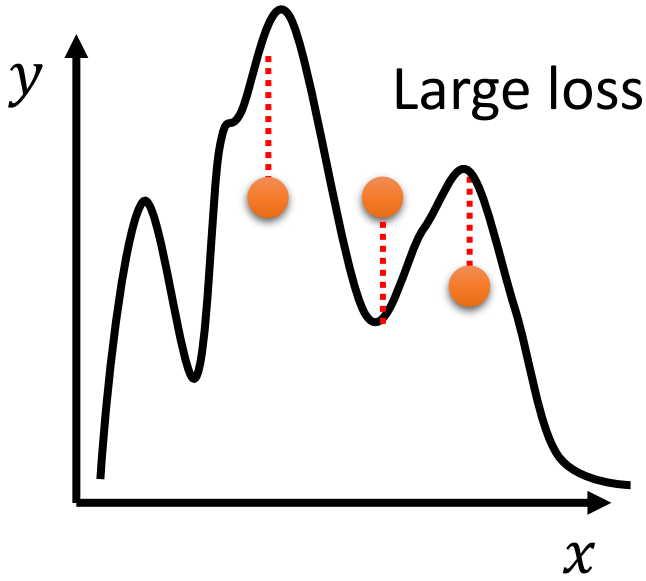
Flexible model



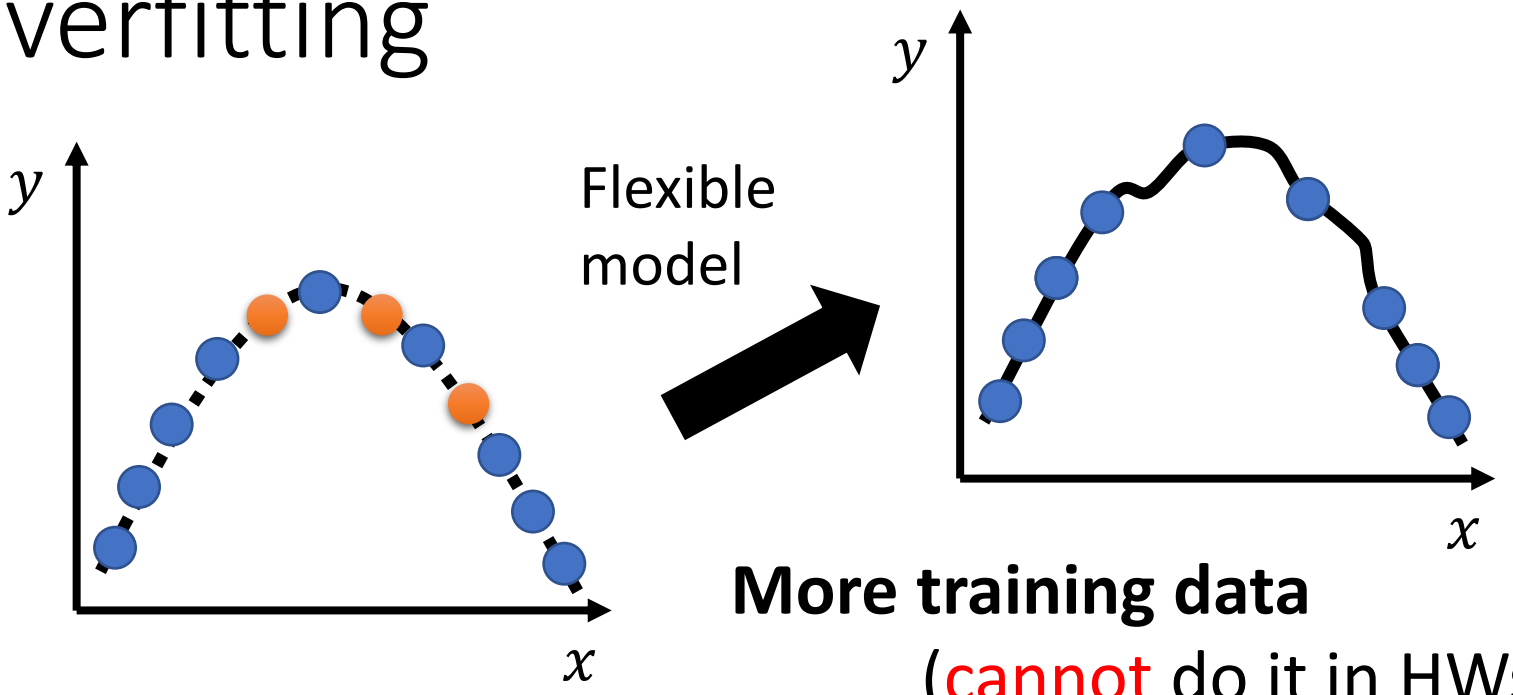
Real data distribution (not observable)

Training data

Testing data



Overfitting



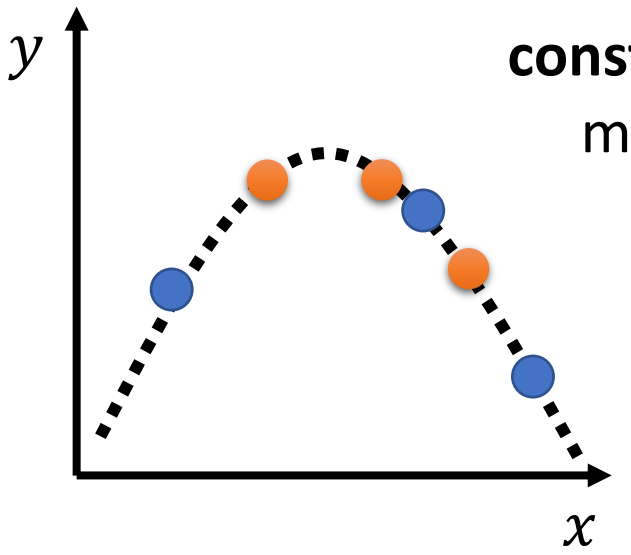
More training data

(cannot do it in HWs)

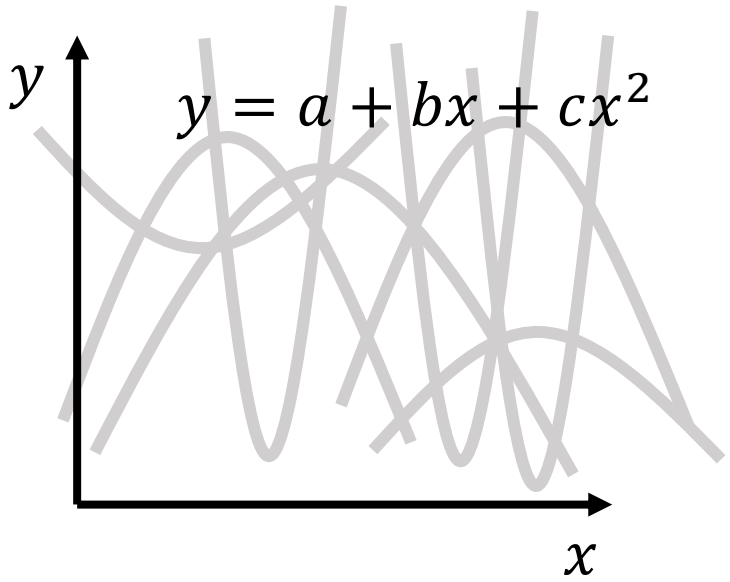
Data augmentation (you can do that in HWs)




Overfitting



constrained model

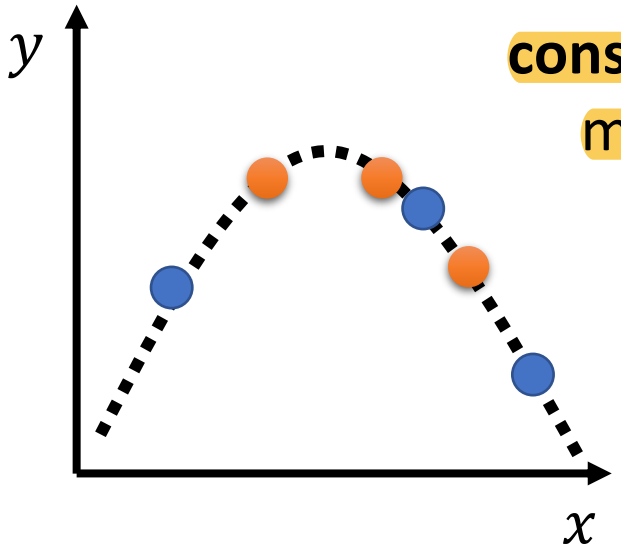


▪▪▪▪ Real data distribution (not observable)

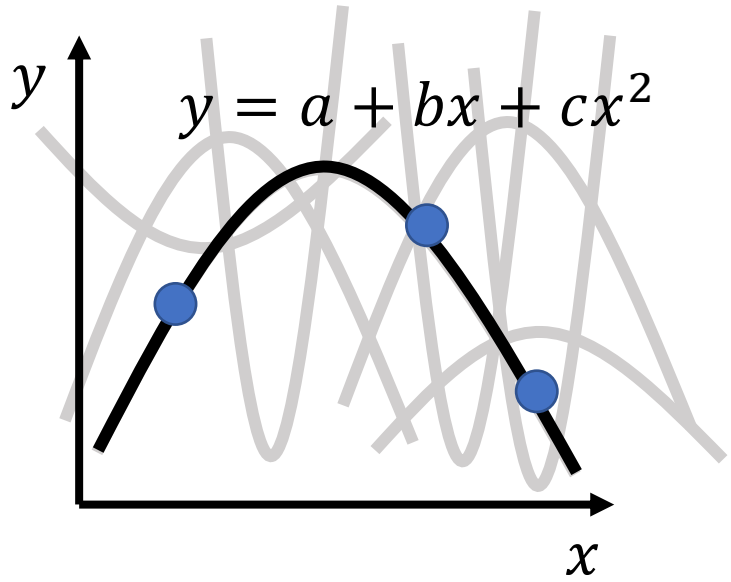
● Training data

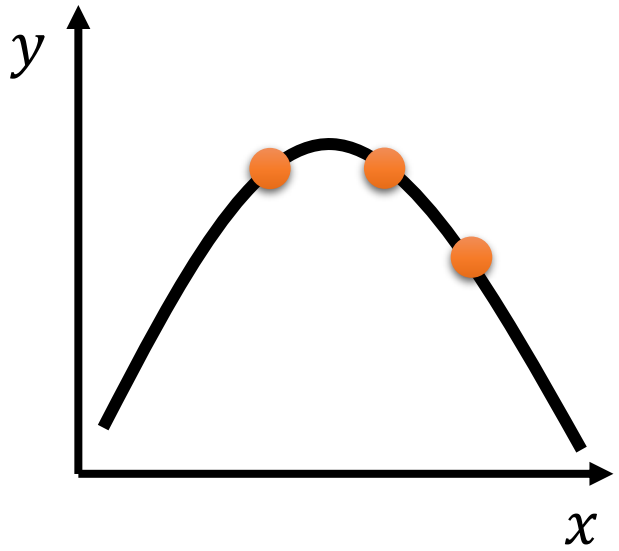
● Testing data

Overfitting



constrained model



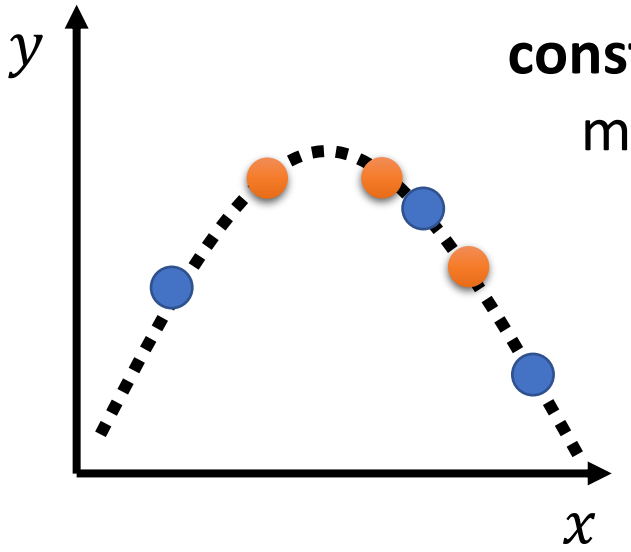


Real data distribution (not observable)

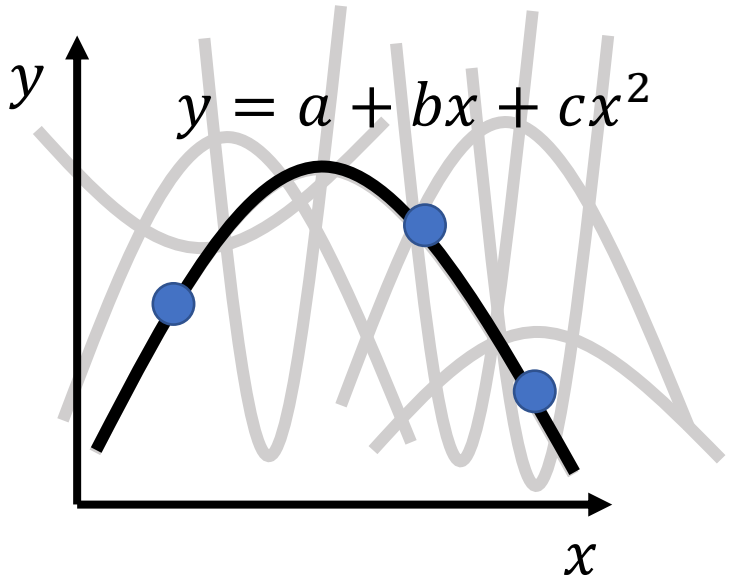
Training data

Testing data

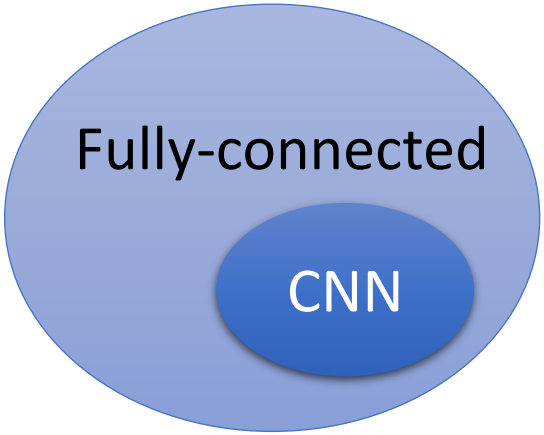
Overfitting



constrained model

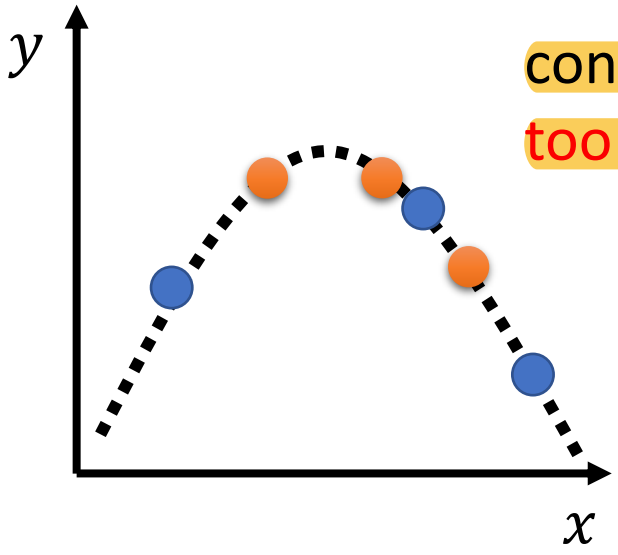


- Less parameters, sharing parameters
- Less features
- Early stopping
- Regularization
- Dropout

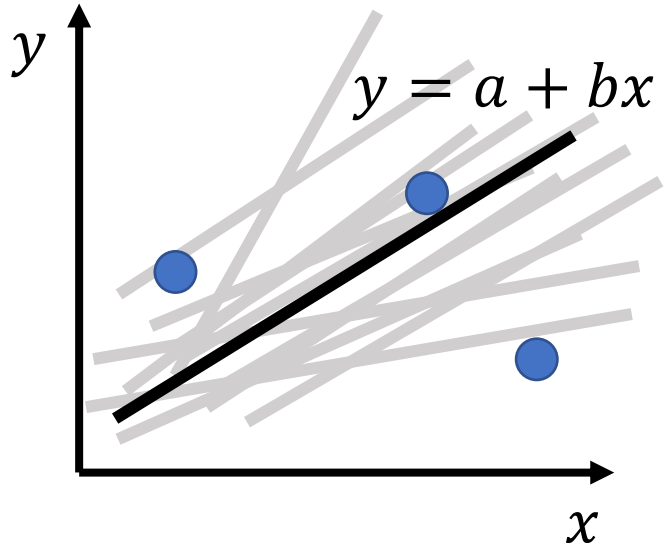


CNN是一個比較沒彈性的model

Overfitting



constrain too much

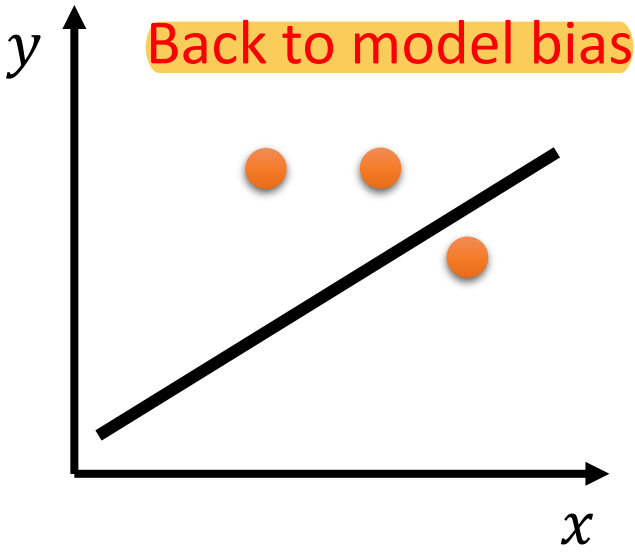


Real data distribution (not observable)

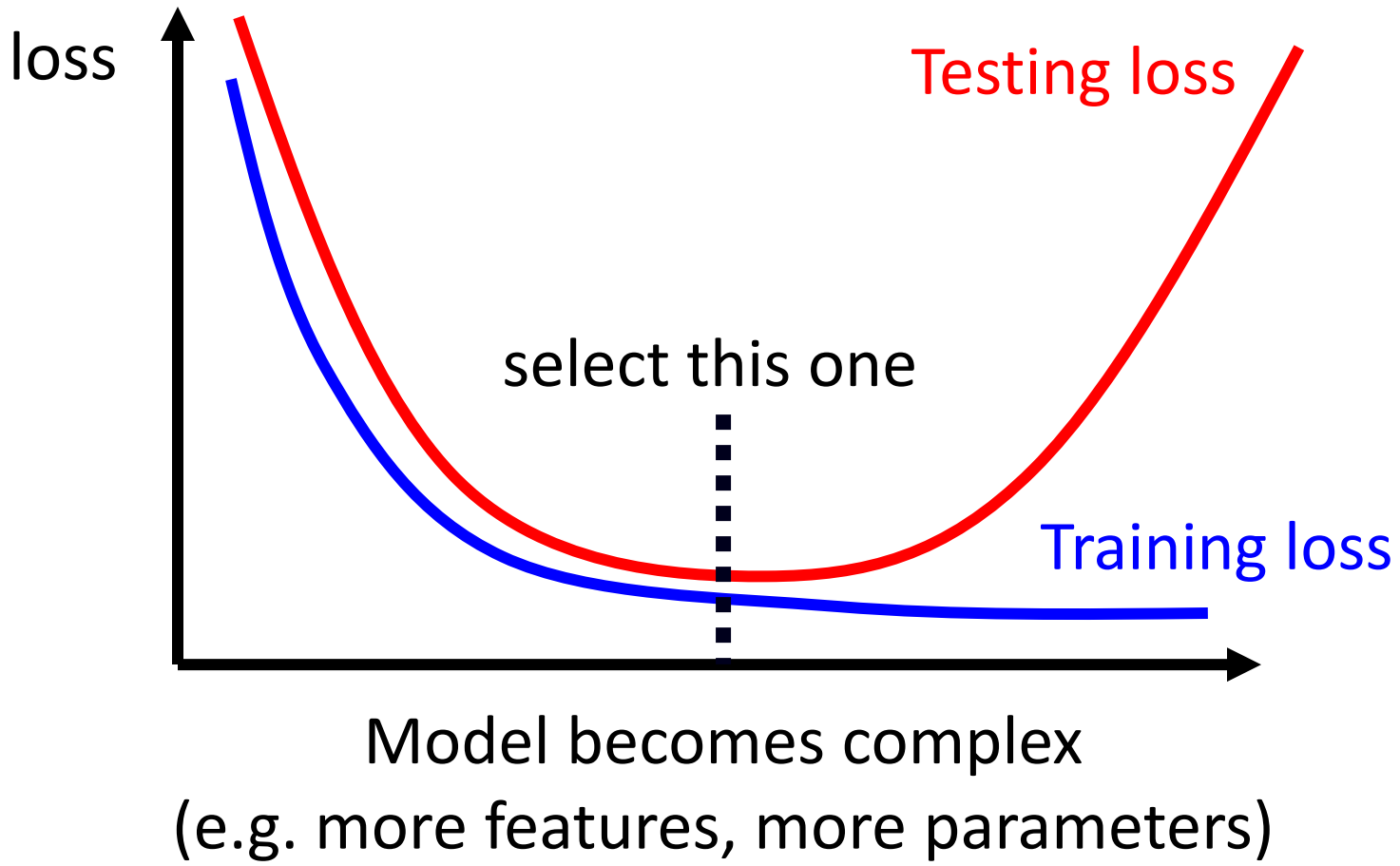
Training data

Testing data

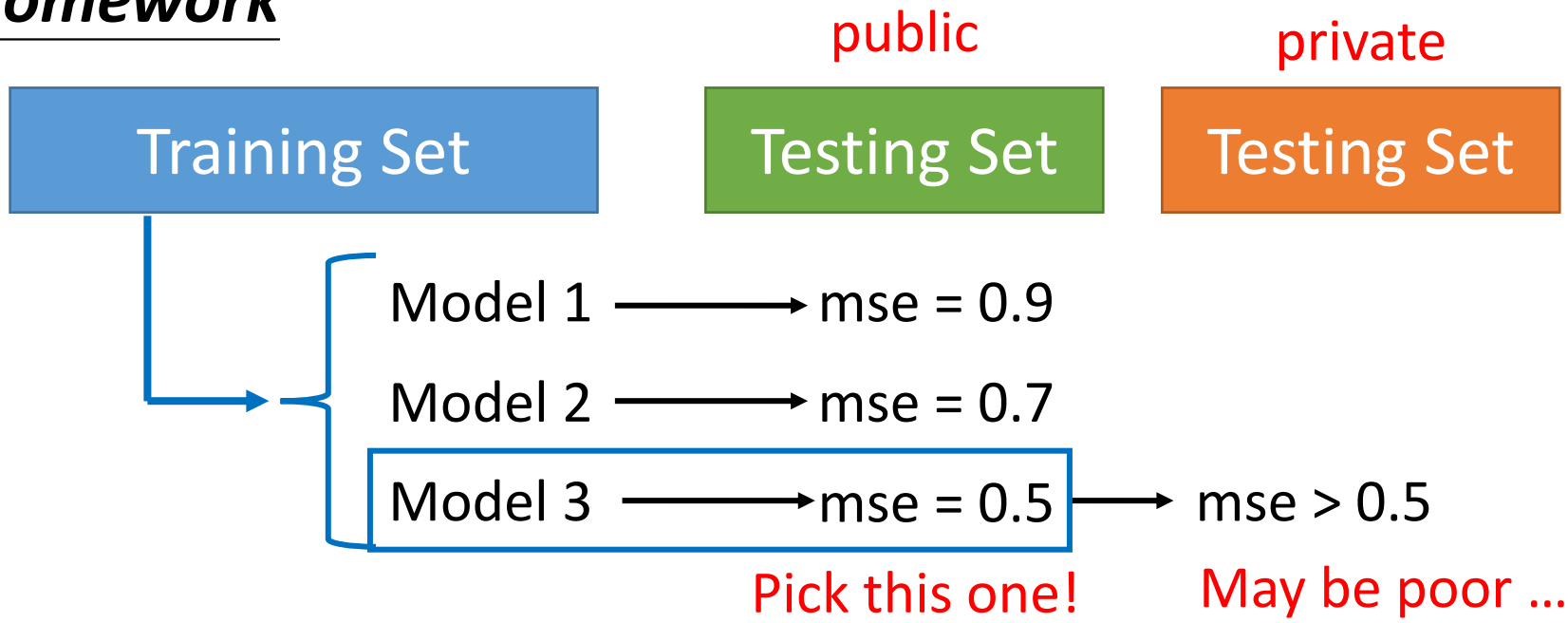
Back to model bias …



Bias-Complexity Trade-off



Homework



The extreme example again

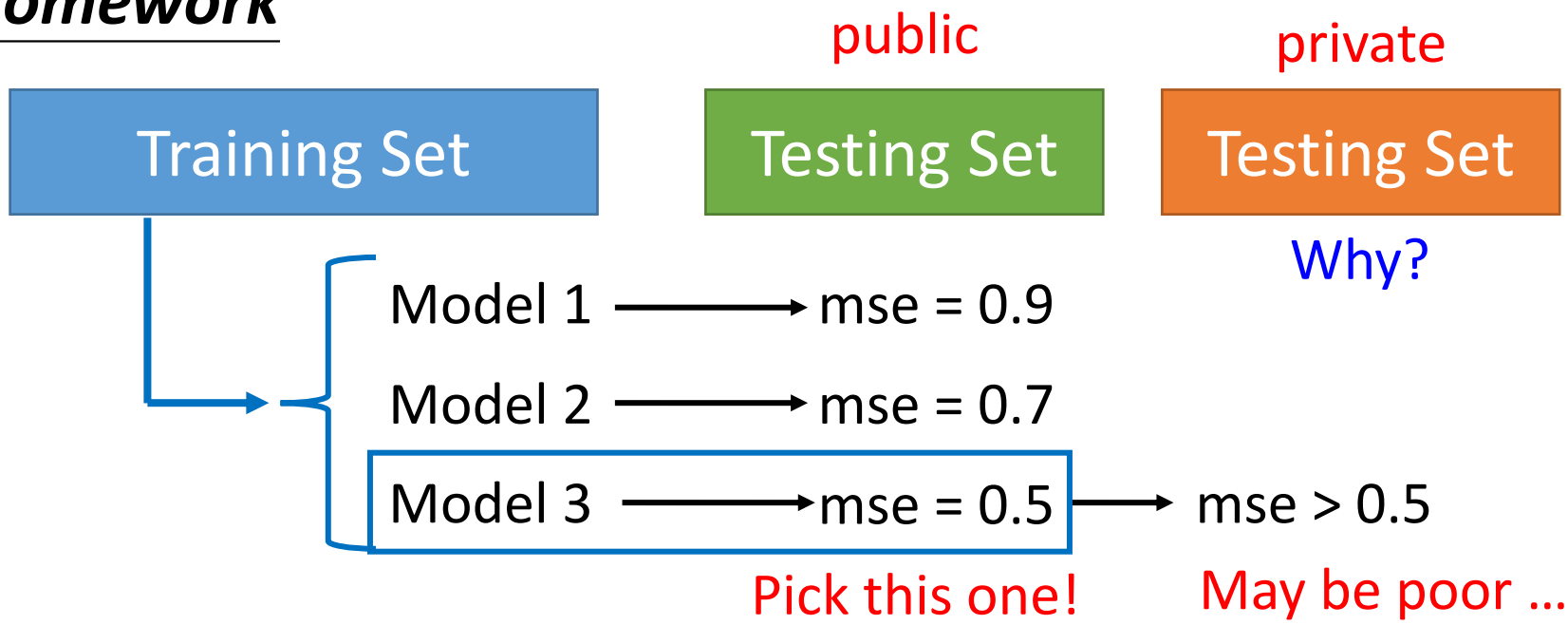
$$f_k(\boldsymbol{x}) = \begin{cases} \hat{y}^i & \exists \boldsymbol{x}^i = \boldsymbol{x} \\ random & otherwise \end{cases}$$

k: 1 - 10000000000000000000

It is possible that $f_{56789}(\boldsymbol{x})$ **happens** to get good performance on public testing set.

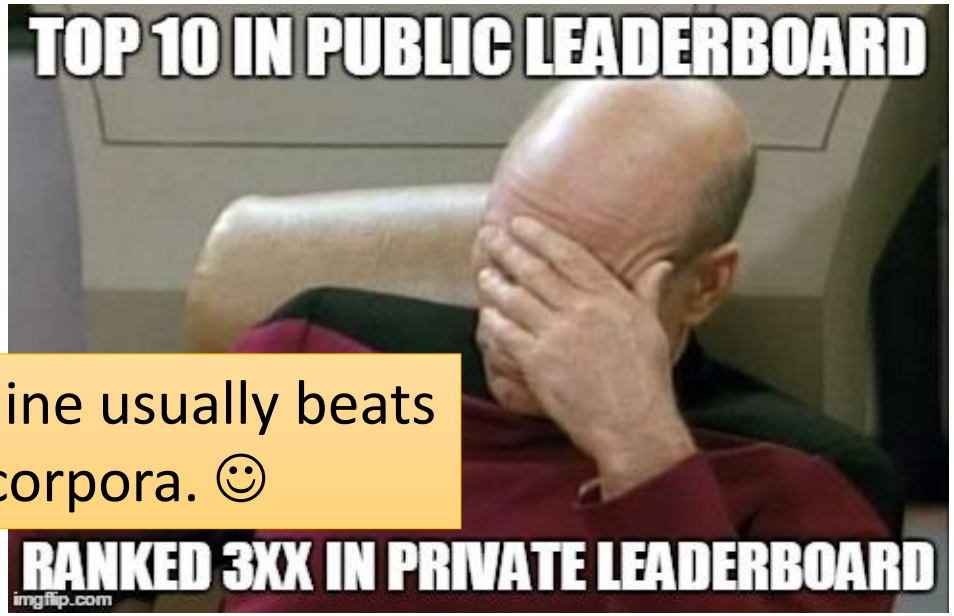
So you select $f_{56789}(\boldsymbol{x})$ …… Random on private testing set

Homework



What will happen?

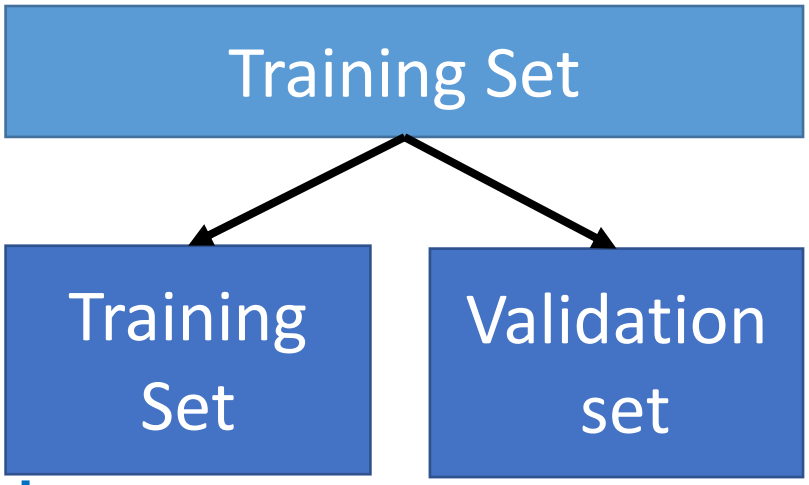
http://www.chioka.in/how-to-select-your-final-models-in-a-kaggle-competitio/



This explains why machine usually beats human on benchmark corpora. ☺

Cross Validation

How to split?



Using the results of public testing data to select your model

You are making public set better than private set.

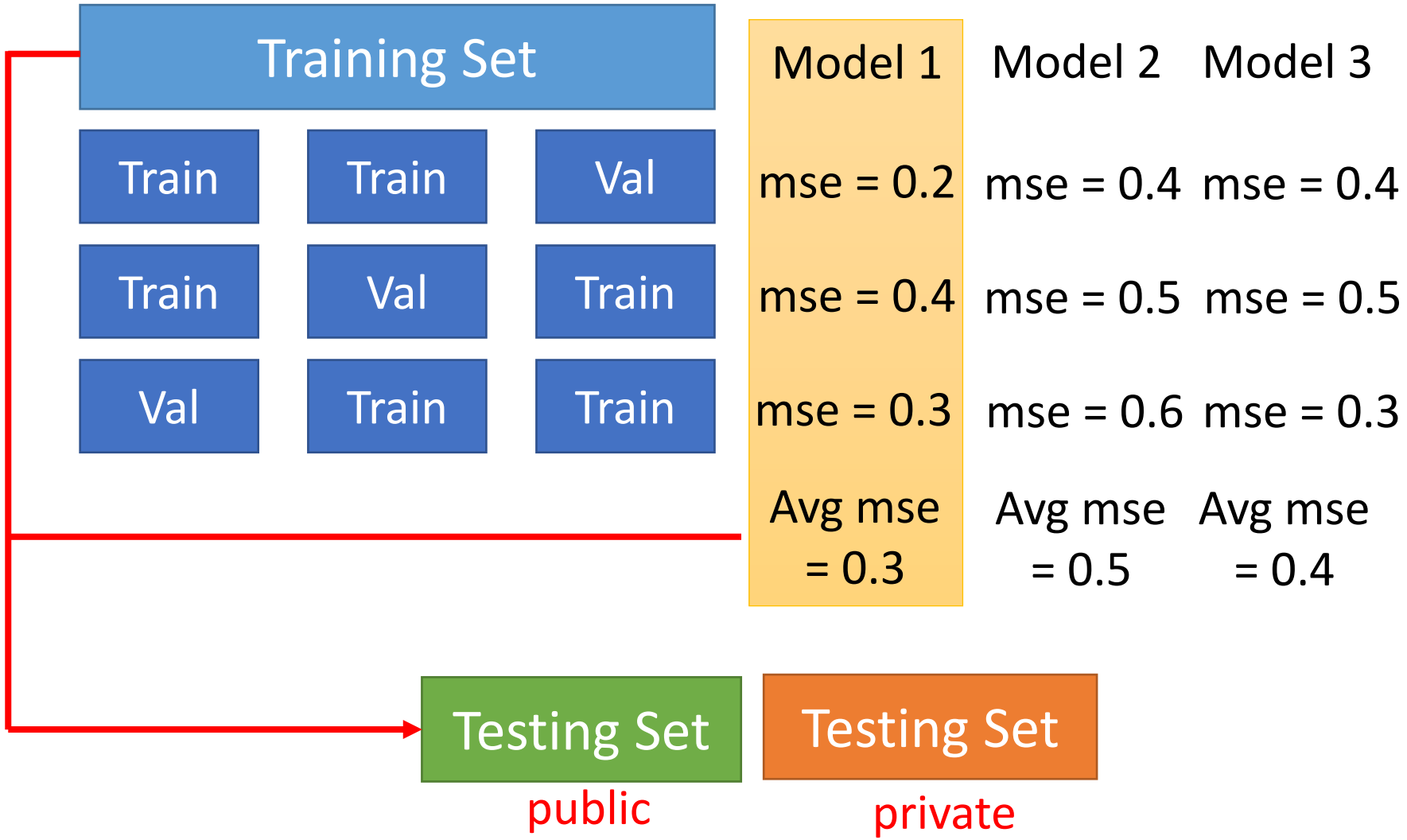
Model 1 ⟶ mse = 0.9

Model 2 ⟶ mse = 0.7

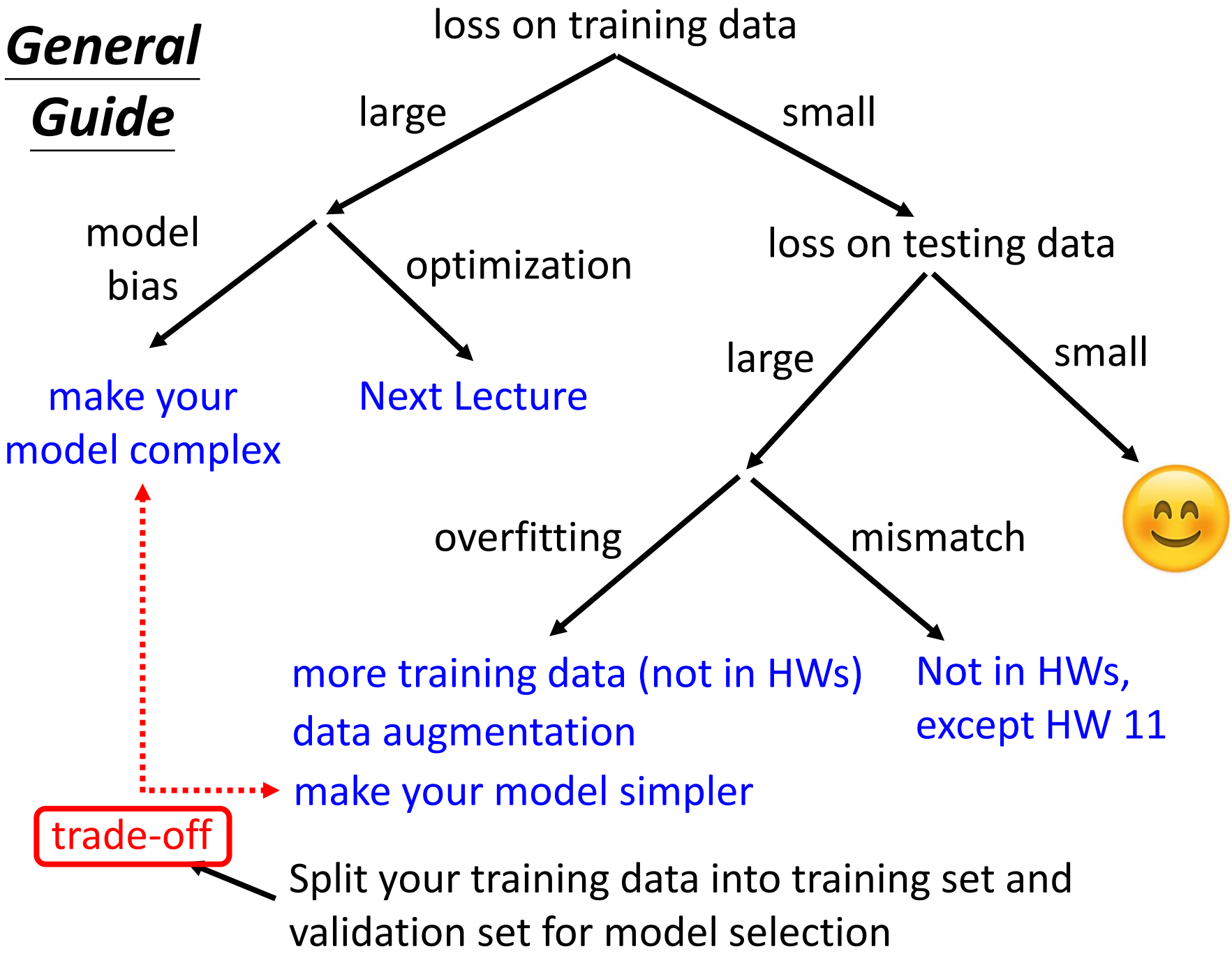
Model 3 ⟶ mse = 0.5 ⟶ mse > 0.5 ⟶ mse > 0.5

Not recommend

N-fold Cross Validation

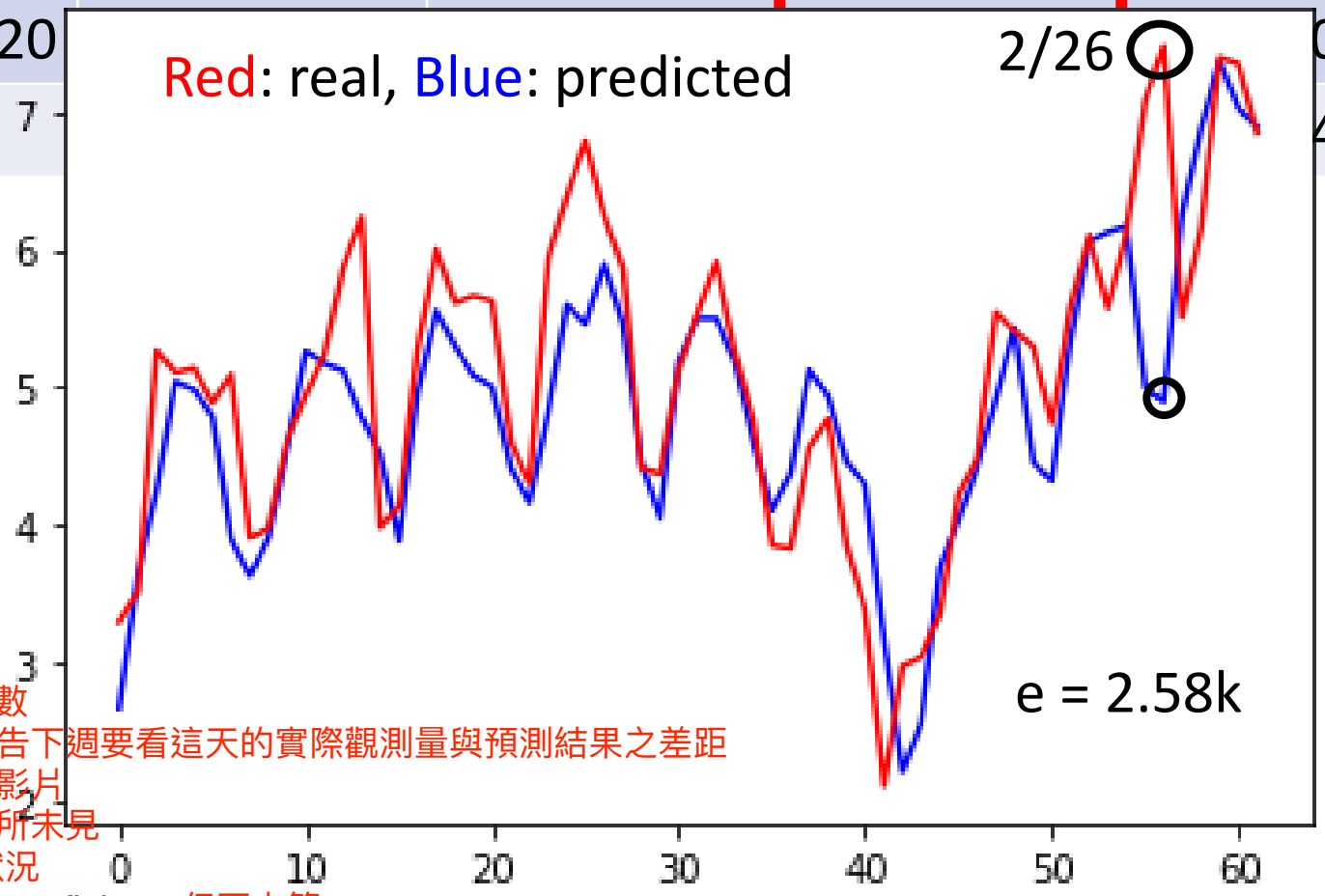


General Guide



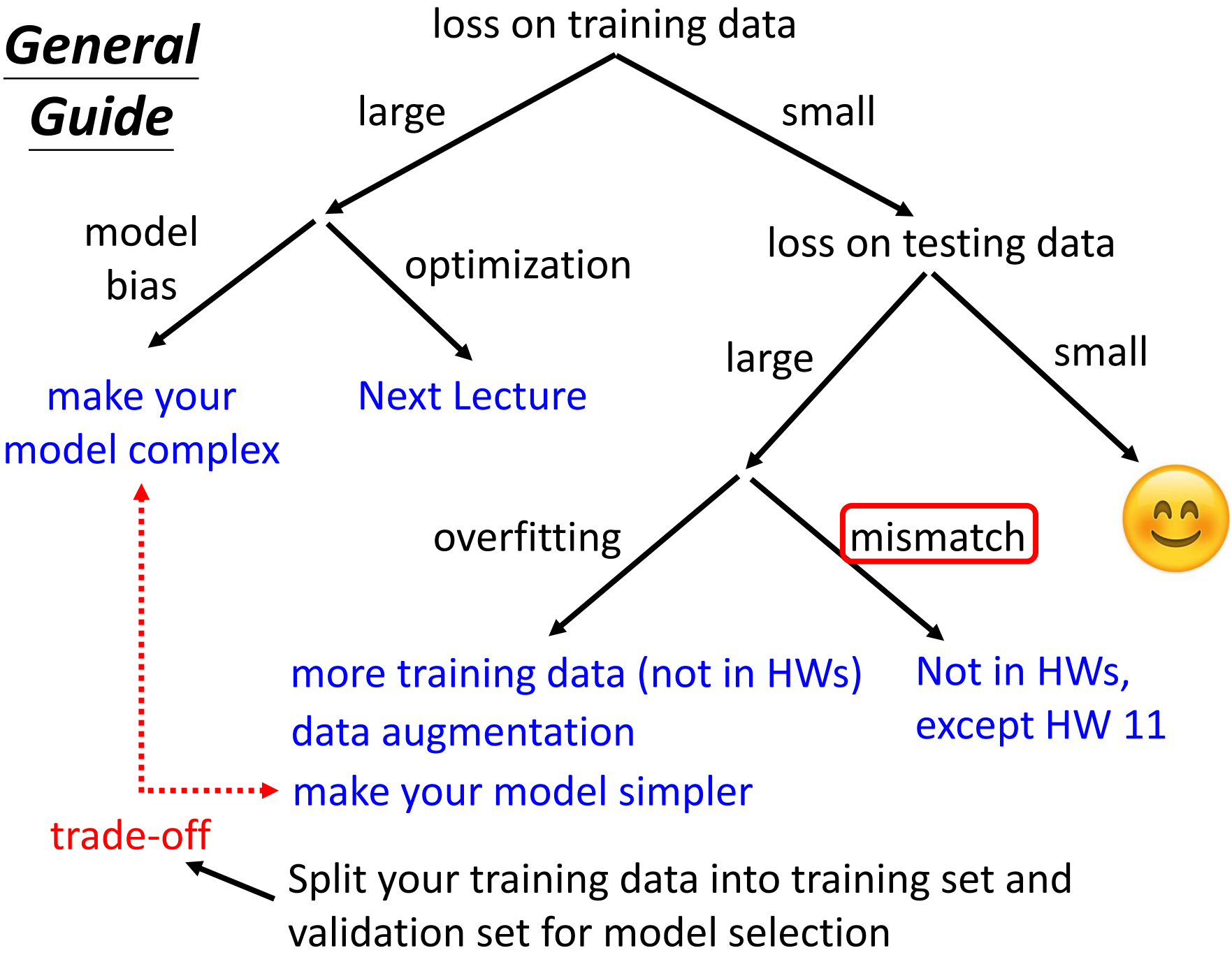
Let’s predict no. of views of 2/26!

	1 layer	2 layer	3 layer	4 layer
2017 – 2020				0k
2021				4k



2/26當天的觀看次數
因為老師事先的預告下週要看這天的實際觀測量與預測結果之差距
因此許多人去點擊影片
而這樣子的現象前所未見
屬於misamtch的狀況
也有些人會稱此為overfitting，但不太算

General Guide



Mismatch

例如，如果拿2020年COVID-19的資料當training data
與2021年COVID-19的資料當testing data
那麼因為這兩個資料本身的distribution就不一樣
因此怎麼train都很難train出來

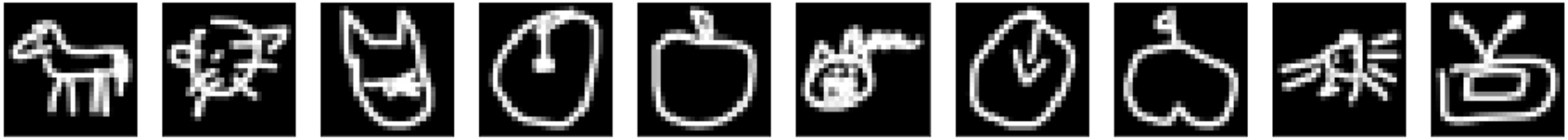
- Your training and testing data have different distributions. Be aware of how data is generated.

Most HWs do not have this problem, except HW11

Training Data

Simply increasing the training data will not help.

Testing Data



General Guide