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Introduction to ML strategy

Why ML Strategy?

Motivating example

90%

Ideas:

- Collect more data
- Collect more diverse training set
- Train algorithm longer with gradient descent
- Try Adam instead of gradient descent
- Try bigger network
- Try smaller network
- Try dropout
- Add L_2 regularization
- Network architecture
  - Activation functions
  - # hidden units
  - …

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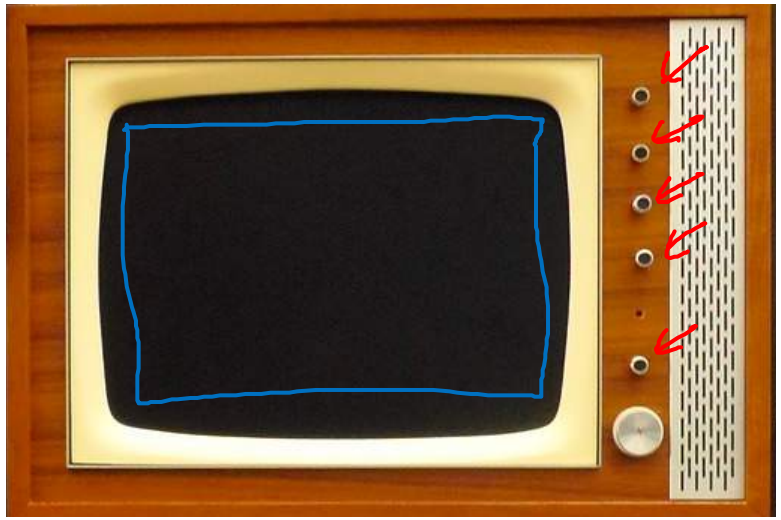
Introduction to ML strategy

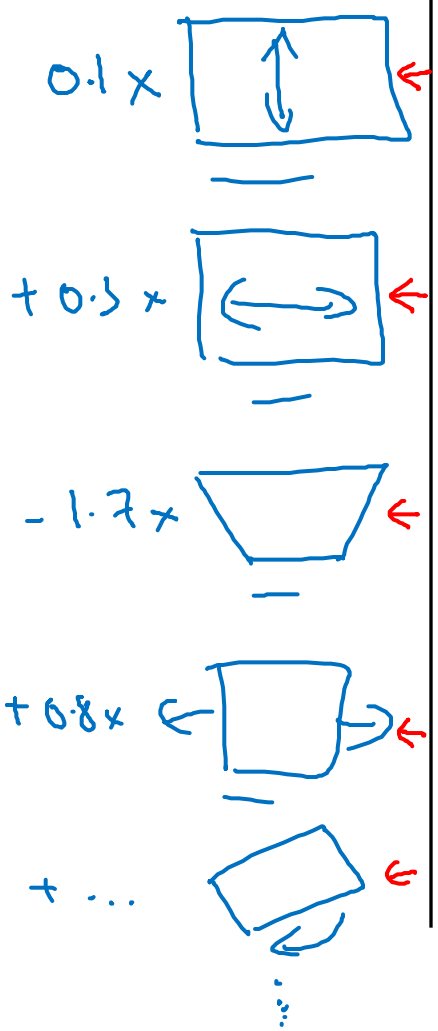
Orthogonalization

TV tuning example

Orthoganlisation referes ki liike for different things we have different control sets like



Orthoganlization



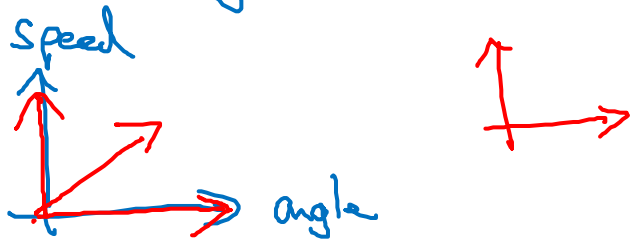
Car

→ Steering

→ {Acceleration, Braking}

→ 0.3 x angle − 0.8 speed

→ 2 x angle + 0.9 speed.



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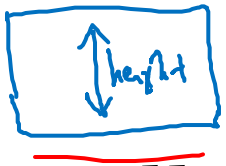
Chain of assumptions in ML

→ Fit training set well on cost function

(≈ human-level performance)

- Bigger network
- Adam
- ...

→ Fit dev set well on cost function



- Regularization
- Bigger training set

early stopping

→ Fit test set well on cost function

Bigger dev set

→ Performs well in real world

(Happy cat pic app users.)

Change dev set or cost function

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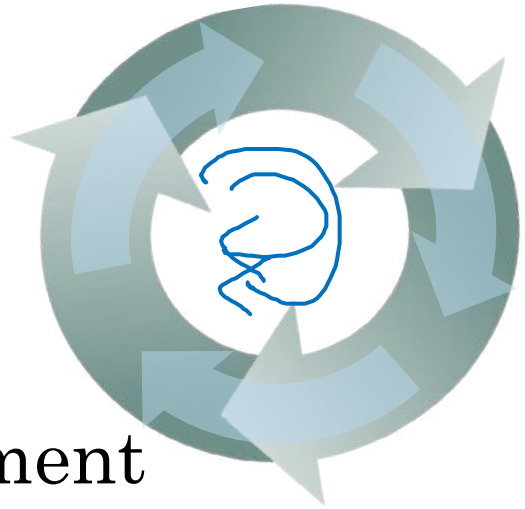
Setting up your goal

Single number evaluation metric

Using a single number evaluation metric

Idea



Experiment Code

There is some tradeoff between precision and recall so we us

Of examples recognized as cat, what % actually are cats?

What % of actual cats are correctly recognized

Classifier	Precision	Recall
A	95%	90%
B	98%	85%

F1 score = "Average" of P and R.

($\frac{2}{\frac{1}{P}+\frac{1}{R}}$. "Harmonic mean")

Dev set + Single number evaluation metric

real Speed up iterating

Another example

Algorithm	US	China	India	Other
A	3%	7%	5%	9%
B	5%	6%	5%	10%
C	2%	3%	4%	5%
D	5%	8%	7%	2%
E	4%	5%	2%	4%
F	7%	11%	8%	12%

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Setting up your goal

Satisficing and optimizing metrics

We want to maintain a balacnde between optimazation i.e accuracy and running time , so we can defien yet another co

Another cat classification example

optimizing ↓ ↓ satisficing

Classifier	Accuracy	Running time
A	90%	80ms
B	92%	95ms
C	95%	1,500ms

Cost = accuracy − 0.5 * running Time

Maximize accuracy

subject to running Time ≤ 100 ms.

N metrics: 1 optimizing

N−1 satisficing

Wakewords / Trigger words

Alexa, OK Google,

Hey Siri, nihaobaidu

你好百度

accuracy.

#false positive

Maximize accuracy.

s.t. ≤ 1 false positive

every 24 hours.

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Always take randomly shuffled dev and test sset training set from

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Setting up your goal

Train/dev/test distributions

Cat classification dev/test sets

development set, hold out cross validation set

Regions:

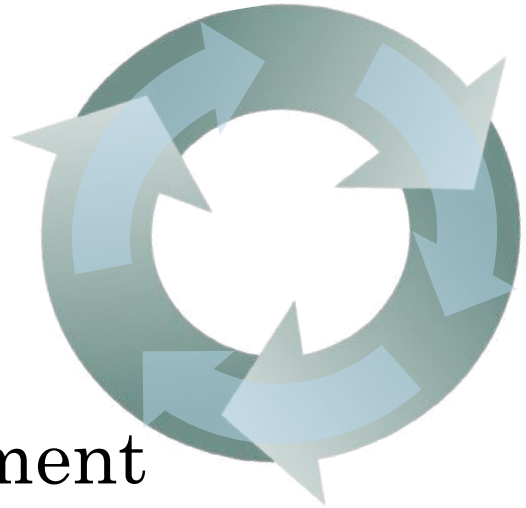
- US
- UK
- Other Europe
- South America
- India
- China
- Other Asia
- Australia

Dev

Test

Randomly shuffle into dev/test

dev set + metric



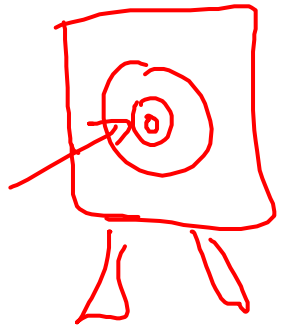
True story (details changed)

Optimizing on dev set on loan approvals for medium income zip codes

$x \rightarrow y$ (repay loan?)

Tested on low income zip codes

~3 month

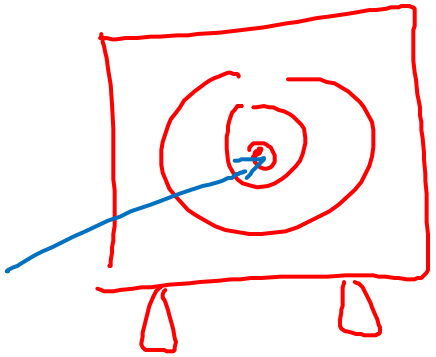


Guideline

Same distribution

Choose a dev set and test set to reflect data you expect to get in the future and consider important to do well on.

training



dev

matrix

test

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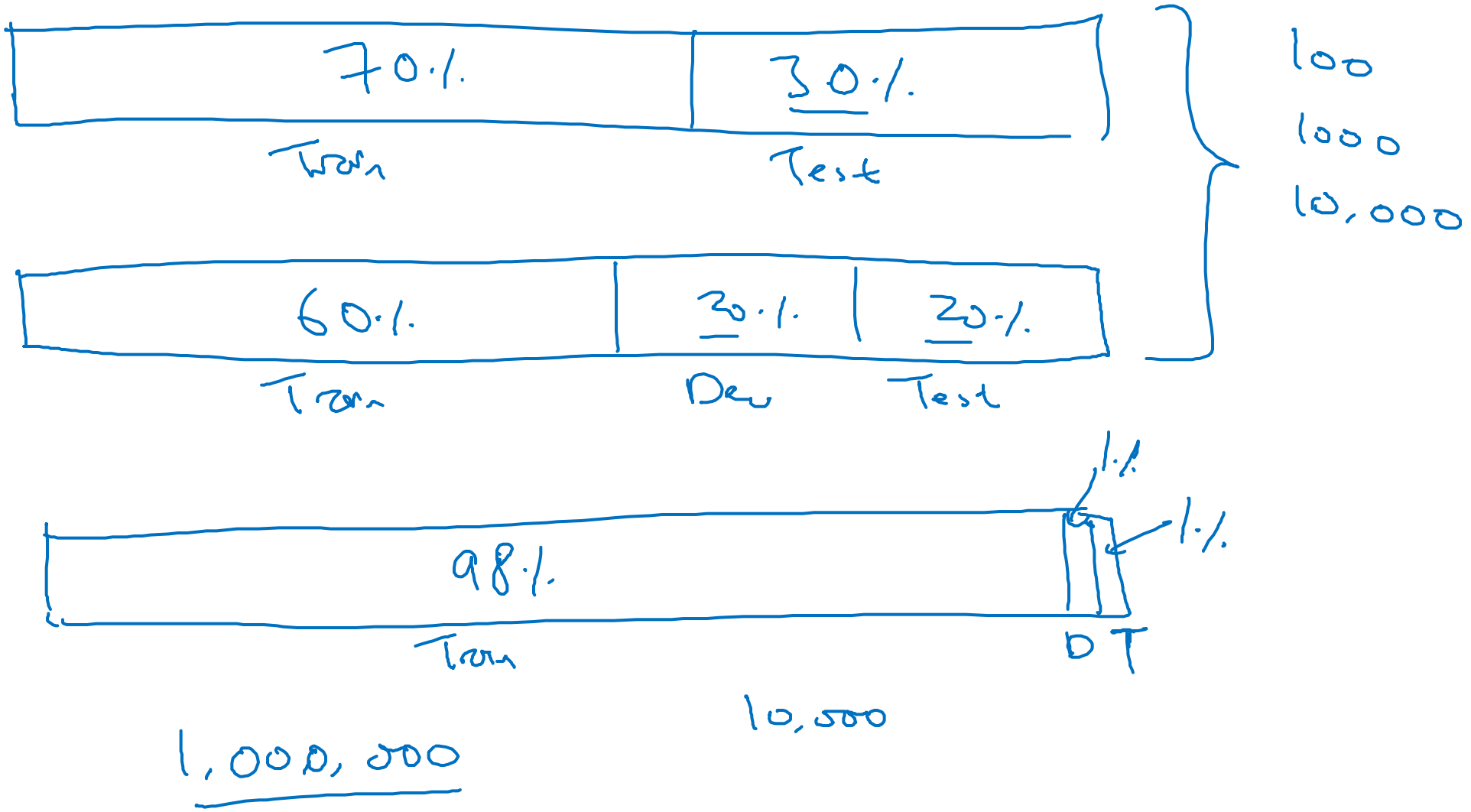
Setting up your goal

Size of dev and test sets

Old way of splitting data



Size of dev set

A B

Set your dev set to be big enough to detect differences in algorithm/models you're trying out.

A B

97% → 97.1%

0.1%

100: small

1%

1,000

10,000

100,000

0.01%

0.001%

Online advertising

Size of test set

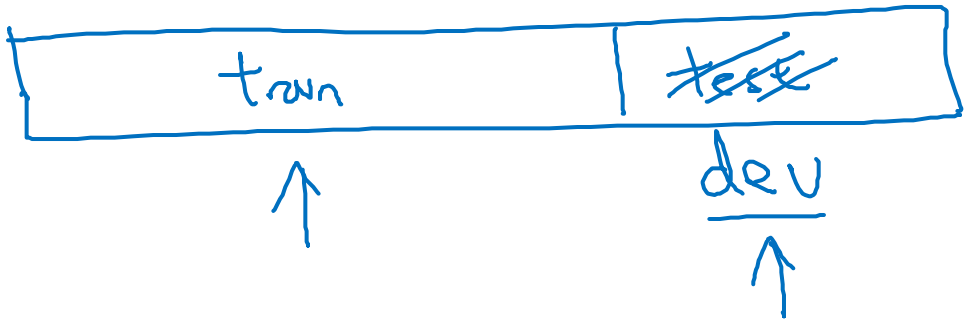
- Set your test set to be big enough to give high confidence in the overall performance of your system.

10,000

100,000

Train + Dev.

No test set.



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Setting up your goal

When to change dev/test sets and metrics

Cat dataset examples

Metric + Dev : Prefer A

Your users : Prefer B.

→ Metric: classification error

Algorithm A: 3% error → pornographic

✓ Algorithm B: 5% error

$$\text{Error}: \frac{1}{\sum w^{(i)}} \cancel{\frac{1}{m_{dev}}} \sum_{i=1}^{m_{dev}} w^{(i)} \mathbb{1}\{y_{pred}^{(i)} \neq y^{(i)}\}$$

$y_{pred}^{(i)}$: predicted value (0/1)

$$\rightarrow w^{(i)} = \begin{cases} 1 & \text{if } x^{(i)} \text{ is non-porn} \\ 10 & \text{if } x^{(i)} \text{ is porn} \end{cases}$$

Orthogonalization for cat pictures: anti-porn

1. So far we've only discussed how to define a metric to evaluate classifiers. ← Place target

2. Worry separately about how to do well on this metric. ← Aim/shoot at target

$$J = \frac{1}{\sum w^{(i)}} \sum_{i=1}^{m} w^{(i)} \mathcal{L}\left(\hat{y}^{(i)}, y^{(i)}\right)$$

Another example

Algorithm A: 3% error

Algorithm B: 5% error

Dev/test

User images

If doing well on your metric + dev/test set does not correspond to doing well on your application, change your metric and/or dev/test set.

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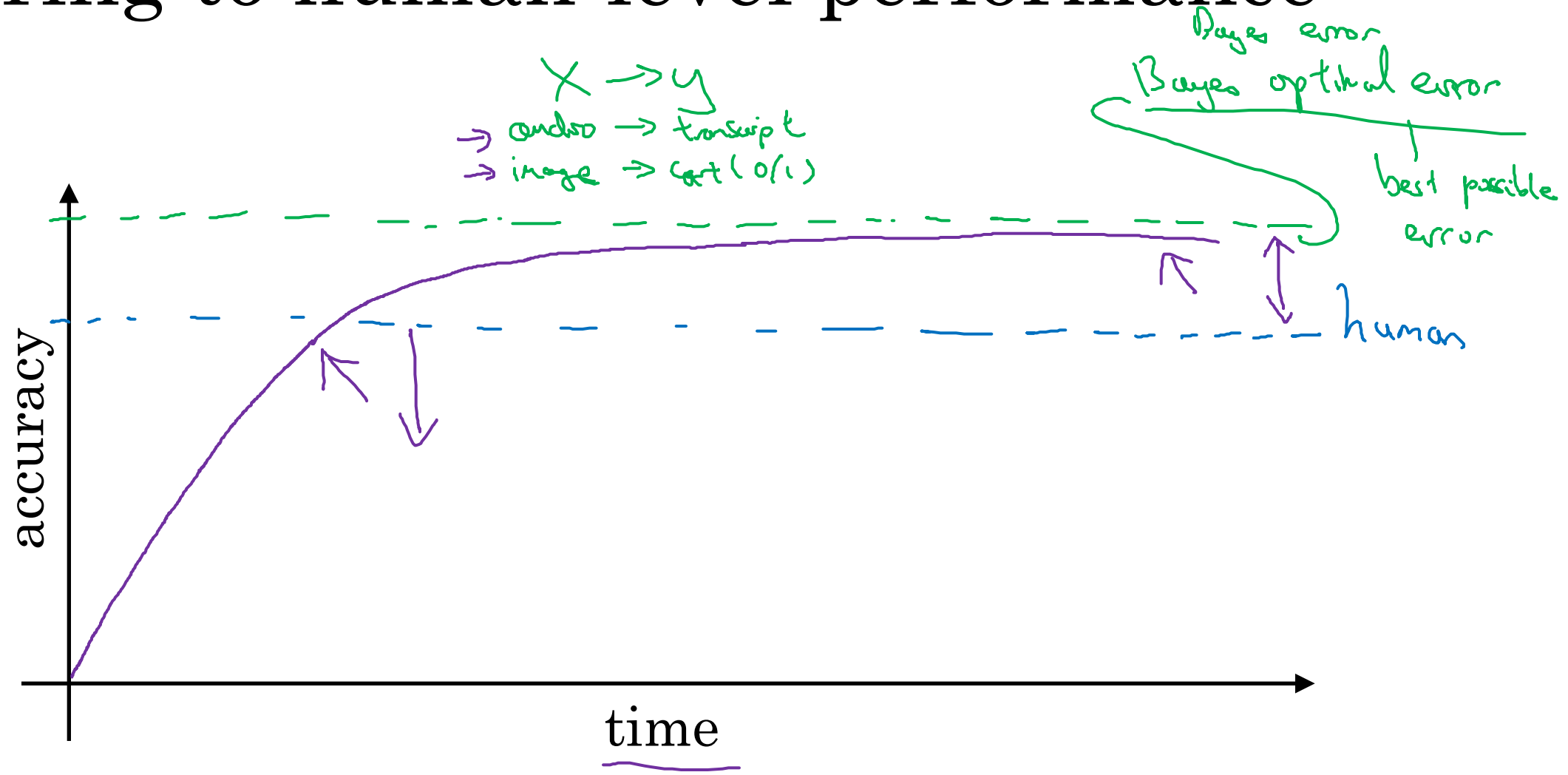
Comparing to human-level performance

Why human-level performance?

Comparing to human-level performance



Why compare to human-level performance

Humans are quite good at a lot of tasks. So long as ML is worse than humans, you can:

- Get labeled data from humans. (x, y)
- Gain insight from manual error analysis: Why did a person get this right?
- Better analysis of bias/variance.

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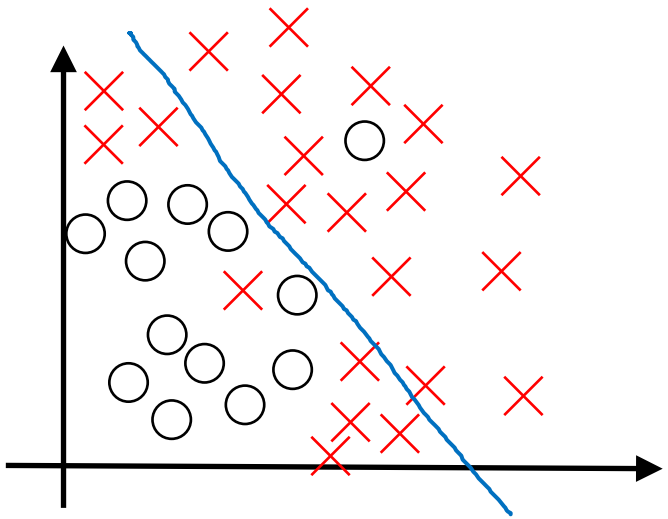
Comparing to human-level performance

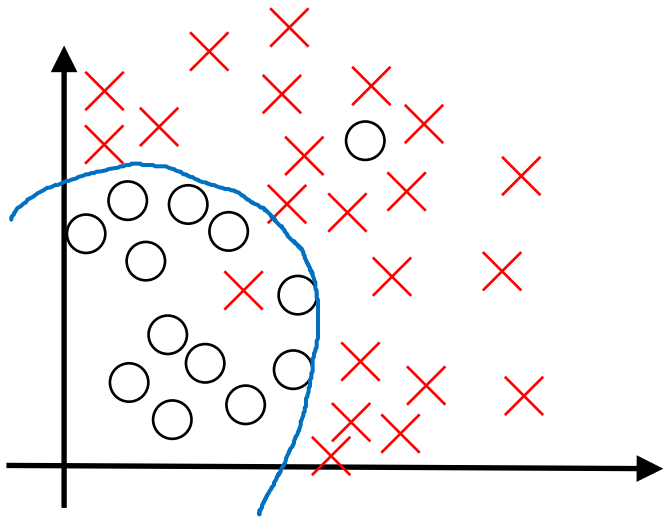
Avoidable bias

Bias and Variance

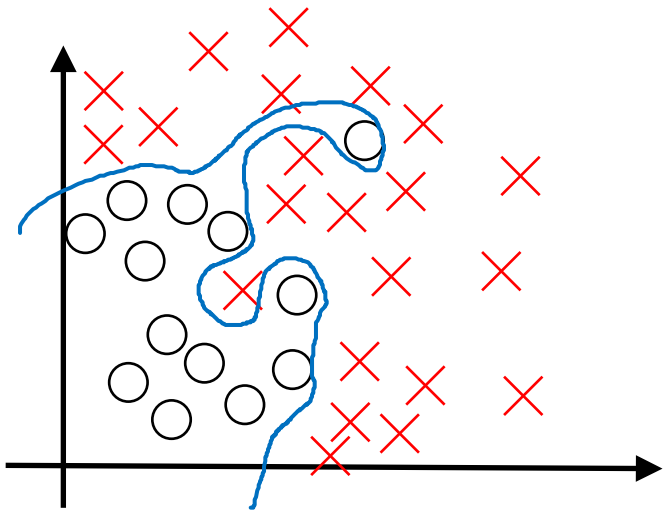


high bias

Underfitting



"just right"



high variance

overfitting.

Bias and Variance

Cat classification

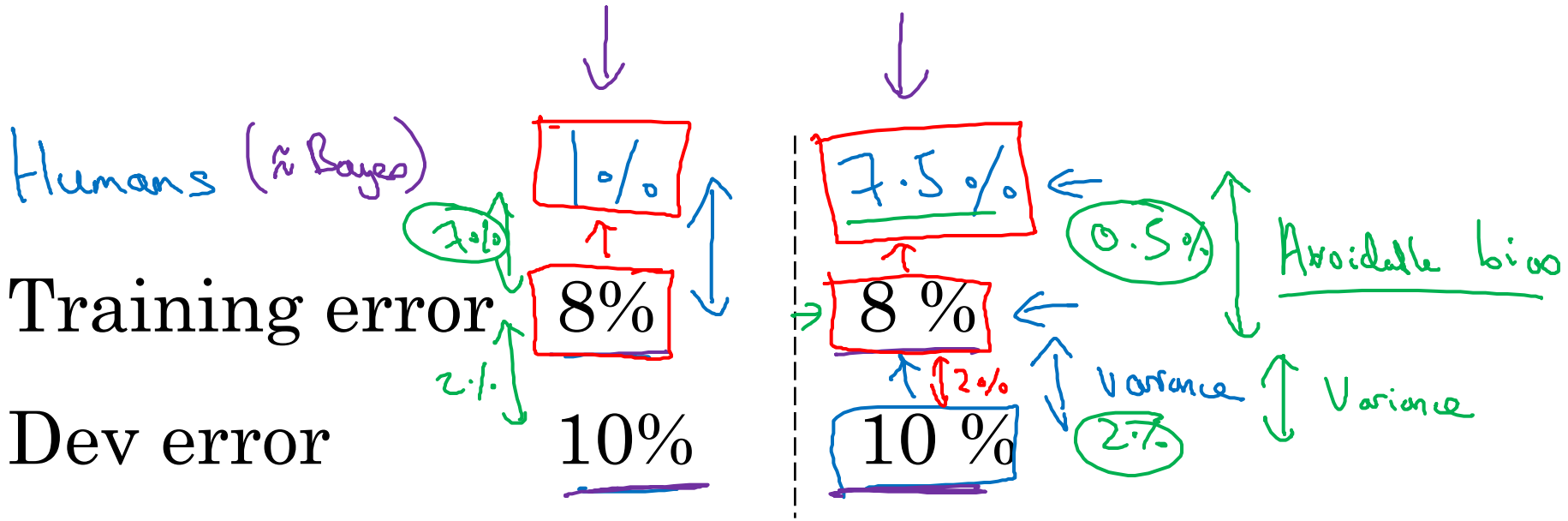
Human-level ≈ 0%

Training set error: 1% | 15% | 15% | 0.5%

Dev set error: 11% | 16% | 30% | 1%

high variance | high bias | high bias, high variance | low bias, low variance

Cat classification example



Human-level error as a proxy for Bayes error.

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Comparing to human-level performance

Understanding human-level performance

Human-level error as a proxy for Bayes error

Medical image classification example:

Suppose:

(a) Typical human ..... 3 % error

(b) Typical doctor ..... 1 % error

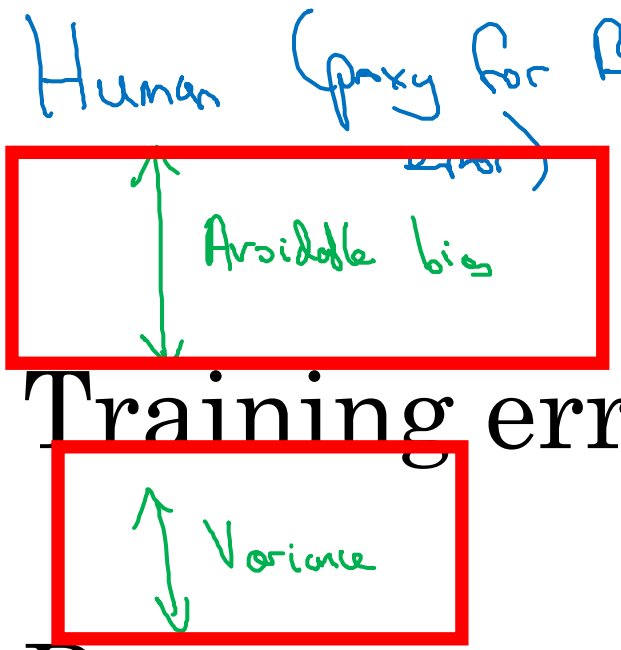
(c) Experienced doctor ..... 0.7 % error

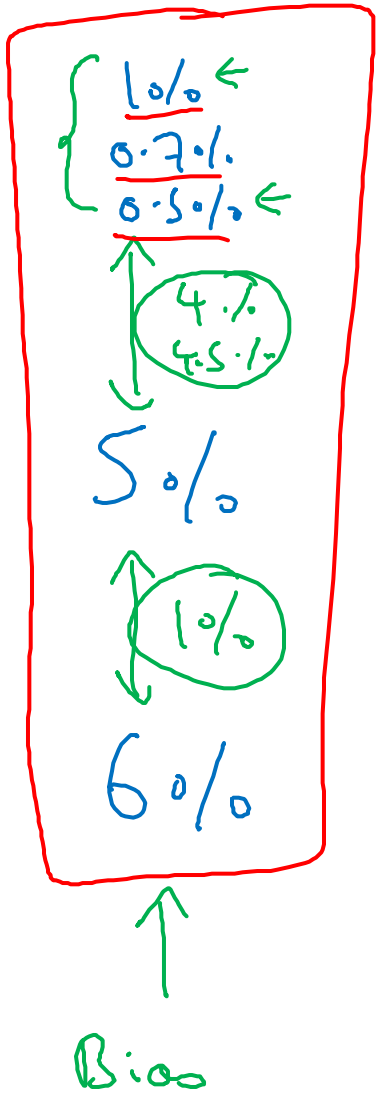
(d) Team of experienced doctors .. 0.5 % error

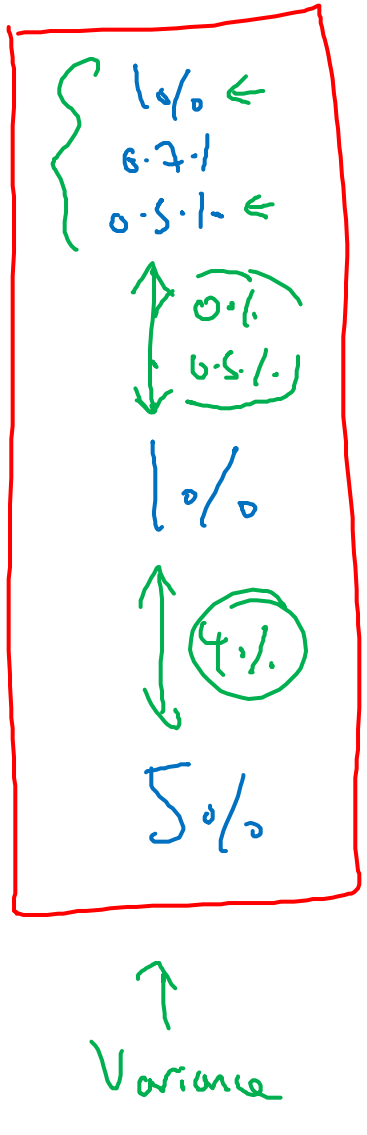
Bayes error $\leq$ 0.5%

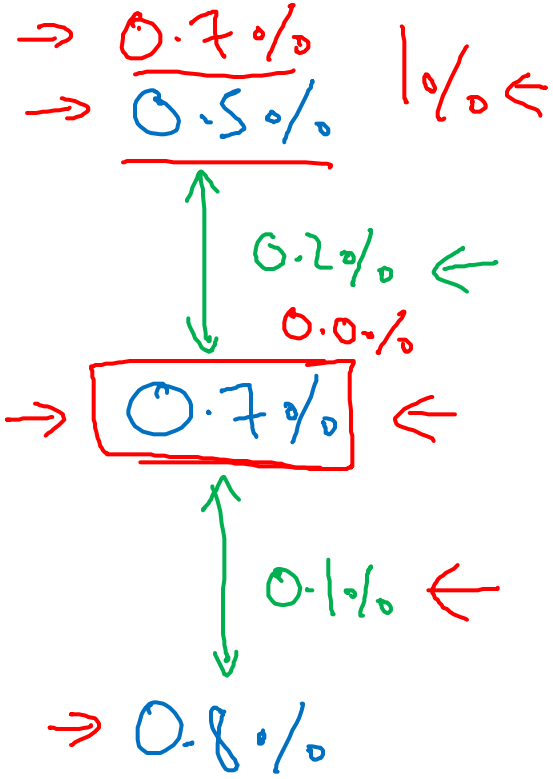
What is "human-level" error?

Error analysis example









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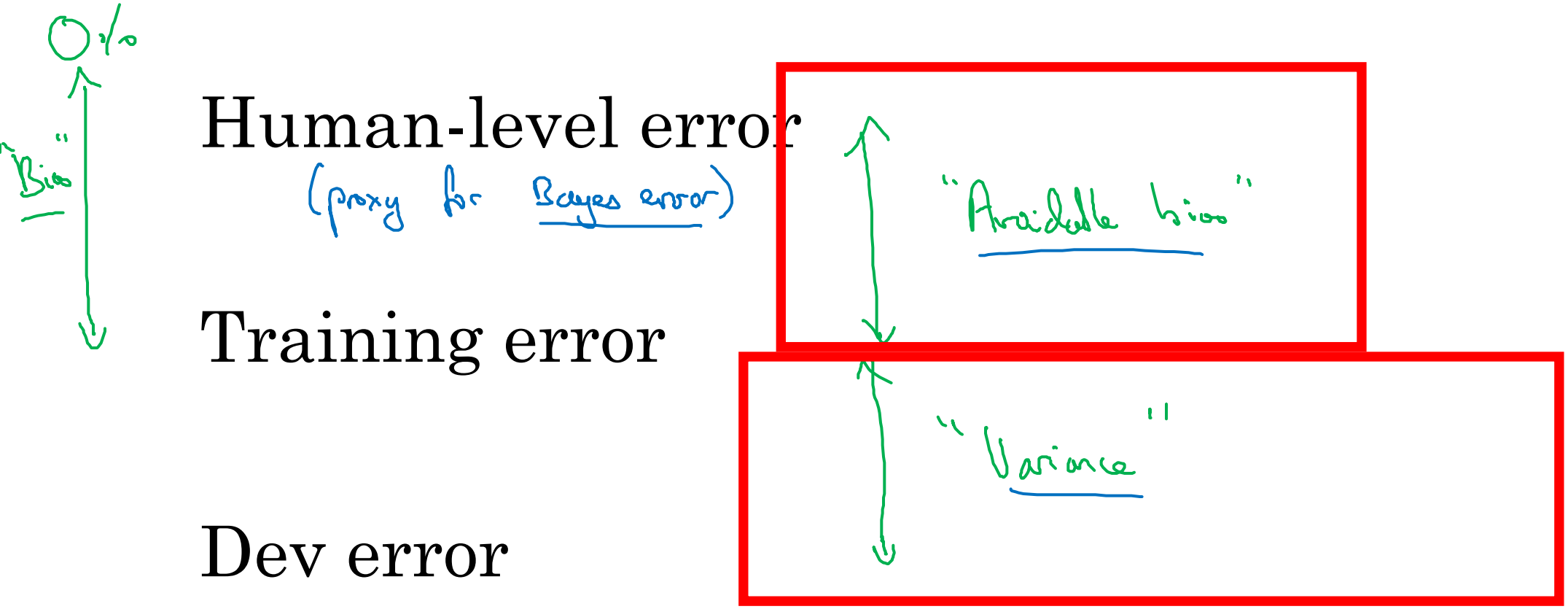
Summary of bias/variance with human-level performance



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Comparing to human-level performance

Surpassing human-level performance

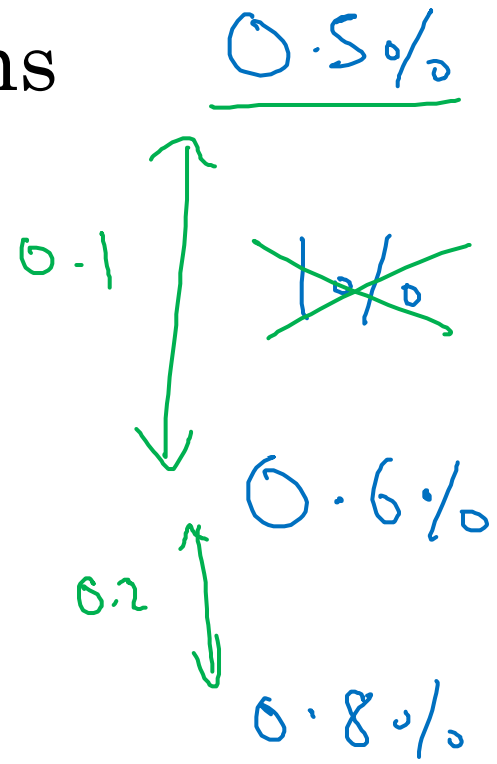
Surpassing human-level performance

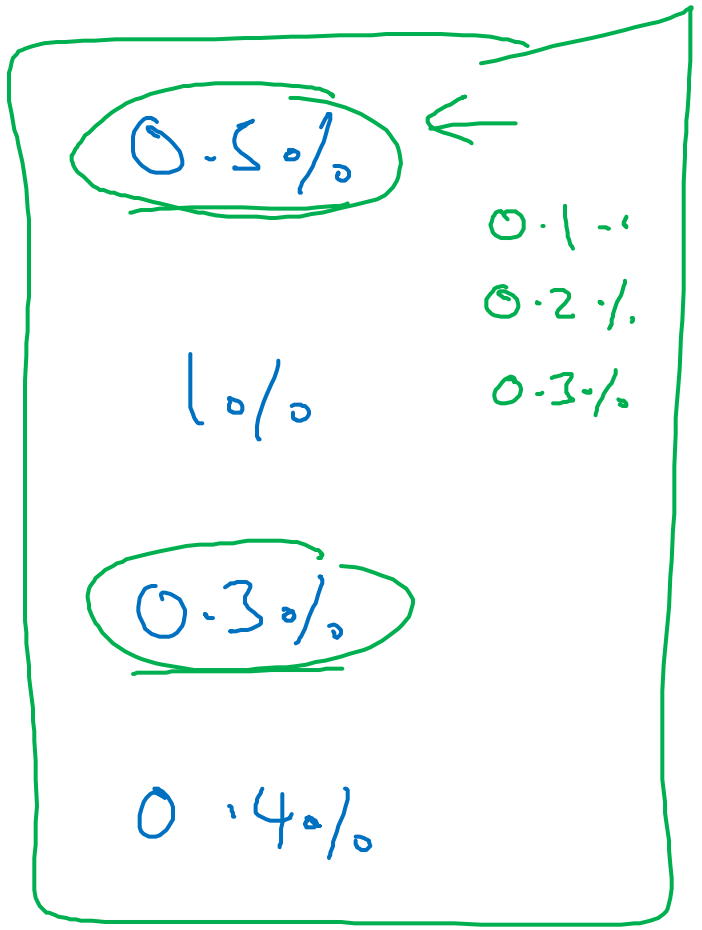
Team of humans

One human

Training error

Dev error





What is avoidable bias?

Problems where ML significantly surpasses human-level performance

- Online advertising
- Product recommendations
- Logistics (predicting transit time)
- Loan approvals

Structured data

Not natural perception

Lots of data

- Speech recognition
- Some image recognition
- Medical
  - ECG, Skin cancer, ...

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Comparing to human-level performance

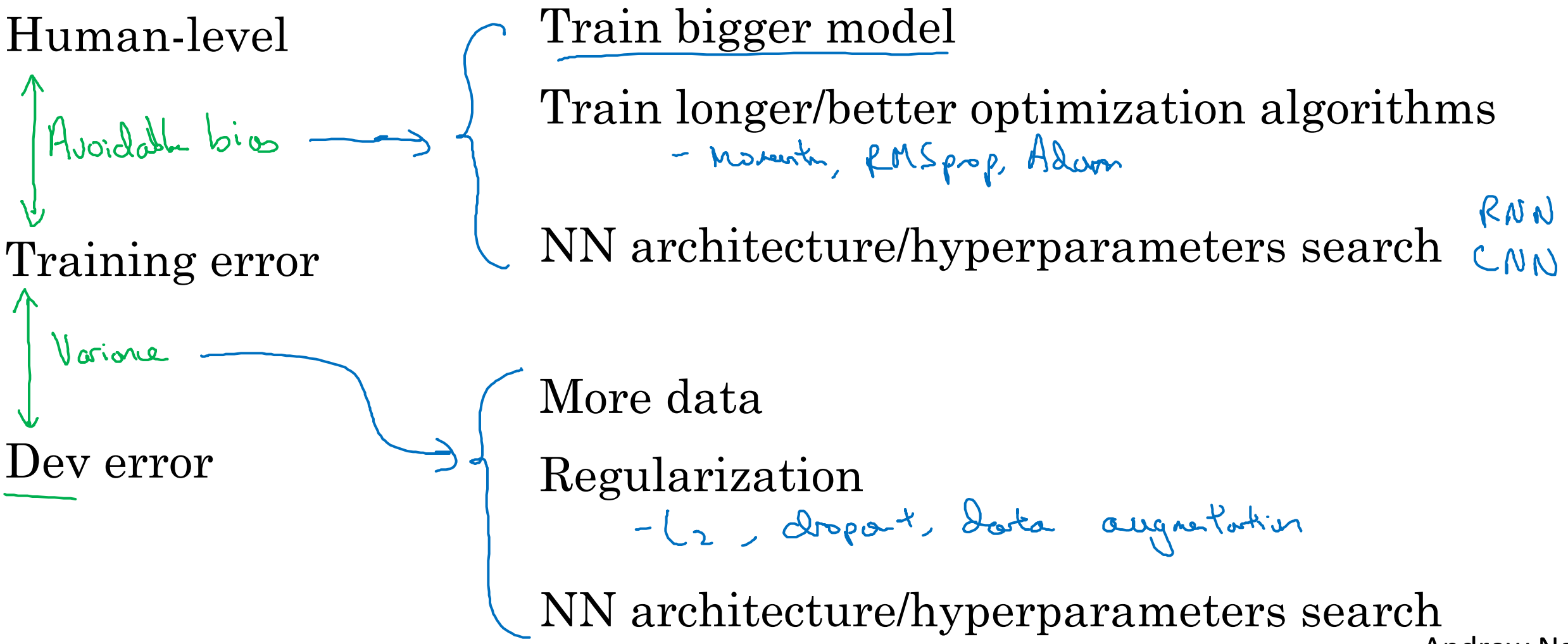
Improving your model performance

The two fundamental assumptions of supervised learning

1. You can fit the training set pretty well.

~ Avoidable bias

2. The training set performance generalizes pretty well to the dev/test set.

~ Variance

Reducing (avoidable) bias and variance