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Error Analysis

Carrying out error analysis

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Look at dev examples to evaluate ideas



Should you try to make your cat classifier do better on dogs?

Error analysis:

- Get ~100 mislabeled dev set examples.
- Count up how many are dogs.

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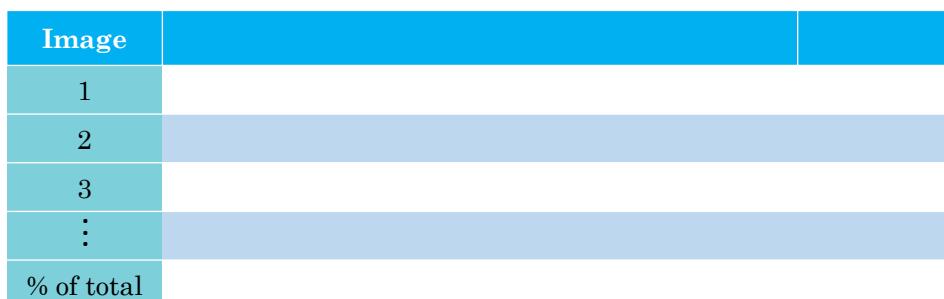
2

1

Evaluate multiple ideas in parallel

Ideas for cat detection:

- Fix pictures of dogs being recognized as cats
- Fix great cats (lions, panthers, etc..) being misrecognized
- Improve performance on blurry images



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Error Analysis

Cleaning up Incorrectly labeled data

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Incorrectly labeled examples

x							
y	1	0	1	1	0	1	1

DL algorithms are quite robust to random errors in the training set.

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Error analysis

Image	Dog	Great Cat	Blurry	Incorrectly labeled	Comments
...					
98				✓	Labeler missed cat in background
99		✓			
100				✓	Drawing of a cat; Not a real cat.
% of total	8%	43%	61%	6%	

Overall dev set error

Errors due incorrect labels

Errors due to other causes

Goal of dev set is to help you select between two classifiers A & B.

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Correcting incorrect dev/test set examples

- Apply same process to your dev and test sets to make sure they continue to come from the same distribution
- Consider examining examples your algorithm got right as well as ones it got wrong.
- Train and dev/test data may now come from slightly different distributions.

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Error Analysis

**Build your first system
quickly, then iterate**

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Speech recognition example

- Noisy background
 - Café noise
 - Car noise
- Accented speech
- Far from microphone
- Young children's speech
- Stuttering
- ...
- Set up dev/test set and metric
- Build initial system quickly
- Use Bias/Variance analysis & Error analysis to prioritize next steps.

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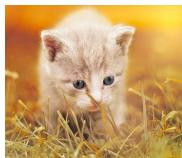
Mismatched training
and dev/test data

Training and testing
on different
distributions

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Cat app example

Data from webpages



Data from mobile app



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Speech recognition example



Training

Purchased data

Smart speaker control

Voice keyboard

...

Dev/test

Speech activated
rearview mirror

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Mismatched training
and dev/test data

Bias and Variance with
mismatched data
distributions

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Cat classifier example

Assume humans get $\approx 0\%$ error.

Training error
Dev error

Training-dev set: Same
distribution as training
set, but not used for
training

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Bias/variance on mismatched training and dev/test sets

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More general formulation

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Mismatched training and dev/test data

Addressing data mismatch

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Addressing data mismatch

- Carry out manual error analysis to try to understand difference between training and dev/test sets
- Make training data more similar; or collect more data similar to dev/test sets

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Artificial data synthesis



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=



“The quick brown
fox jumps
over the lazy dog.”

Car noise

Synthesized
in-car audio

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Artificial data synthesis

Car recognition:



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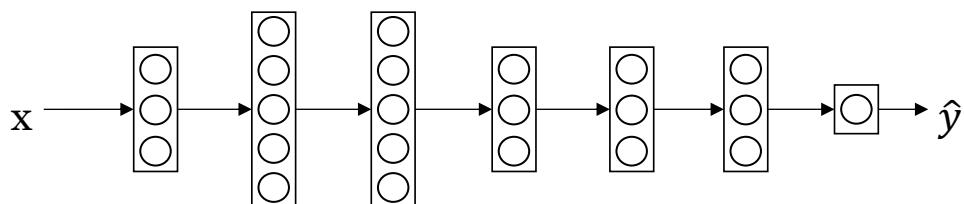
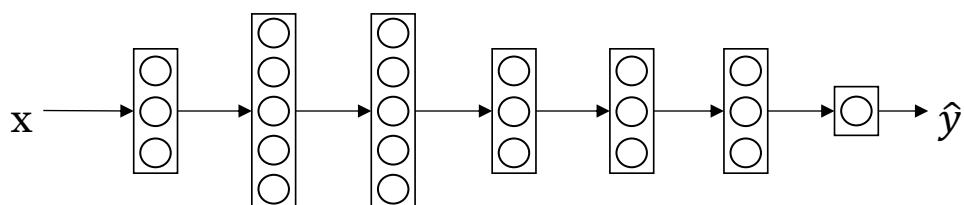
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Learning from multiple tasks

Transfer learning

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Transfer learning



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When transfer learning makes sense

- Task A and B have the same input x .
- You have a lot more data for Task A than Task B.
- Low level features from A could be helpful for learning B.

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Learning from
multiple tasks

Multi-task
learning

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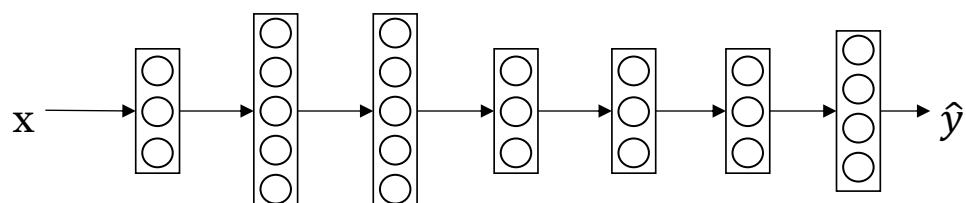
Simplified autonomous driving example



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Neural network architecture



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When multi-task learning makes sense

- Training on a set of tasks that could benefit from having shared lower-level features.
- Usually: Amount of data you have for each task is quite similar.
- Can train a big enough neural network to do well on all the tasks.

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End-to-end deep
learning

What is
end-to-end
deep learning

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What is end-to-end learning?

Speech recognition example

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Face recognition



[Image courtesy of Baidu]

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More examples

Machine translation

Estimating child's age:



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End-to-end deep
learning

Whether to use
end-to-end learning

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Pros and cons of end-to-end deep learning

Pros:

- Let the data speak
- Less hand-designing of components needed

Cons:

- May need large amount of data
- Excludes potentially useful hand-designed components

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Applying end-to-end deep learning

Key question: Do you have sufficient data to learn a function of the complexity needed to map x to y?



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