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Error Analysis

Carrying out error
analysis

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.

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

Image		
1		
2		
3		
⋮		
% of total		



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Error Analysis

Cleaning up
Incorrectly labeled
data

Incorrectly labeled examples

x							
y	1	0	1	1	0	1	1

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

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.

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

Speech recognition example

- Noisy background
 - Café noise
 - Car noise
- Accent
- Far from microphone
- Young
- Stutter
- ...

Guideline:

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

- 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

Cat app example

Data from webpages



Data from mobile app



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

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

Bias/variance on mismatched training and dev/test sets

More general formulation



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Mismatched training
and dev/test data

Addressing data
mismatch

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

Artificial data synthesis



+



=



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

Car noise

Synthesized
in-car audio

Artificial data synthesis

Car recognition:



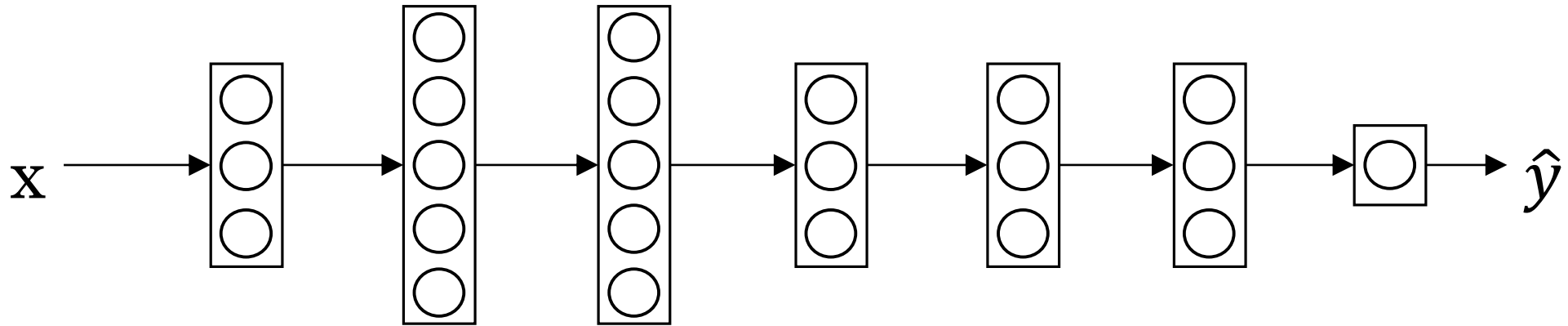
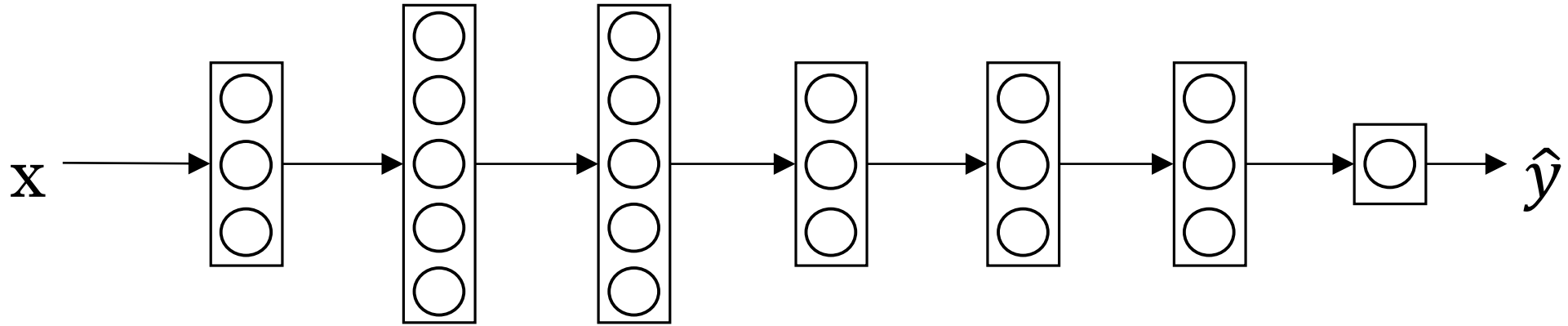


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Learning from
multiple tasks

Transfer learning

Transfer learning



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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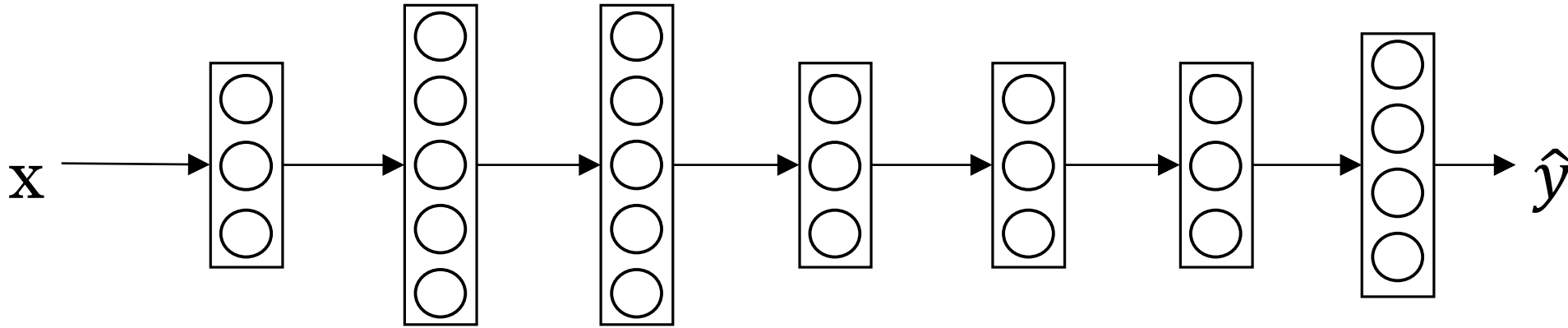
Learning from
multiple tasks

Multi-task
learning

Simplified autonomous driving example



Neural network architecture



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

What is end-to-end learning?

Speech recognition example

Face recognition



[Image courtesy of Baidu]

More examples

Machine translation

Estimating child's age:





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End-to-end deep
learning

Whether to use
end-to-end learning

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

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 ?

