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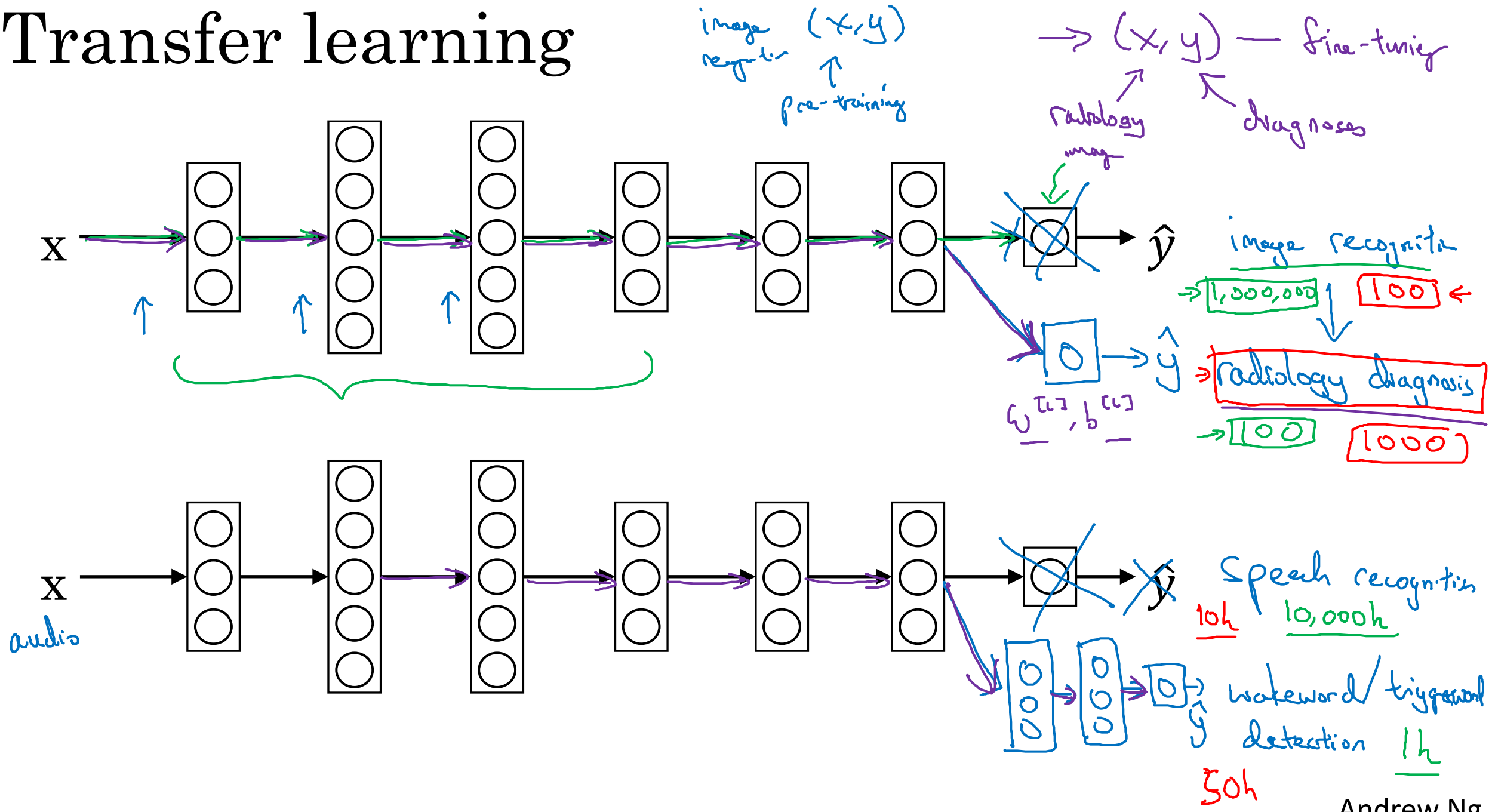
Learning from multiple tasks

Transfer learning

Transfer learning



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When transfer learning makes sense

Transfer from A → B

- 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

$x^{(i)}$

$y^{(i)}$ $(4,1)$

Pedestrians	0
Cars	1
Stop signs	1
Traffic lights	0
⋮	⋮

$$Y = \begin{bmatrix} | & | & | & & | \\ y^{(1)} & y^{(2)} & y^{(3)} & \cdots & y^{(m)} \\ | & | & | & & | \end{bmatrix}$$

$(4, m)$

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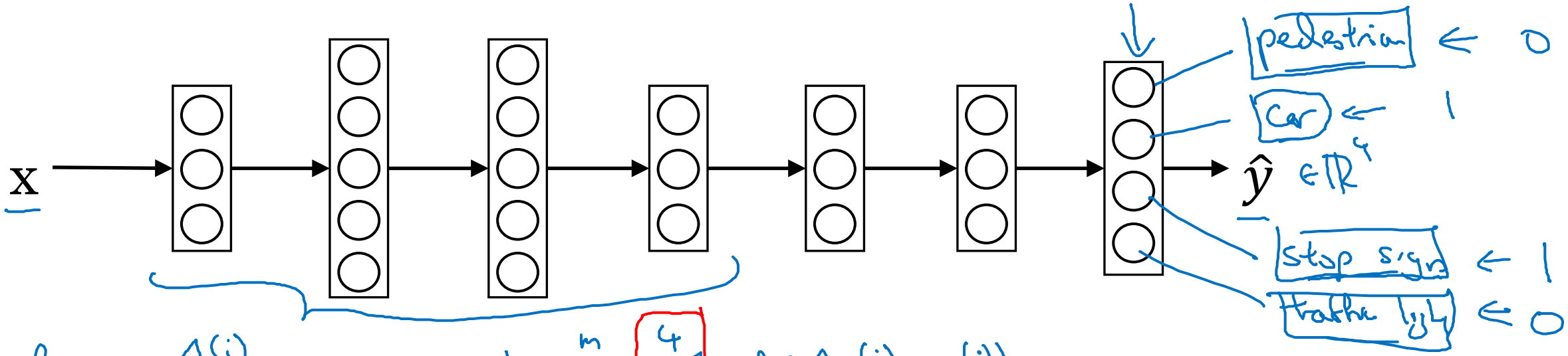
Neural network architecture



Loss: $\hat{y}^{(i)}_{(4,1)} \rightarrow \frac{1}{m}\sum_{i=1}^{m}\boxed{\sum_{j=1}^{4}} \mathcal{L}(\hat{y}_j^{(i)}, y_j^{(i)})$

Sum only over value of j with 0/1 label.

→ Usual logistic loss

$-y_j^{(i)}\log \hat{y}_j^{(i)} - (1-y_j^{(i)})\log(1-\hat{y}_j^{(i)})$

Unlike softmax regression:

One image can have multiple labels

Multi-task learning ←

$$Y = \begin{bmatrix} 1 & \boxed{1} & & \boxed{0} & & ? & \\ 0 & \boxed{1} & \cdots & \boxed{1} & \cdots & 1 & \cdots \\ \boxed{?} & ? & & \boxed{1} & & ? & \\ ? & ? & & \boxed{0} & & ? & \end{bmatrix} \leftarrow$$

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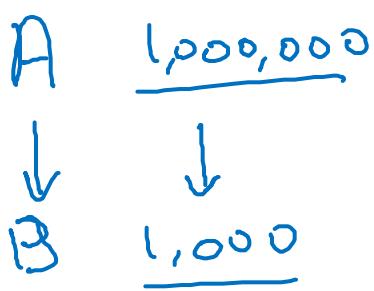
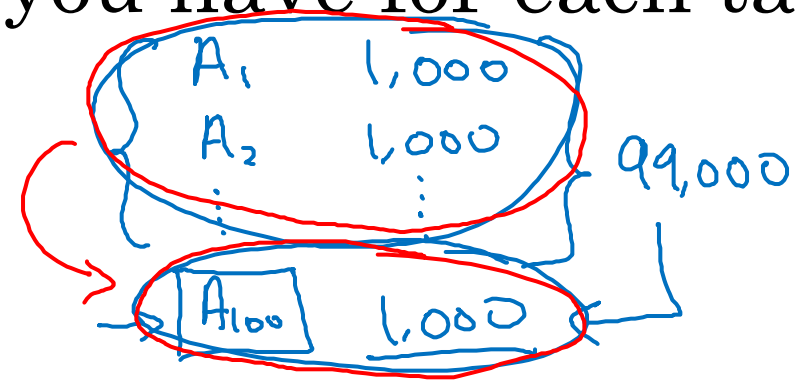
When multi-task learning makes sense

- 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

What is end-to-end learning?

Speech recognition example

"cat"

x

MFCC

ML

y

→ audio → features → phonemes → words → transcript

audio → phonemes → ... → transcript

→ audio → transcript

3,000h

10,000h

⋮

100,000h

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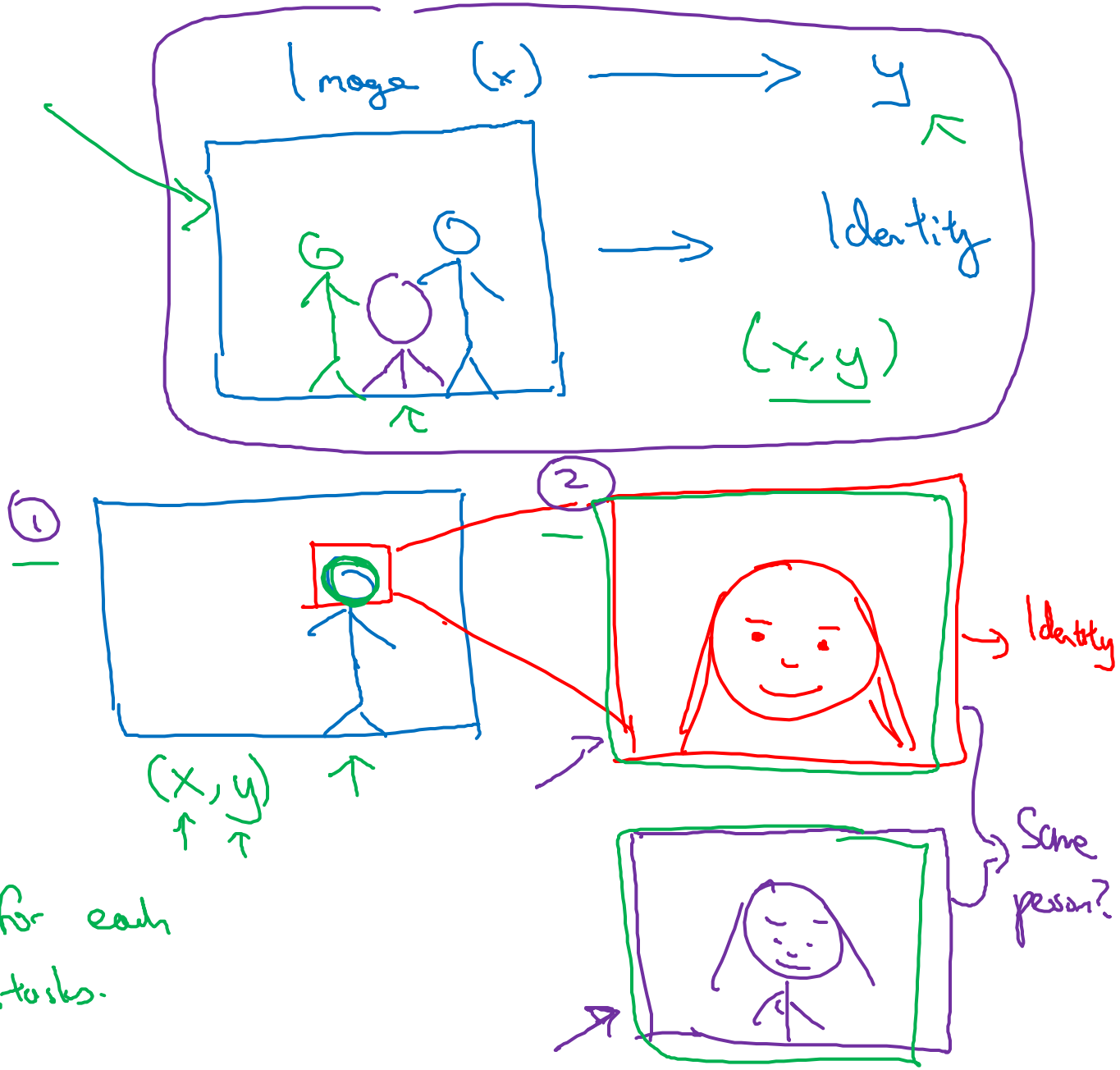
Face recognition

[Image courtesy of Baidu]



Have data for each of 2 subtasks.

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More examples

Machine translation

(x, y)

English → text analysis → ... → French

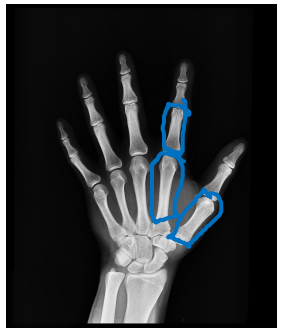
English → French

English French

Estimating child's age:

Image ① → bones ② → age

Image → 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

$x \longrightarrow y$

→ "phonemes"
c a t

- Less hand-designing of components needed

$x \longrightarrow y$

Cons:

- May need large amount of data

input end

output end

$x \longrightarrow y$

(x, y)

- Excludes potentially useful hand-designed components

Data.

Hand-design.

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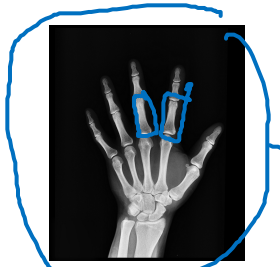
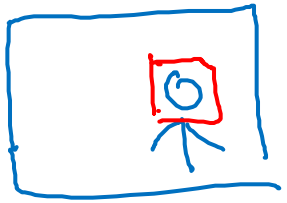
Applying end-to-end deep learning

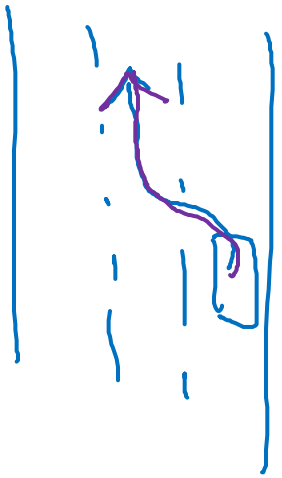
Key question: Do you have sufficient data to learn a function of the complexity needed to map x to y?

$X \to y$



→ age





image, radar, lidar → (DL) cars, (DL) pedestrians → (motion planning) route → (control) steering

- Use DL to learn individual components
- Carefully choose $X \to Y$ depending what tasks you can get data for.

→ image → steering

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