

# Intro to Deep Learning and Transfer Learning

How to quickly employ deep learning in my Hackathon project



Presenter: Zhizhen Qin

Co-founder and ex-president of Chinese Engineering Society (CES) at UC San Diego

Master Student in Computer Science at UC San Diego

Research Areas: Deep Learning, Reinforcement Learning, Safe Autonomous Driving

9/4/2020

# Outline

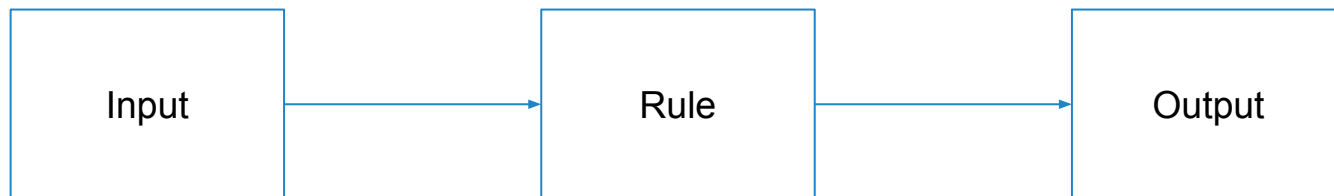
- What is Deep Learning
- What's "wrong" with training a model from scratch
- What is Transfer Learning (with Demo)
- What else can Deep Learning do

# Outline

- What is Deep Learning
- What's "wrong" with training a model from scratch
- What is Transfer Learning (with Demo)
- What else can Deep Learning do

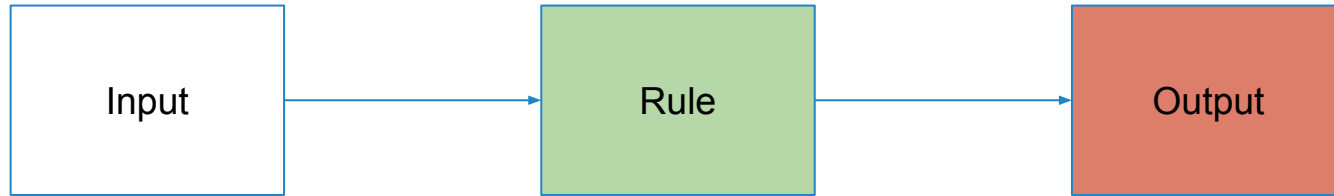
# What is Deep Learning

Question: Given some input, what is the output?



# What is Deep Learning

Question: Given some input, what is the output?



Traditionally: Rule is Known

# What is Deep Learning

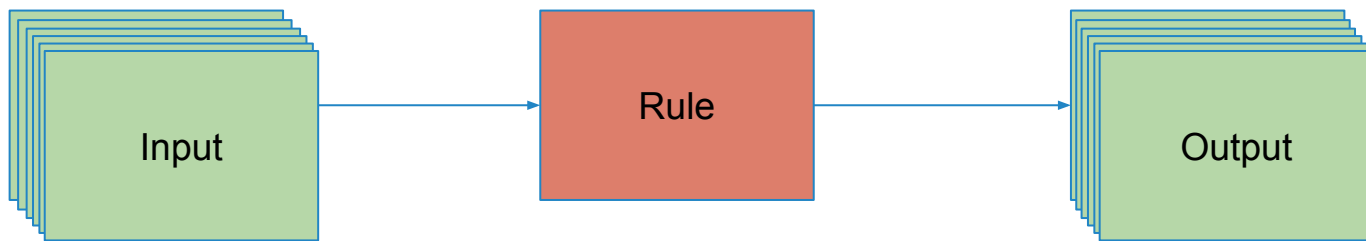
Question: Given some input, what is the output?



Deep Learning: Learn the rule

# What is Deep Learning

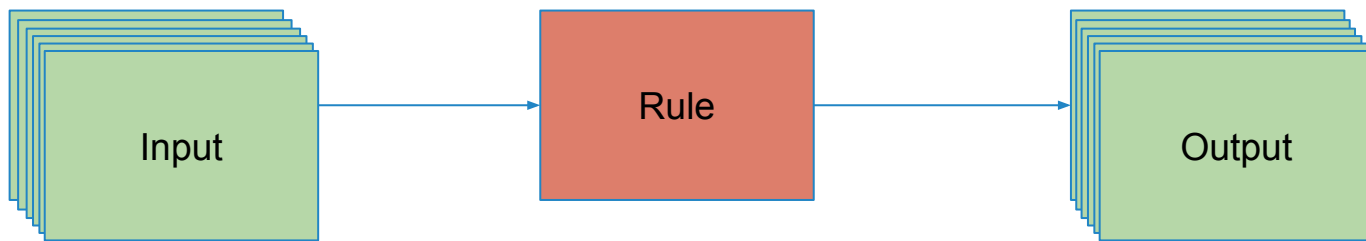
Question: Given some input, what is the output?



Deep Learning: Learn the rule

# What is Deep Learning

Question: Given some input, what is the output?



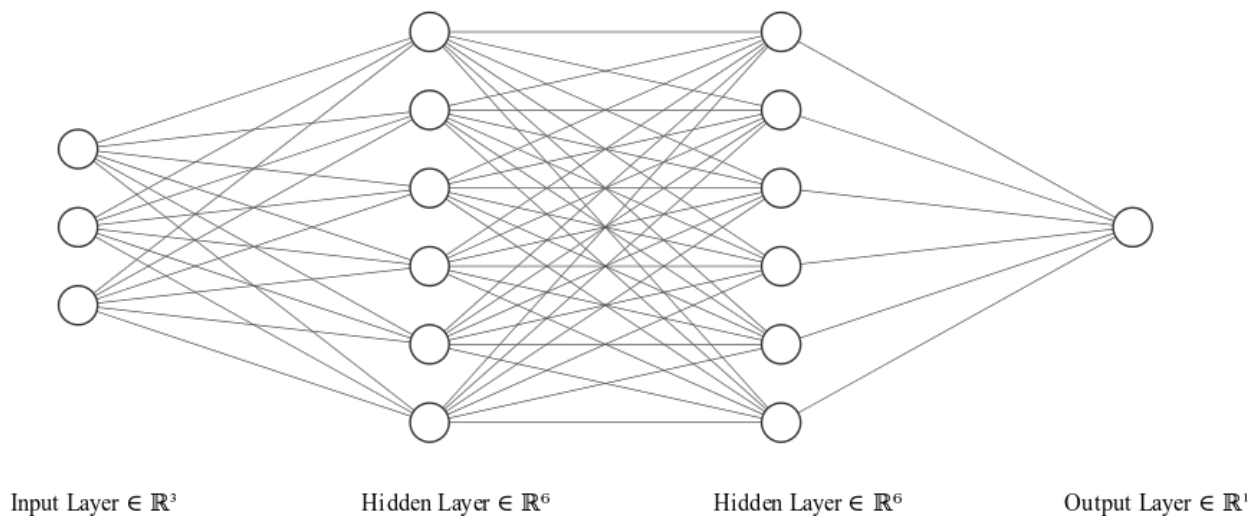
Deep Learning: Learn the rule

How is this "Rule" represented?



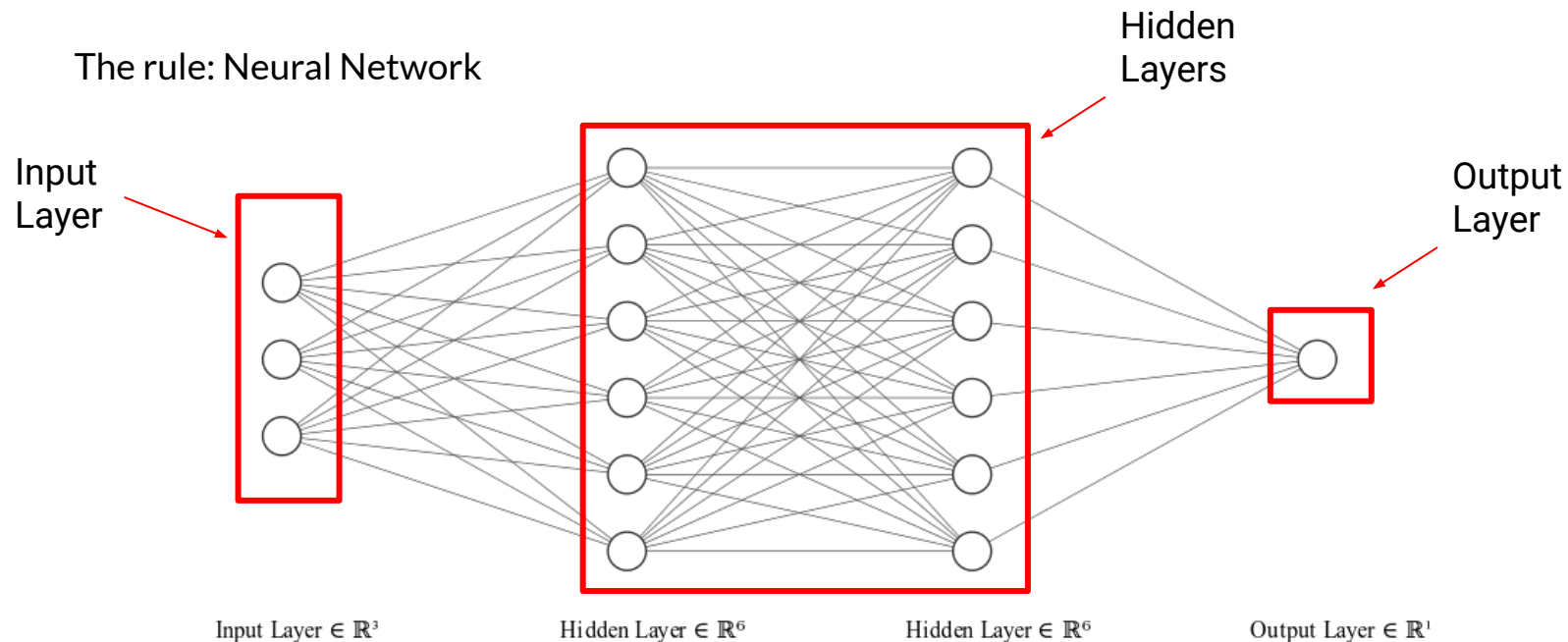
# What is Deep Learning

The rule: Neural Network



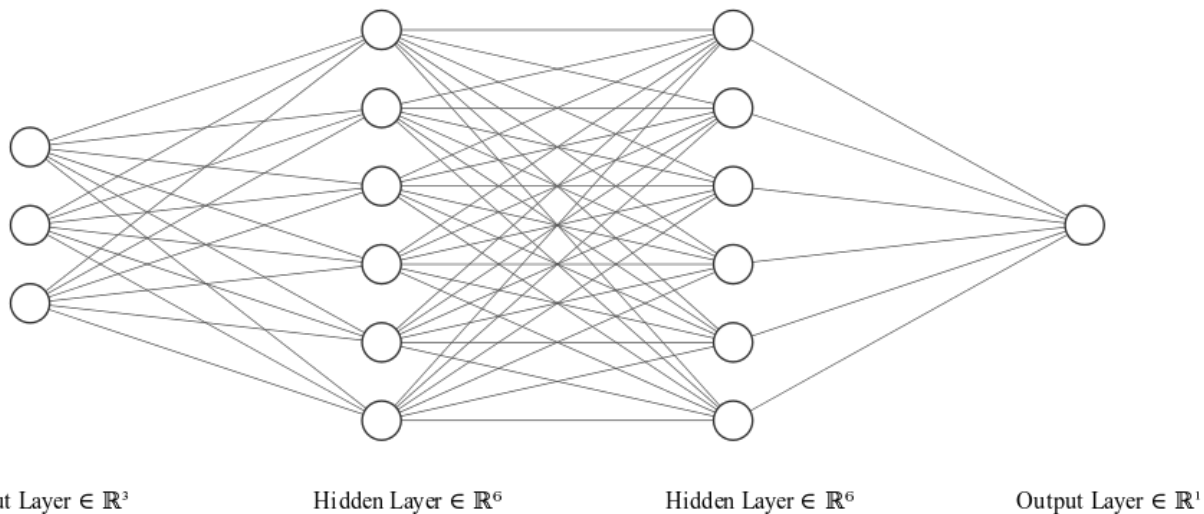
# What is Deep Learning

The rule: Neural Network



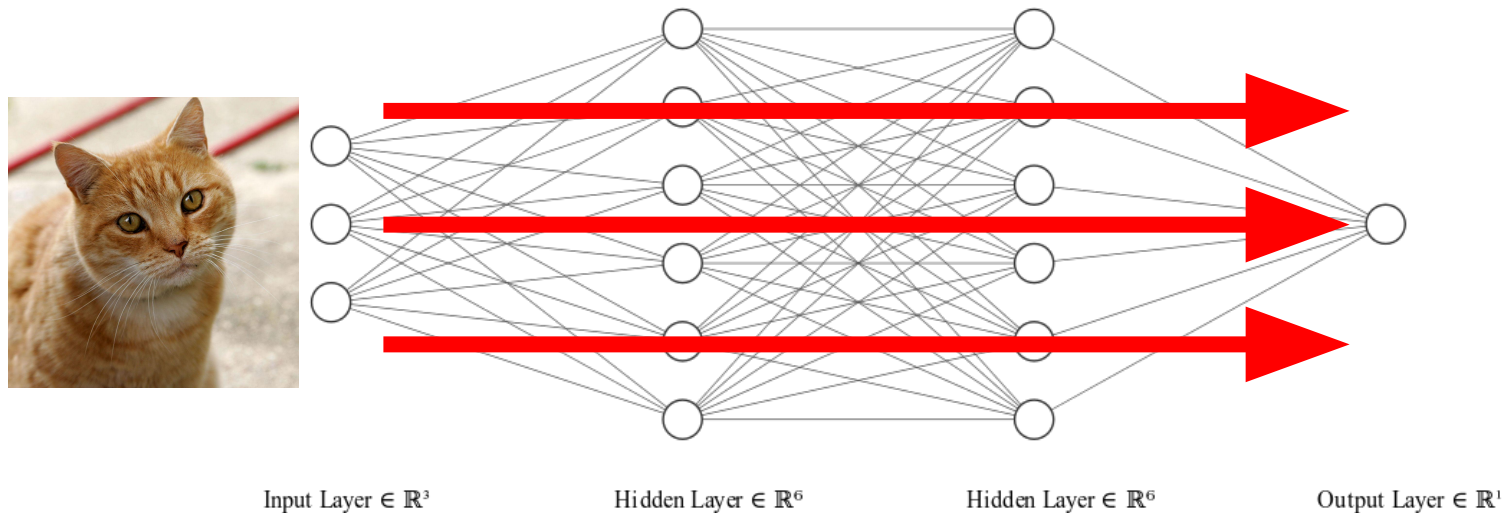
# What is Deep Learning

## Forward Propagation



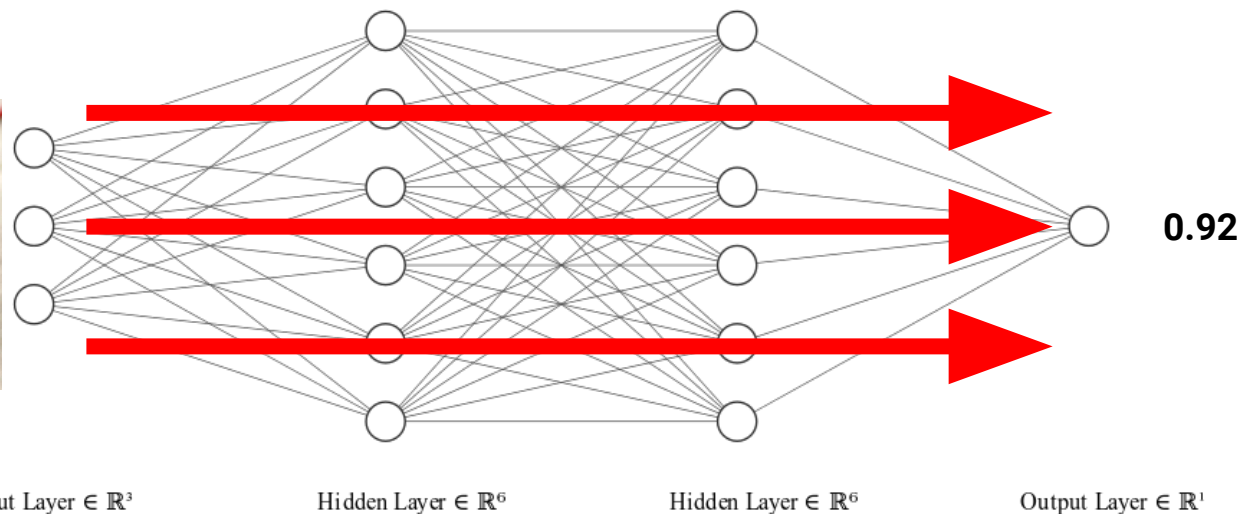
# What is Deep Learning

## Forward Propagation



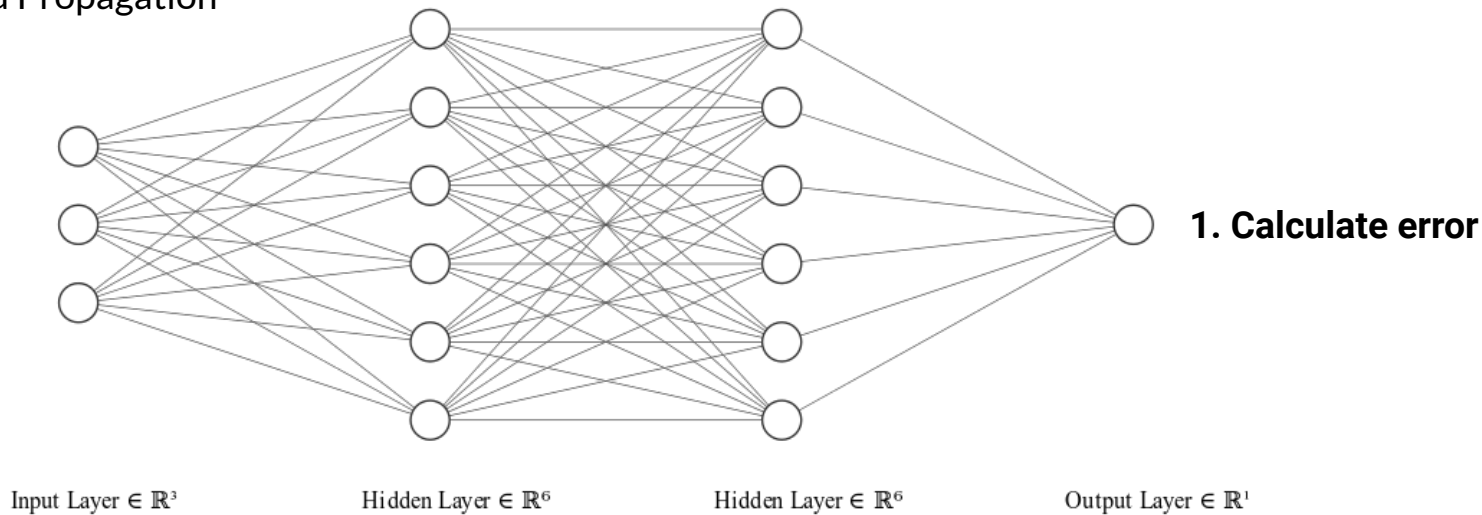
# What is Deep Learning

## Forward Propagation



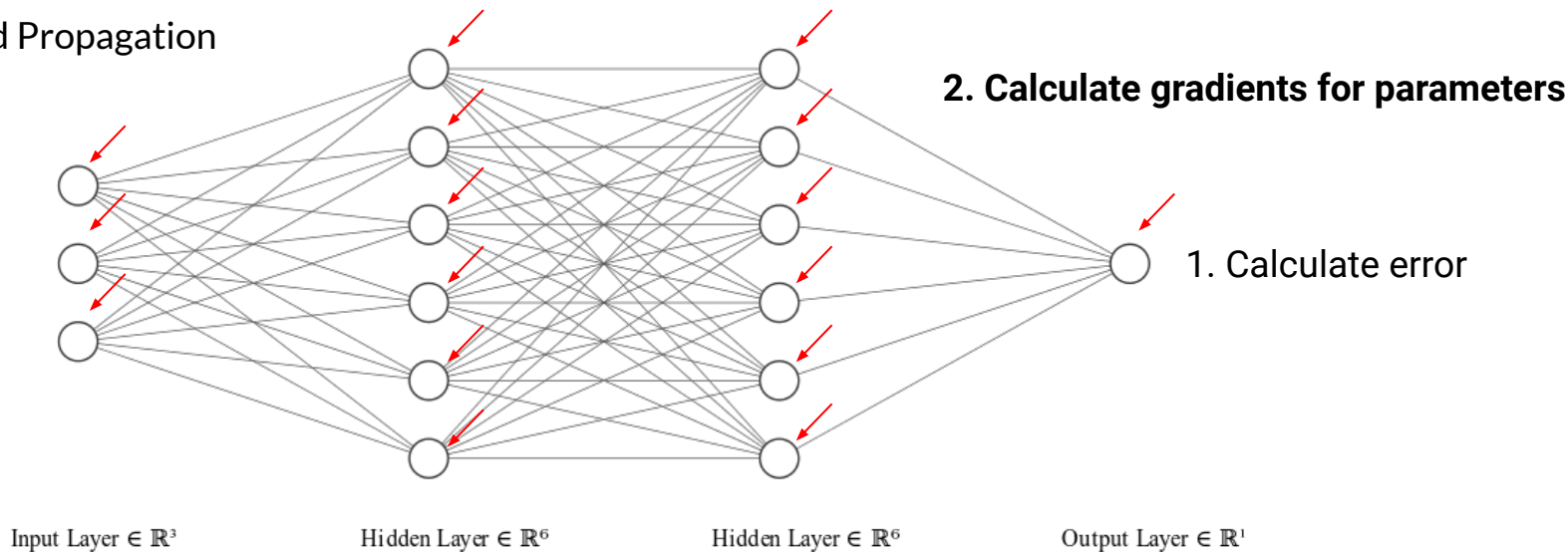
# What is Deep Learning

## Backward Propagation



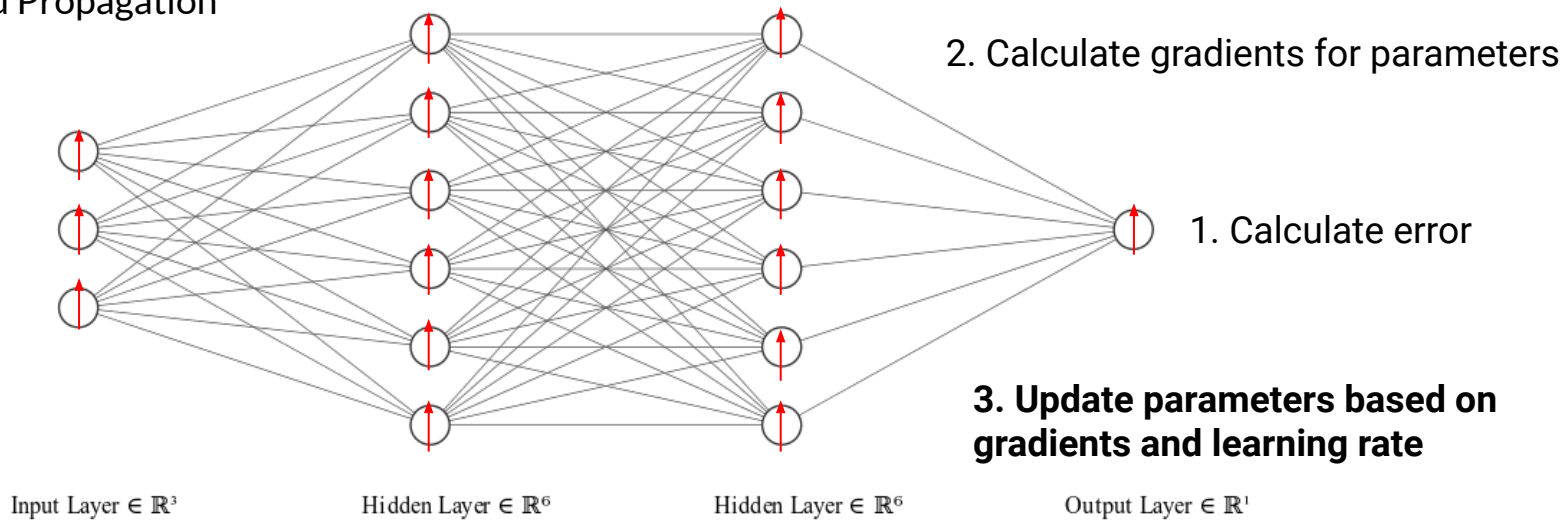
# What is Deep Learning

Backward Propagation



# What is Deep Learning

## Backward Propagation





# What is Deep Learning

After many forward/backward propagations (oftentimes tens of thousands), the network (rule) is able to accurately perform the classification.

# Outline

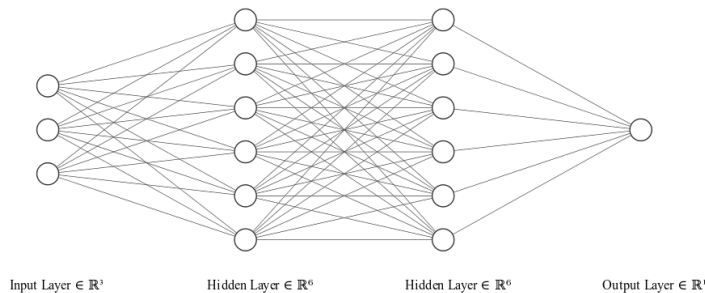
- What is Deep Learning
- What's "wrong" with training a model from scratch
- What is Transfer Learning (with Demo)
- What else can Deep Learning do

# What's "wrong" with training a model from scratch

- Too many parameters to train

# What's "wrong" with training a model from scratch

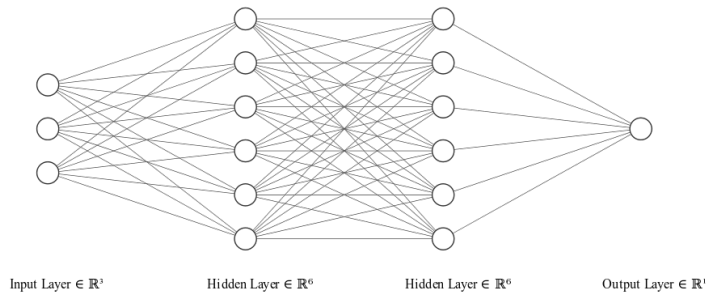
- Too many parameters to train



This is REALLY minimal

# What's "wrong" with training a model from scratch

- Too many parameters to train



This is REALLY minimal

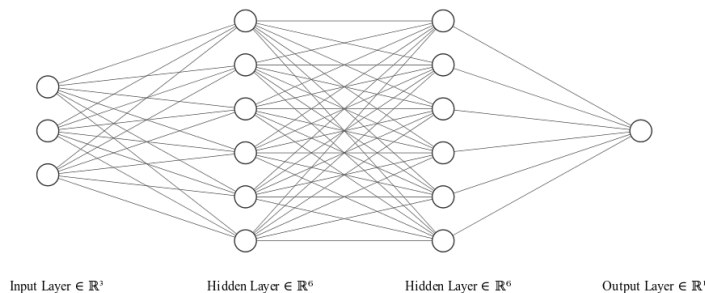


In fact, to get a good model for image

- 256\*256 image -> 65536 pixels
- 10 categories -> 10 output units
- 4 layers, with 1024 hidden units each
- Total number of parameters:  $65536 * 1024 + 1024 * 1024 + 1024 * 1024 + 1024 * 1024 + 1024 * 10 = 70,264,832$

# What's "wrong" with training a model from scratch

- Too many parameters to train



This is REALLY minimal



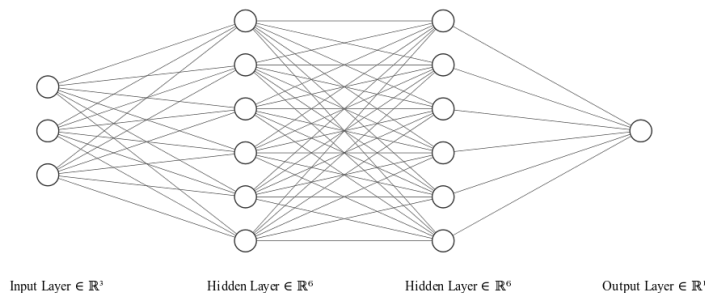
In fact, to get a good model for image

- 256\*256 image -> 65536 pixels
- 10 categories -> 10 output units
- 4 layers, with 1024 hidden units each
- Total number of parameters:  $65536 * 1024 + 1024 * 1024 + 1024 * 1024 + 1024 * 1024 + 1024 * 10 = 70,264,832$

Each iteration would involve a forward path and a backward path of these parameters, and we need at least tens of thousands of such iterations

# What's "wrong" with training a model from scratch

- Too many parameters to train



This is REALLY minimal



In fact, to get a good model for image

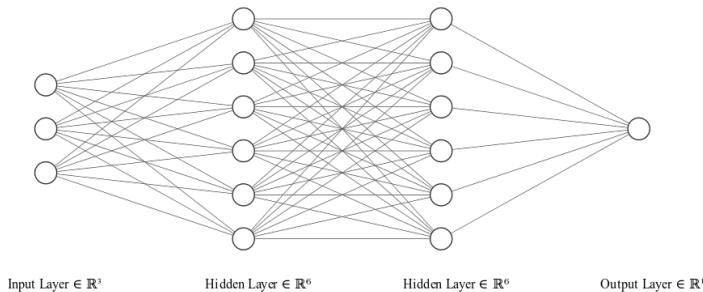
- 256\*256 image -> 65536 pixels
- 10 categories -> 10 output units
- 4 layers, with 1024 hidden units each
- Total number of parameters:  $65536 * 1024 + 1024 * 1024 + 1024 * 1024 + 1024 * 1024 + 1024 * 10 = 70,264,832$

Each iteration would involve a forward path and a backward path of these parameters, and we need at least tens of thousands of such iterations

# What's "wrong" with training a model from scratch

- Too many parameters to train

**This leaves us with a long time to properly train the model...**



This is REALLY minimal

In fact, to get a good model for image

- 256\*256 image -> 65536 pixels
- 10 categories -> 10 output units
- 4 layers, with 1024 hidden units each
- Total number of parameters:  $65536 * 1024 + 1024 * 1024 + 1024 * 1024 + 1024 * 1024 + 1024 * 10 = 70,264,832$

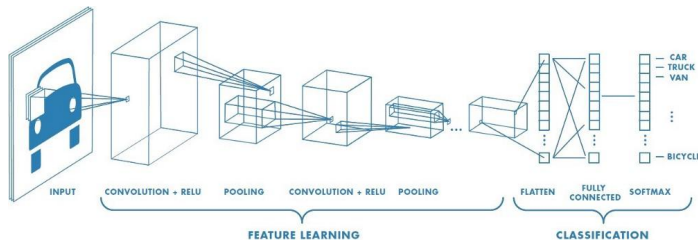
Each iteration would involve a forward path and a backward path of these parameters, and we need at least tens of thousands of such iterations



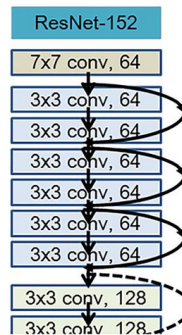
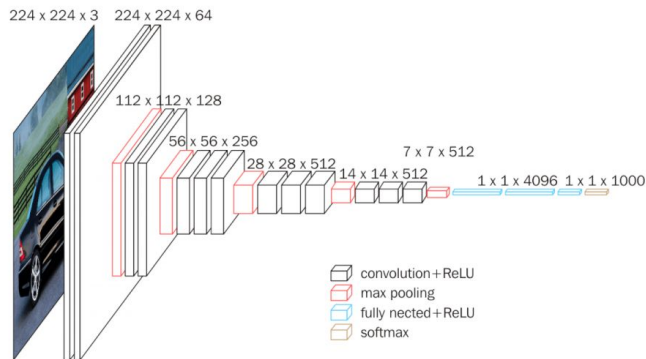
# What's "wrong" with training a model from scratch

- Too many parameters to train
- Variations of models

# Convolutional Neural Network (CNN)

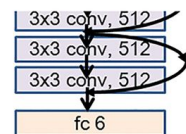


## VGG-19



ResNet-152

152 layers

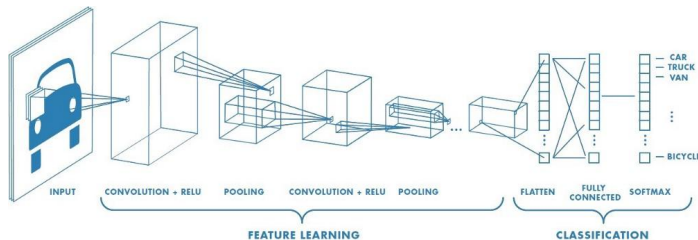


Images: <https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53> (CNN), <https://neurohive.io/en/popular-networks/vgg16/> (VGG-19), [https://www.researchgate.net/figure/The-representation-of-model-architecture-image-for-ResNet-152-VGG-19-and-two-layered\\_fig2\\_322621180](https://www.researchgate.net/figure/The-representation-of-model-architecture-image-for-ResNet-152-VGG-19-and-two-layered_fig2_322621180) (ResNet-152)

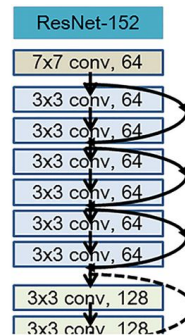
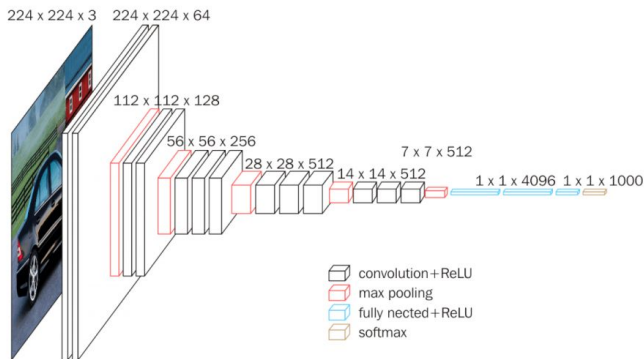
# What's "wrong" with training a model from scratch

- Too many parameters to train
- Variations of models

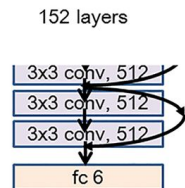
## Convolutional Neural Network (CNN)



## VGG-19



## ResNet-152



# What's "wrong" with training a model from scratch

- Too many parameters to train
- Variations of models
- **Not enough data**

# What's "wrong" with training a model from scratch

- Too many parameters to train
- Variations of models
- Not enough data

Typically, to train a neural network accurately classifies images, we would typically need at least thousands of samples



Doheny →  
vs  
← Geisel



# Outline

- What is Deep Learning
- What's "wrong" with training a model from scratch
- **What is Transfer Learning (with Demo)**
- What else can Deep Learning do

# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

**The pretrained model:** trained on very large dataset (for example, imagenet, which contains **14,197,122** images and **1000** classes).

# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

**The pretrained model:** trained on very large dataset (for example, imagenet, which contains **14,197,122** images and **1000** classes).

**Advantage:** the pretrained model has a solid knowledge on the features of objects.



# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

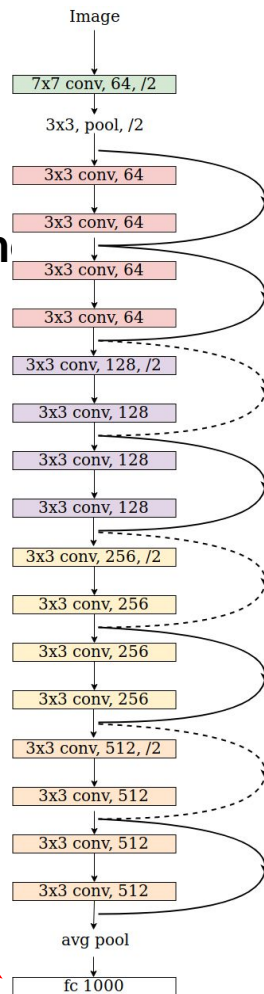
How to use "someone else's model"?

# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

**How to use "someone else's model"?**

This layer was for "categorizing 1000 classes"



ResNet-18

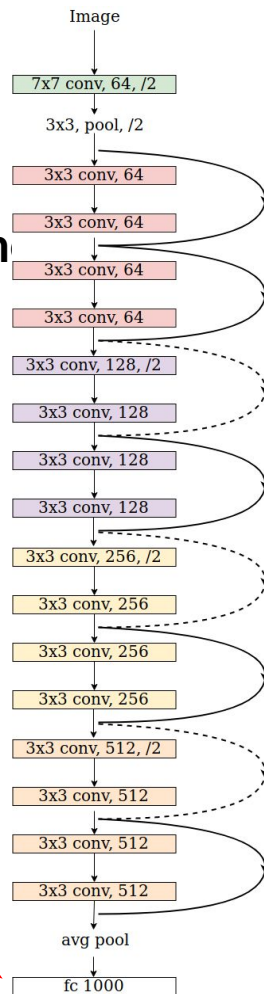
# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

**How to use "someone else's model"?**

This layer was for "categorizing 1000 classes"

For "Doheny vs Geisel", we want two



ResNet-18

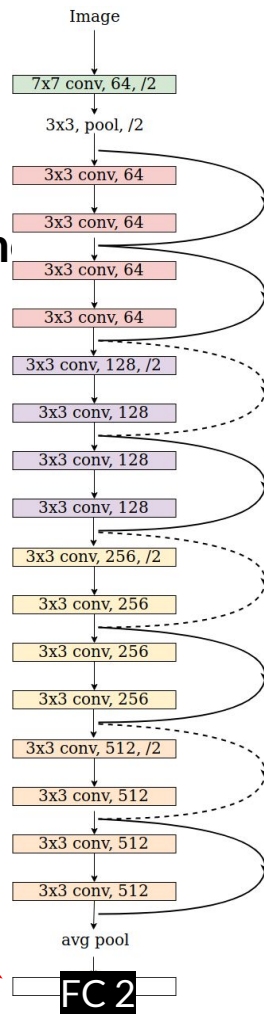
# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

**How to use "someone else's model"?**

This layer was for "categorizing 1000 classes"

For "Doheny vs Geisel", we want two



ResNet-18

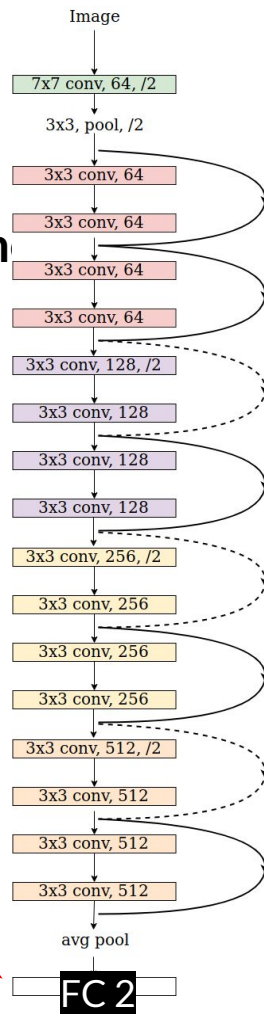
# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

**How to use "someone else's model"?**

This layer was for "categorizing 1000 classes"

For "Doheny vs Geisel", we want two



ResNet-18

Then, we can freeze all other layers, and train only this layer

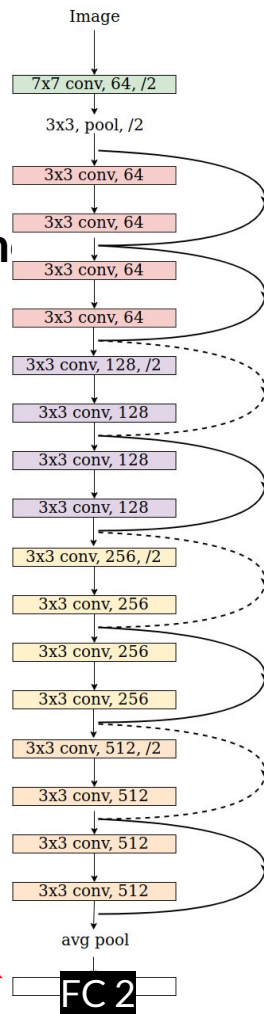
# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

**How to use "someone else's model"?**

This layer was for "categorizing 1000 classes"

For "Doheny vs Geisel", we want two



ResNet-18

Then, we can freeze all other layers, and train only this layer **with less data and less iterations**

# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

Where to find those "pretrained models"?

# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

Where to find those "pretrained models"?

Just search on Google and there are a lot of them



# What is Transfer Learning

**Key idea: Take someone else's pretrained model and use it for my application**

Where to find those "pretrained models"?

Just search on Google and there are a lot of them

Even easier why: inside PyTorch: <https://pytorch.org/docs/stable/torchvision/models.html>

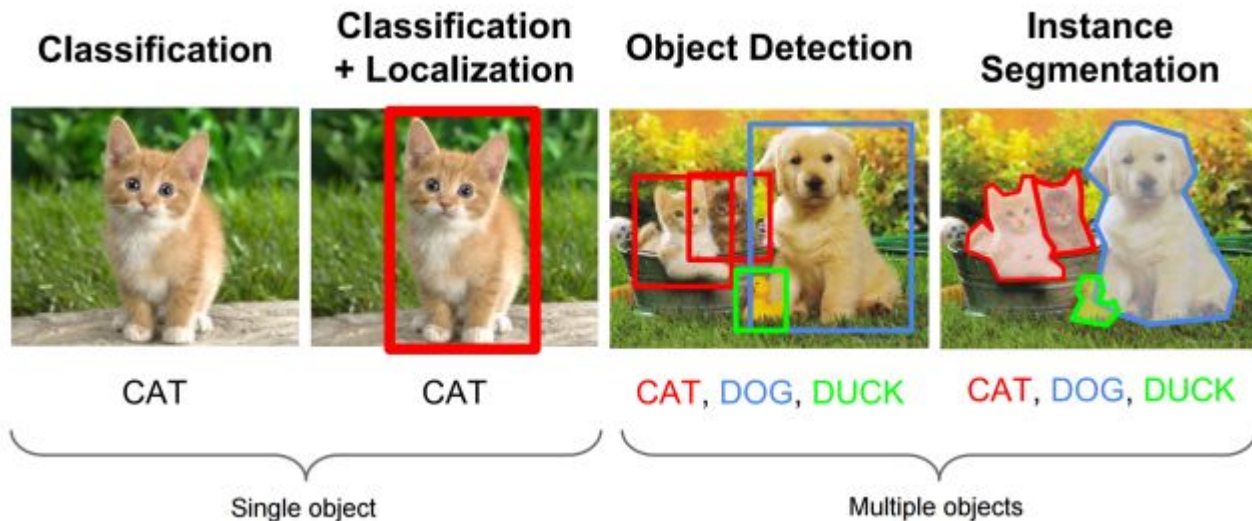
# DEMO

# Outline

- What is Deep Learning
- What's "wrong" with training a model from scratch
- What is Transfer Learning (with Demo)
- What else can Deep Learning do

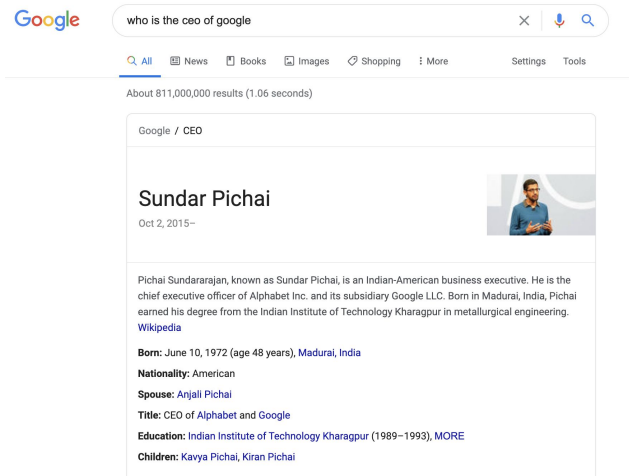
# What else can Deep Learning do

## Compute Vision



# What else can Deep Learning do

## Natural Language Processing



A screenshot of a Google search result for the query "who is the ceo of google". The search bar shows the query and a microphone icon. Below the search bar, there are tabs for "All", "News", "Books", "Images", "Shopping", and "More". The search results show "About 811,000,000 results (1.06 seconds)". The main result is for "Sundar Pichai", CEO of Google, with a photo and a brief biography. The biography mentions that he is an Indian-American business executive, born in Madurai, India, and earned his degree from the Indian Institute of Technology Kharagpur in metallurgical engineering. It also lists his birth date (June 10, 1972), nationality (American), spouse (Anjali Pichai), title (CEO of Alphabet and Google), education (Indian Institute of Technology Kharagpur), and children (Kavya Pichai, Kiran Pichai).

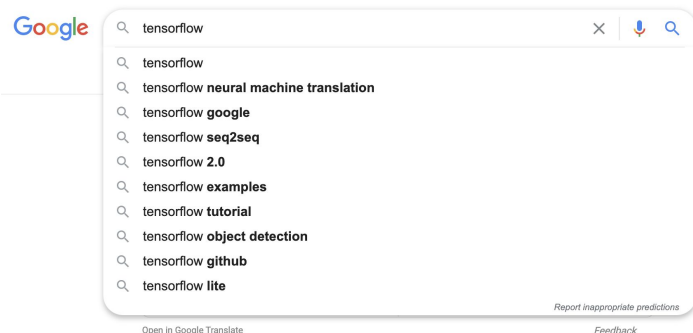
Google / CEO

**Sundar Pichai**  
Oct 2, 2015–

Pichai Sundararajan, known as Sundar Pichai, is an Indian-American business executive. He is the chief executive officer of Alphabet Inc. and its subsidiary Google LLC. Born in Madurai, India, Pichai earned his degree from the Indian Institute of Technology Kharagpur in metallurgical engineering.  
[Wikipedia](#)

**Born:** June 10, 1972 (age 48 years), Madurai, India  
**Nationality:** American  
**Spouse:** Anjali Pichai  
**Title:** CEO of Alphabet and Google  
**Education:** Indian Institute of Technology Kharagpur (1989–1993), MORE  
**Children:** Kavya Pichai, Kiran Pichai

## Question and Answering



A screenshot of a Google search results page for the query "tensorflow". The search bar shows the query and a microphone icon. Below the search bar, there are tabs for "All", "News", "Books", "Images", "Shopping", and "More". The search results show "About 811,000,000 results (1.06 seconds)". The main result is for "Sundar Pichai", CEO of Google, with a photo and a brief biography. The biography mentions that he is an Indian-American business executive, born in Madurai, India, and earned his degree from the Indian Institute of Technology Kharagpur in metallurgical engineering. It also lists his birth date (June 10, 1972), nationality (American), spouse (Anjali Pichai), title (CEO of Alphabet and Google), education (Indian Institute of Technology Kharagpur), and children (Kavya Pichai, Kiran Pichai).

Google

tensorflow

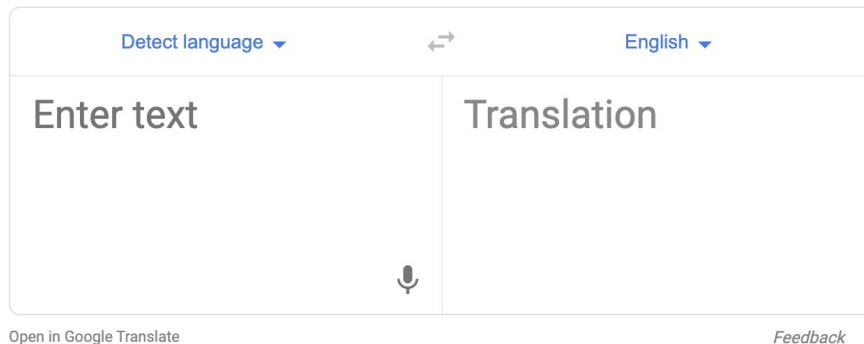
- tensorflow
- tensorflow neural machine translation
- tensorflow google
- tensorflow seq2seq
- tensorflow 2.0
- tensorflow examples
- tensorflow tutorial
- tensorflow object detection
- tensorflow github
- tensorflow lite

Open in Google Translate

Report inappropriate predictions

Feedback

## Auto-Completion



A screenshot of the Google Translate interface. The top bar shows "Detect language" and "English". Below the bar, there are two main sections: "Enter text" and "Translation". The "Enter text" section has a microphone icon. The "Translation" section is empty. At the bottom, there are links for "Open in Google Translate" and "Feedback".

Detect language

English

Enter text

Translation

Open in Google Translate

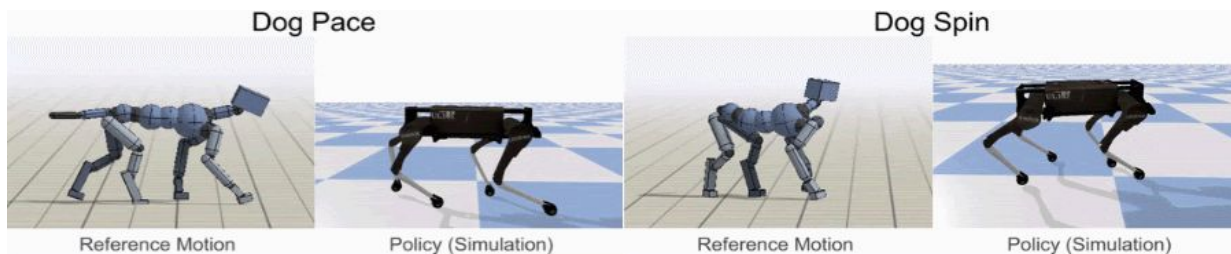
Feedback

## Machine Translation

# What else can Deep Learning do

## Reinforcement Learning

(e.g. play video games, autonomous driving, robotics, etc.)



# Thanks!

# Questions?

Zhizhen Qin

WeChat: qzz\_ckpt

Email: zhizhenqin@ucsd.edu