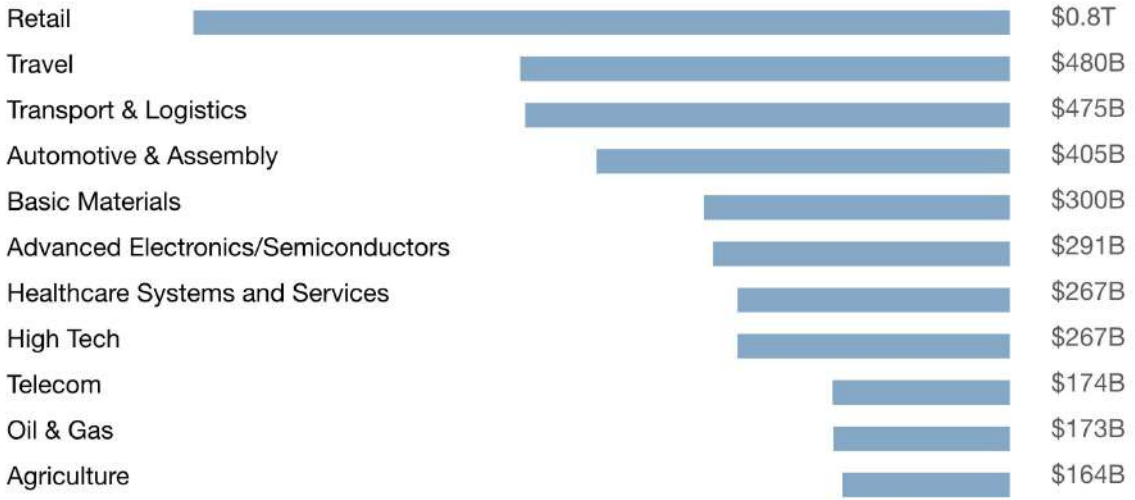
Introduction

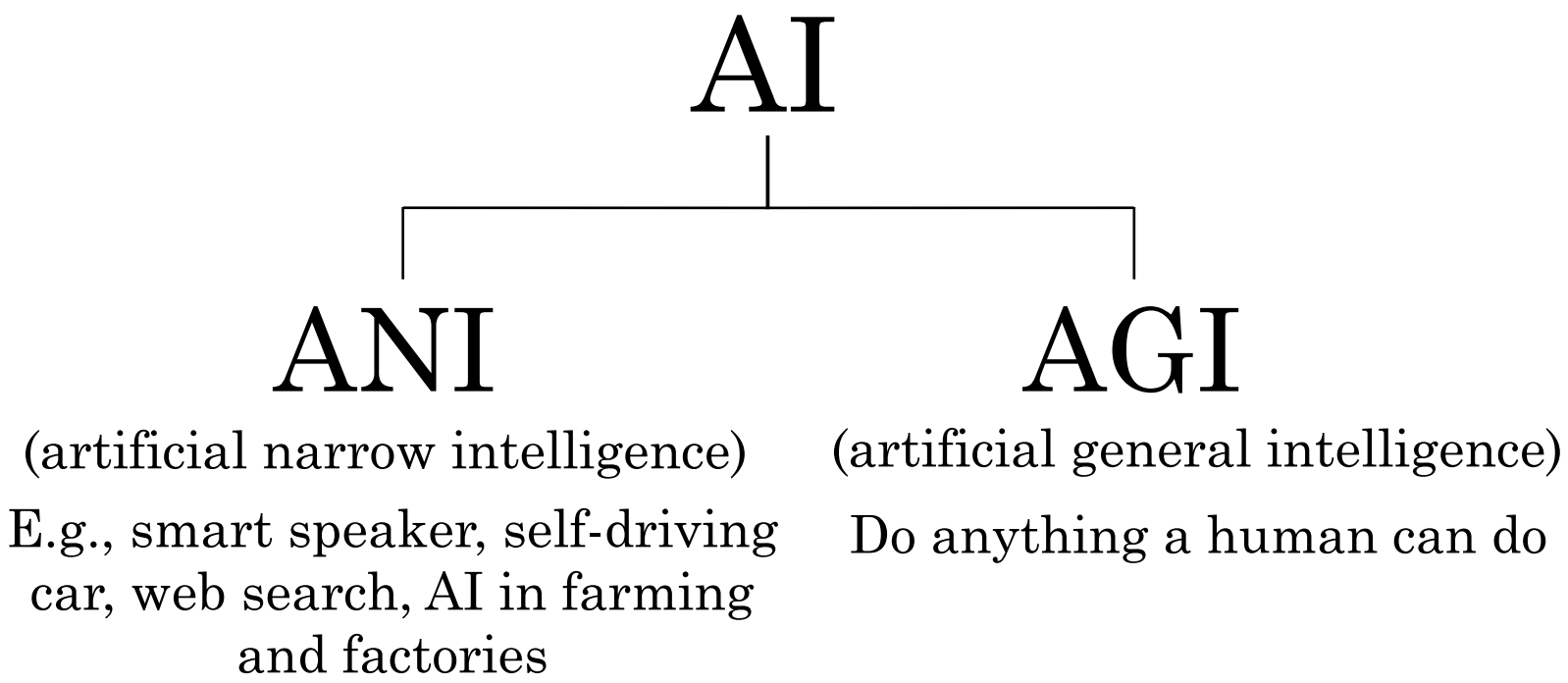
AI value creation by 2030

$13 trillion



[Source: McKinsey Global Institute.]

Demystifying AI



What you'll learn

- What is AI?
  - Machine Learning
  - Data
  - What makes an AI company
  - What machine learning can and cannot do
  - Optional: Intuitive explanation of Deep Learning
- Building AI projects
- Building AI in your company
- AI and society

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What is AI

Machine Learning

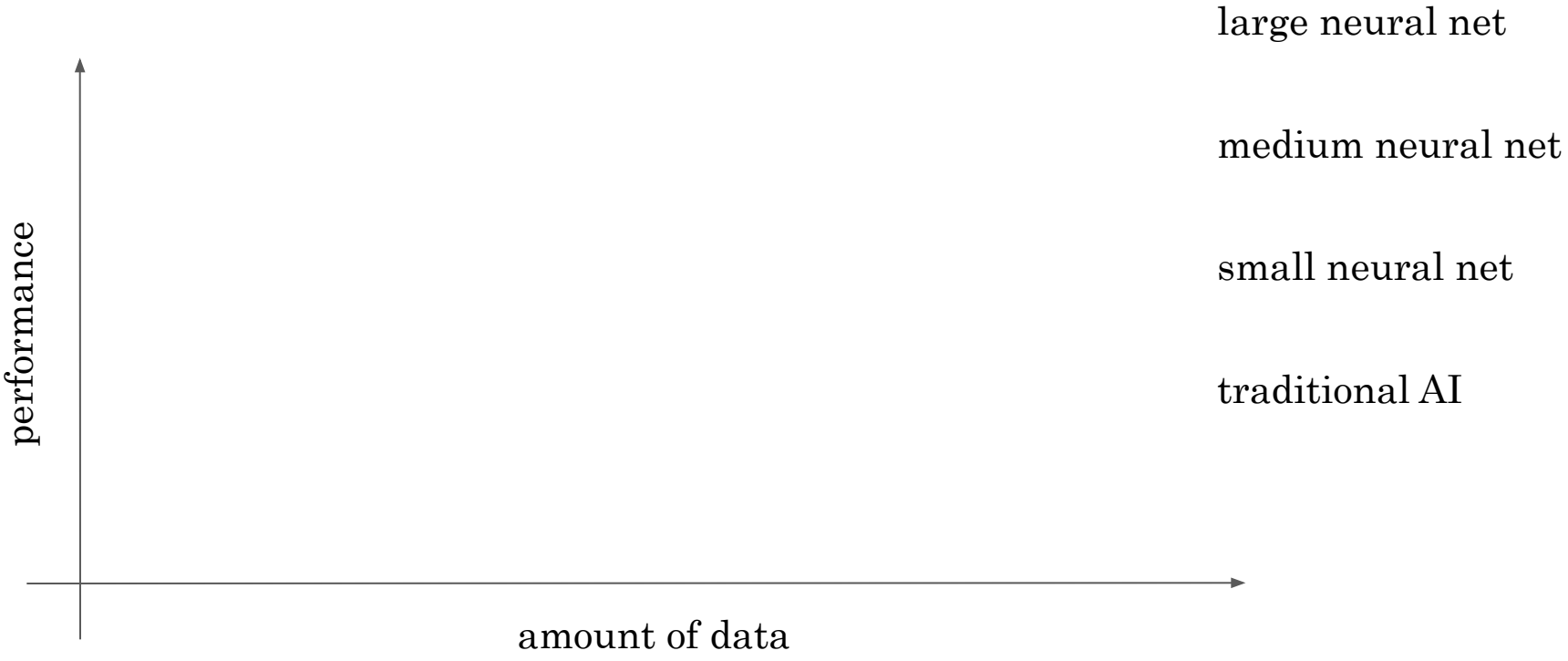
Andrew Ng

Supervised Learning

Input	Output

Input (A)	Output (B)	Application
email	spam? (0/1)	spam filtering
audio	text transcripts	speech recognition
English	Chinese	machine translation
ad, user info	click? (0/1)	online advertising
image, radar info	position of other cars	Self-driving car
image of phone	defect? (0/1)	visual inspection

Why Now?


large neural net
medium neural net
small neural net
traditional AI
performance
amount of data

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What is AI

What is data

Andrew Ng

Example of a table of data (dataset)

house (square feet)	# of bedrooms	price (1000$)
523	1	100
645	1	150
708	2	200
1034	3	300
2290	4	350
2545	4	440

image	label
	cat
	not cat
	cat
	not cat

"Google cat"

Acquiring data

- Manual labeling


cat


not cat


cat


not cat

- From observing user behaviors

user ID	time	price ($)	purchased
4783	Jan 21 08:15.20	7.95	yes
3893	March 3 11:30.15	10.00	yes
8384	June 11 14:15.05	9.50	no
0931	Aug 2 20:30.55	12.90	yes

machine	temperature (◦C)	pressure (psi)	machine fault
17987	60	7.65	N
34672	100	25.50	N
08542	140	75.50	Y
98536	165	125.00	Y

- Download from websites / partnerships

Use and mis-use of data

Don’t throw data at an AI team and assume it will be valuable.

Data is messy

- Garbage in, garbage out

- Data problems
  - Incorrect labels
  - Missing values

- Multiple types of data

  images, audio, text

house (square feet)	# of bedrooms	price (1000$)
523	1	100
645	1	0.001
708	unknown	200
1034	3	unknown
unknown	4	350
2545	unknown	440

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What is AI

The terminology of AI

Andrew Ng

Machine learning vs. data science

Home prices

size (square feet)	# of bedrooms	# of bathrooms	newly renovated	price (1000$)
523	1	2	N	100
645	1	3	N	150
708	2	1	N	200
1034	3	3	Y	300
2290	4	4	N	350
2545	4	5	Y	440

Homes with 3 bedrooms are more expensive than homes with 2 bedrooms of a similar size.

Newly renovated homes have a 15% premium.

Running AI system
(e.g., websites / mobile app)

Machine learning vs. data science

Machine learning

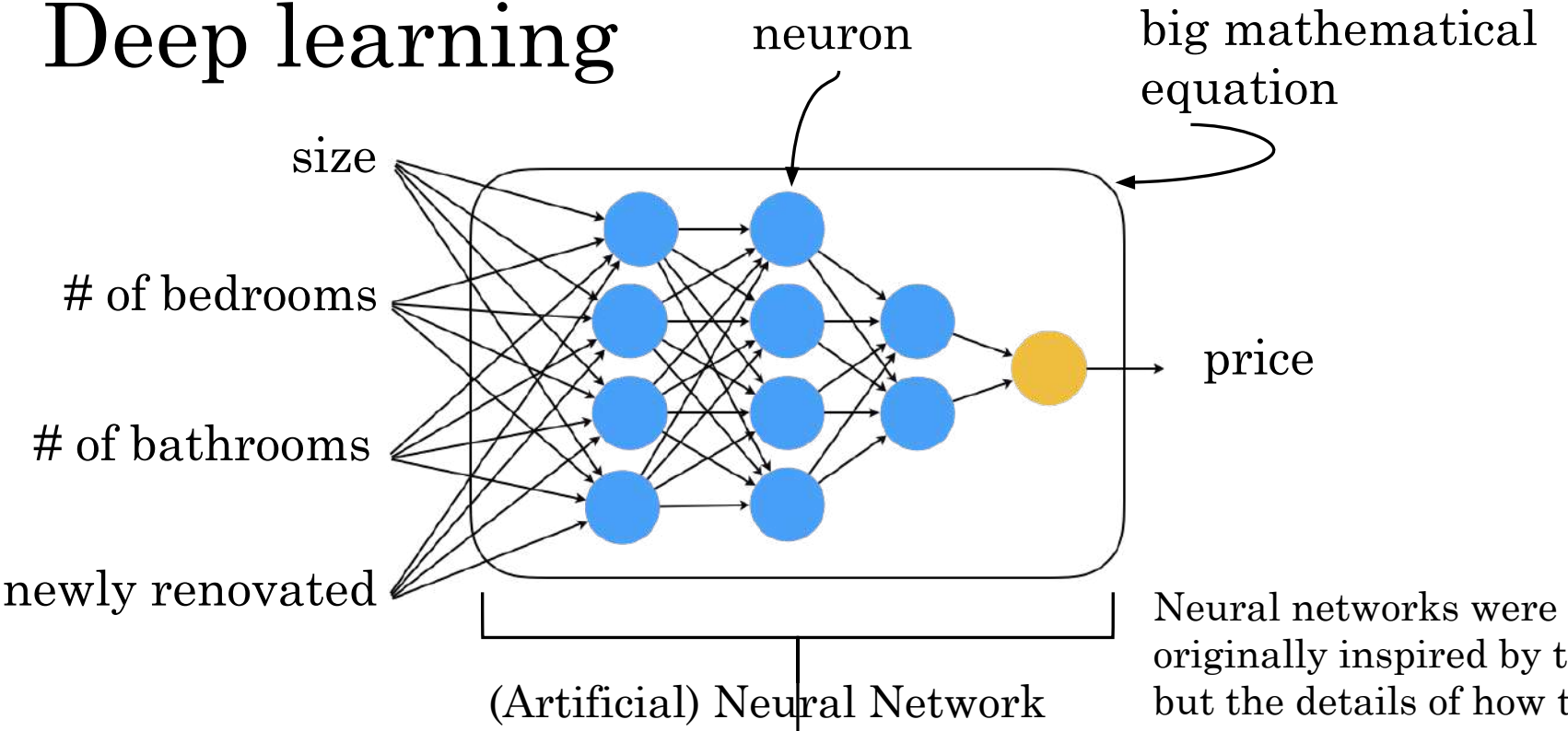
"Field of study that gives computers the ability to learn without being explicitly programmed."

-Arthur Samuel (1959)

Data science

Science of extracting knowledge and insights from data.

Deep learning



Neural networks were originally inspired by the brain, but the details of how they work are almost completely unrelated to how biological brains work.

AI has many tools

- Machine learning and data science

-Deep learning / neural network

-Other buzzwords: Unsupervised learning, graphical models, planning, knowledge graph, …

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What is AI

What makes an AI company?

Andrew Ng

A lesson from the rise of the Internet

Internet Era

Shopping mall + website
≠ Internet company

- A/B testing
- Short iteration time
- Decision making pushed down to engineers and other specialized roles

AI era

Any company + deep learning
≠ AI company

- Strategic data acquisition
- Unified data warehouse
- Pervasive automation
- New roles (e.g., MLE) and division of labor

AI Transformation

1. Execute pilot projects to gain momentum
2. Build an in-house AI team
3. Provide broad AI training
4. Develop an AI strategy
5. Develop internal and external communication

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What is AI

What machine learning can and cannot do

Andrew Ng

Supervised Learning

Input (A)	Output (B)	Application
email	spam? (0/1)	spam filtering
audio	text transcripts	speech recognition
English	Chinese	machine translation
ad, user info	click? (0/1)	online advertising
image, radar info	position of other cars	Self-driving car
image of phone	defect? (0/1)	visual inspection

Anything you can do with 1 second of thought,
we can probably now or soon automate.

What machine learning today can and cannot do

The toy arrived two days late, so I wasn't able to give it to my niece for her birthday.
Can I return it?

"Refund request"

Oh, sorry to hear that.
I hope your niece had a good birthday.
Yes, we can help with….

Input text

Refund/ Support/ Shipping

What happens if you try?

Input (A)		Output (B)
User email	→	2-3 paragraph response
1000 examples		
“My box was damaged.”	→	Thank you for your email.
“Where do I write a review?”	→	Thank you for your email.
“What’s the return policy?”	→	Thank you for your email.
“When is my box arriving?”	→	Thank yes now your….

What makes an ML problem easier

1. Learning a “simple” concept

2. Lots of data available

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What is AI

More examples of what machine learning can and cannot do

Andrew Ng

Self-driving car

Can do

Cannot do

stop

hitchhiker

bike turn left signal

1. Data
2. Need high accuracy

X-ray diagnosis





Can do

Diagnose pneumonia from
~10,000 labeled images

Cannot do

Diagnose pneumonia from
10 images of a medical textbook
chapter explaining pneumonia

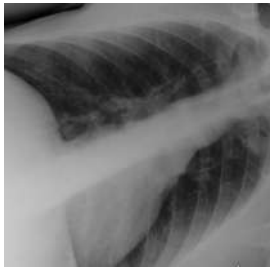
Strengths and weaknesses of machine learning

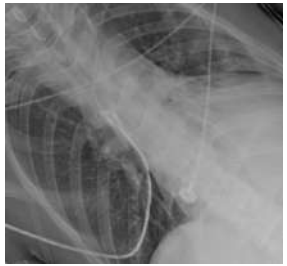
ML tends to work well when:

1. Learning a “simple” function
2. There is lots of data available

ML tends to work poorly when:

1. Learning complex functions from small amounts of data
2. It is asked to perform on new types of data that it learned from





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What is AI

Non-technical explanation of deep learning I (optional)

Andrew Ng

Demand prediction

price → demand

“neuron”

Demand prediction

price

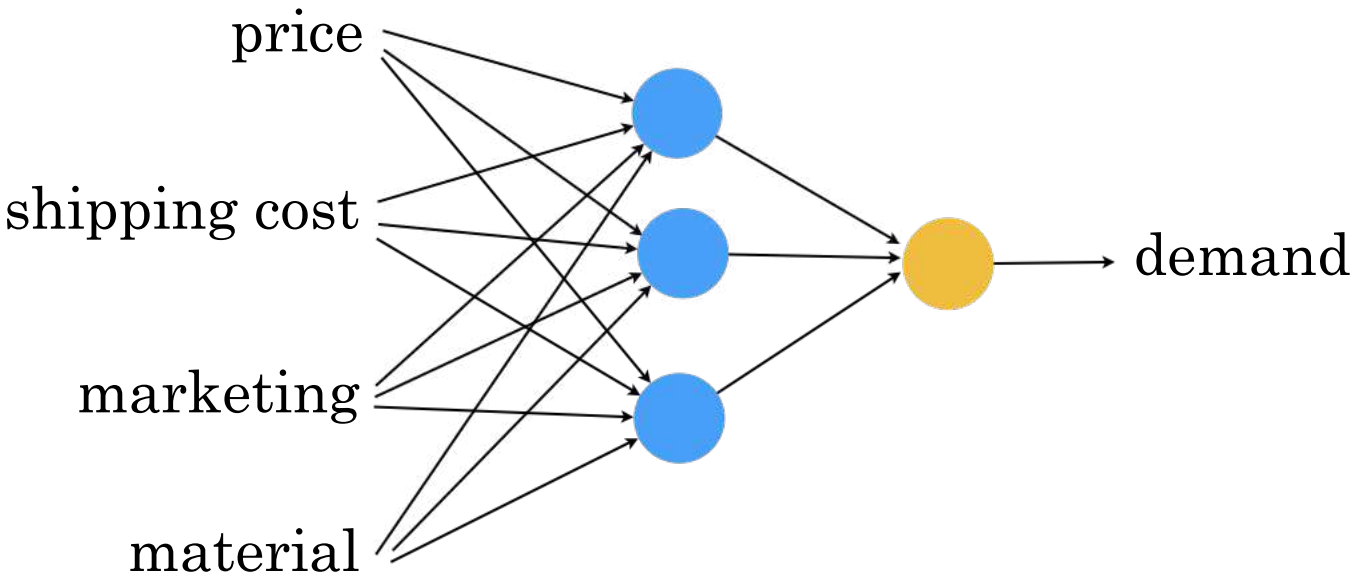
shipping cost

marketing

material

demand

Demand prediction



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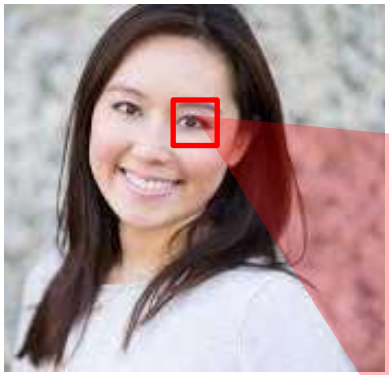
What is AI

Non-technical explanation of deep learning II (optional)

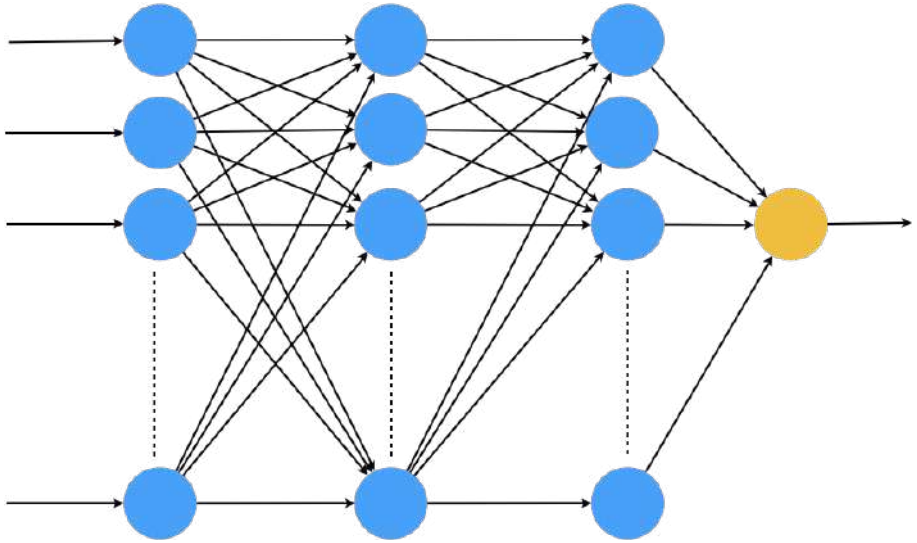
Andrew Ng

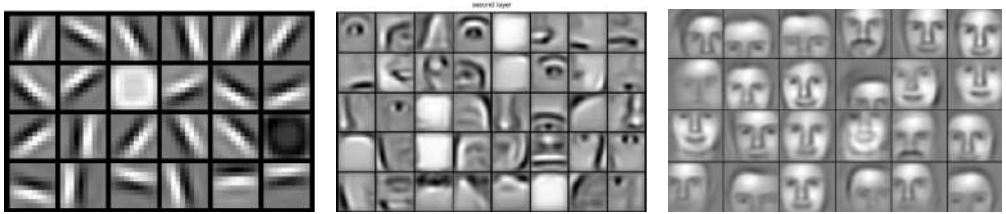
Face recognition



30	32	22	12	10	10	12	33	35	30
12	11	12	234	170	176	13	15	12	12
234	222	220	230	200	222	230	234	56	78
190	220	186	112	110	110	112	180	30	32
49	250	250	250	4	2	254	200	44	6
55	250	250	250	3	1	250	245	25	3
189	195	199	150	110	110	182	190	199	55
200	202	218	222	203	200	200	208	215	222
219	215	220	220	222	214	215	210	220	220
220	220	220	220	221	220	221	220	220	222

Face recognition





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Building AI Projects

Starting an AI project

Andrew Ng

Starting an AI project

- Workflow of projects
- Selecting AI projects
- Organizing data and team for the projects

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Building AI Projects

Workflow of a machine learning project

Andrew Ng

Example: Speech recognition

Amazon
Echo / Alexa

Google
Home

Apple
Siri

Baidu
DuerOS

Key steps of a machine learning project

Echo / Alexa

1. Collect data

2. Train model
   Iterate many times until good enough

3. Deploy model
   Get data back
   Maintain / update model

Key steps of a machine learning project

Self-driving car

1. Collect data

image



position of other cars

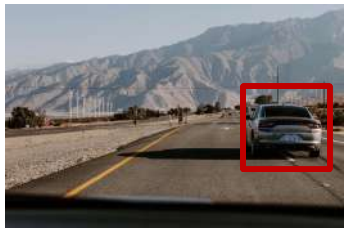
2. Train model

   Iterate many times until good enough

3. Deploy model

   Get data back

   Maintain / update model

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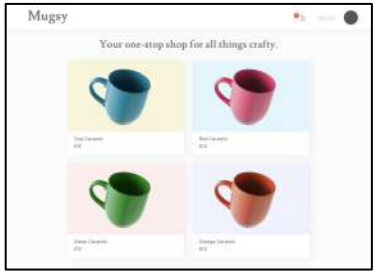
Building AI Projects

Workflow of a data science project

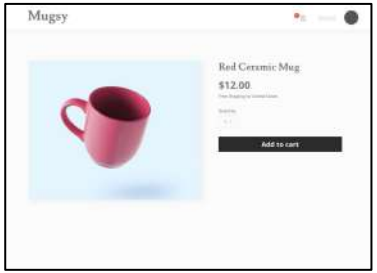
Andrew Ng

Example: Optimizing a sales funnel

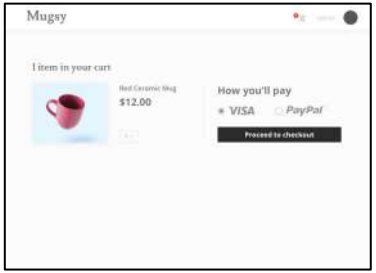
Visit website



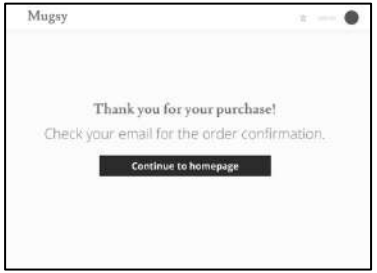
Product page



Shopping cart



Checkout



Key steps of a data science project

Optimizing a sales funnel

User ID	Country	Time	Webpage
2009	Spain	08:34:30 Jan 5	home.html
2897	USA	13:20:22 May 18	redmug.html
4893	Philippines	22:45:16 Jun 11	mug.html

1. Collect data
2. Analyze data
   Iterate many times to get good insights
3. Suggest hypotheses/actions
   Deploy changes
   Re-analyze new data periodically

Key steps of a data science project

Manufacturing line

Mix clay

Shape mug

Add glaze

Fire kiln

Final inspection

Clay Batch #	Supplier	Mixing time (minutes)
001	ClayCo	35
034	GooClay	22
109	BrownStuff	28

1. Collect data
2. Analyze data
   - Iterate many times to get good insight
3. Suggest hypotheses/actions
   - Deploy changes
   - Re-analyze new data periodically

Mug Batch #	Country	Humidity	Temperature in kiln (F)	Duration in kiln (hours)
301	Spain	0.002%	1410º	22
302	USA	0.003%	1520º	24
303	Malaysia	0.002%	1420º	22

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Building AI Projects

Every job function
needs to learn how to use data

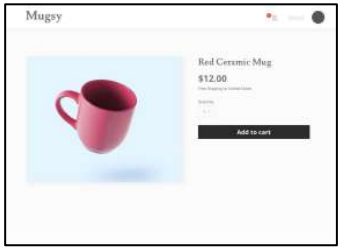
Andrew Ng

Sales

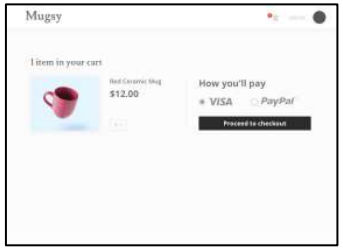
Data science

Visit website

Product page



Shopping cart



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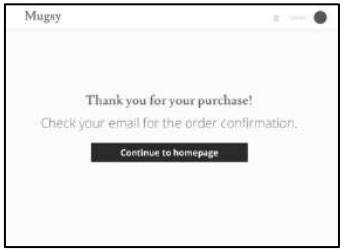


Optimize sales funnel

Machine learning

Name	Title	Company size	Email	Priority
Tayler	CEO	3050	tay@a..	high
Janet	Manager	230	jan@b..	medium
David	Intern	30	dave@c..	low

Automated lead sorting

Manufacturing line manager

Data science

Mix clay

Shape mug

Add glaze

Fire kiln

Final inspection

Optimize sales funnel

Machine learning

ok

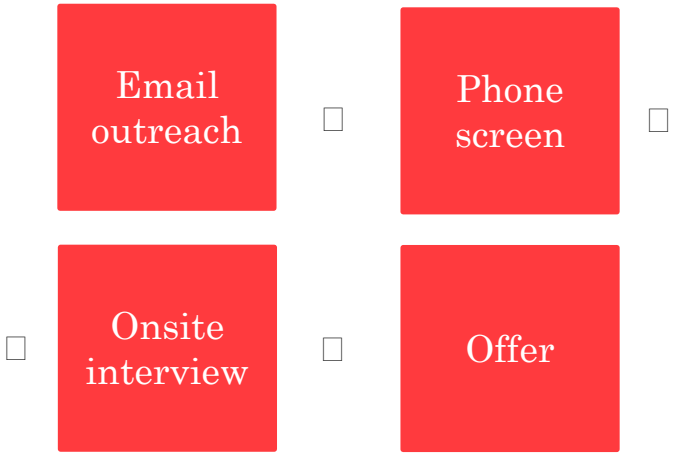
ok

defect

Automated visual inspection

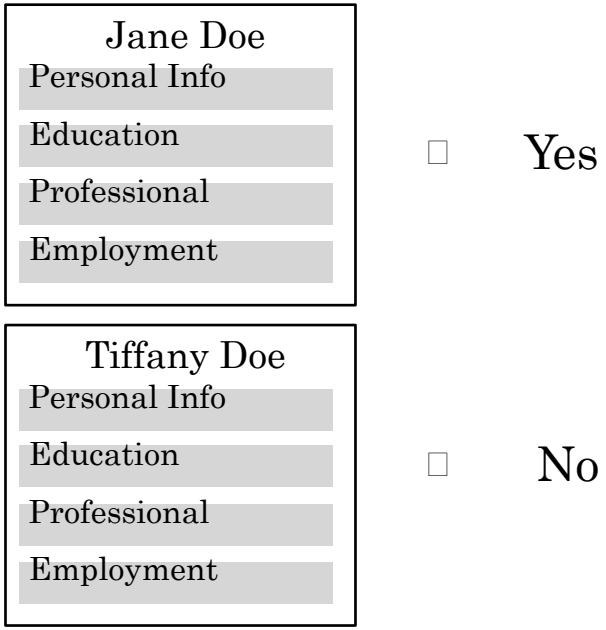
Recruiting

Data science



Optimize recruiting funnel

Machine learning

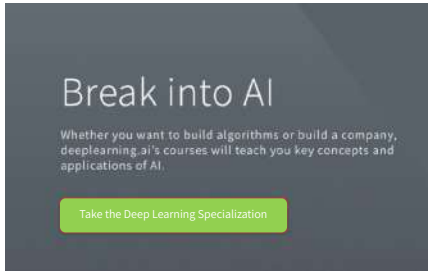


Automated resume screening

Marketing

Data science

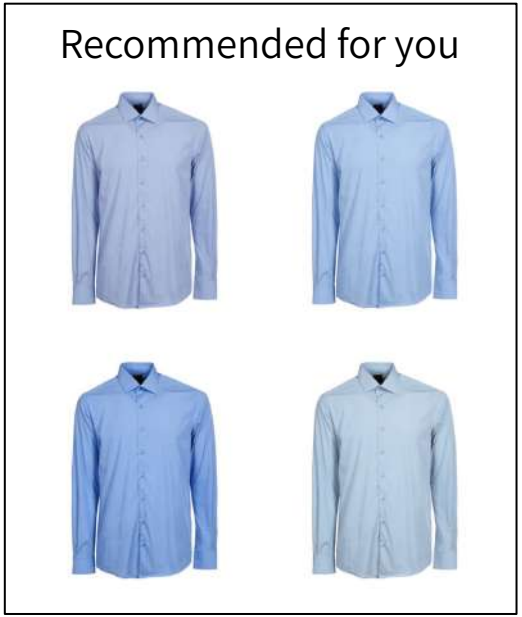
A



B

A/B testing

Machine learning



Customized product recommendation

Agriculture

Data science

Crop analytics

Machine learning

Precision weed killing

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Building AI Projects

How to choose an AI project I

Andrew Ng

AI knowledge and domain knowledge

What AI can do

Things valuable for your business

AI experts

Domain experts

Brainstorming framework

- Think about optimizing tasks rather than automating jobs. E.g., call center routing, radiologists.
- What are the main drivers of business value?
- What are the main points in your business?

You can make progress even without big data

- Having more data almost never hurts.
- Data makes some businesses (like web search) defensible.
- But with small datasets, you might still make progress.

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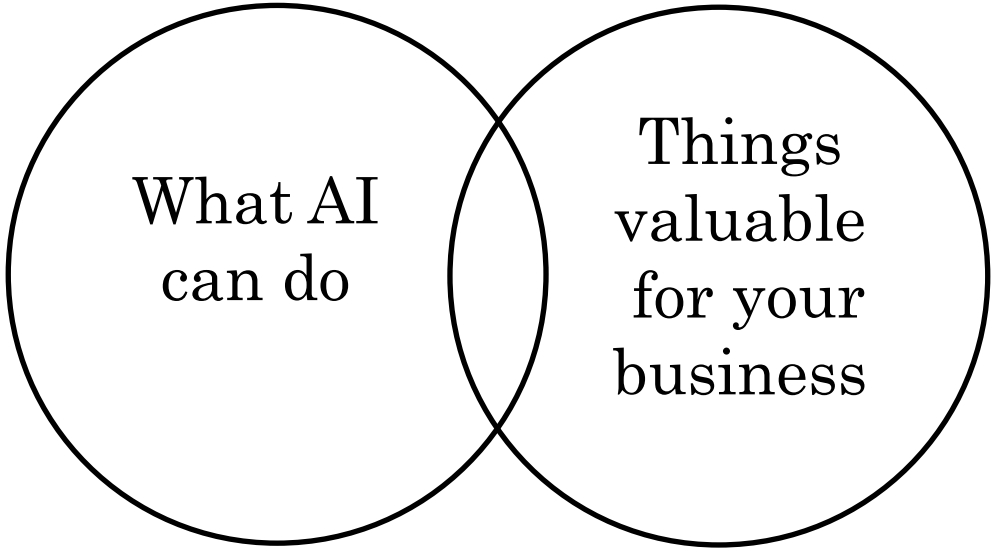
Building AI Projects

How to choose an AI project II

Andrew Ng

Due diligence on project



Due diligence on project

Technical diligence

- Can AI system meet desired performance
- How much data is needed
- Engineering timeline

Business diligence

- Lower costs
- Increase revenue

current business

- Launch new product or business

new business

Build vs. buy

- ML projects can be in-house or outsourced
- DS projects are more commonly in-house
- Some things will be industry standard – avoid building those.

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Building AI Projects

Working with an AI team

Andrew Ng

Specify your acceptance criteria

ok

ok

defect

Goal: detect defects with 95% accuracy

Provide AI team a dataset on which to measure their performance

How AI teams think about data

Training set

ok

ok

ok

Test set

ok

ok

defect

Pitfall: Expecting 100% accuracy

Test set


ok


ok


ok


defect


ok

- Limitations of ML
- Insufficient data
- Mislabeled data
- Ambiguous label

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Building AI Projects

Technical tools for AI teams (optional)

Andrew Ng

Open-source frameworks

Machine learning frameworks:

- TensorFlow
- PyTorch
- Keras
- MXNet
- CNTK
- Caffe
- PaddlePaddle
- Scikit-learn
- R
- Weka

Research publications

- Arxiv

Open source repositories:

- GitHub

CPU vs. GPU

CPU: Computer processor (Central Processing Unit)

GPU: Graphics Processing Unit

Cloud vs. On-premises

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Building AI in Your Company

Introduction

Andrew Ng

Building AI in your company

- Case studies of complex AI products
- Roles in an AI team
- AI Transformation Playbook
- Taking your first step

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Building AI in Your Company

Case study: Smart speaker

Andrew Ng

Smart speaker

Amazon
Echo / Alexa

Google
Home

Apple
Siri

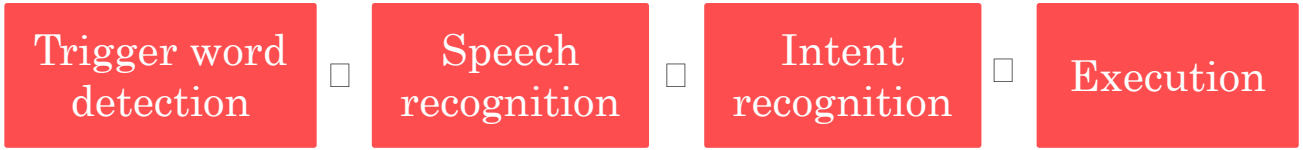
Baidu
DuerOS

"Hey device, tell me a joke"

“*Hey device, tell me a joke*”

Steps to process the command:

1. Trigger word/wakeword detection — Audio — “Hey device”? (0/1)
2. Speech recognition — Audio — “tell me a joke”
3. Intent recognition — “tell me a joke” — joke? time? music? call? weather?
4. Execute joke



“*Hey device, set timer for 10 minutes*”

Steps to process the command:

1. Trigger word/wakeword detection Audio “Hey device”? (0/1)
2. Speech recognition Audio “set timer for 10 minutes”
3. Intent recognition “set timer for 10 minutes” timer
4. a) Extract duration
   “Set timer for 10 minutes”
   “Let me know when 10 minutes is up”
   b) Start timer with set duration

Other functions

- Play music
- Volume up/down
- Make call
- Current time
- Units conversion
- Simple question
- …

Key steps:

1. Trigger/wakeword detection
2. Speech recognition
3. Intent recognition
4. Specialized program to execute command

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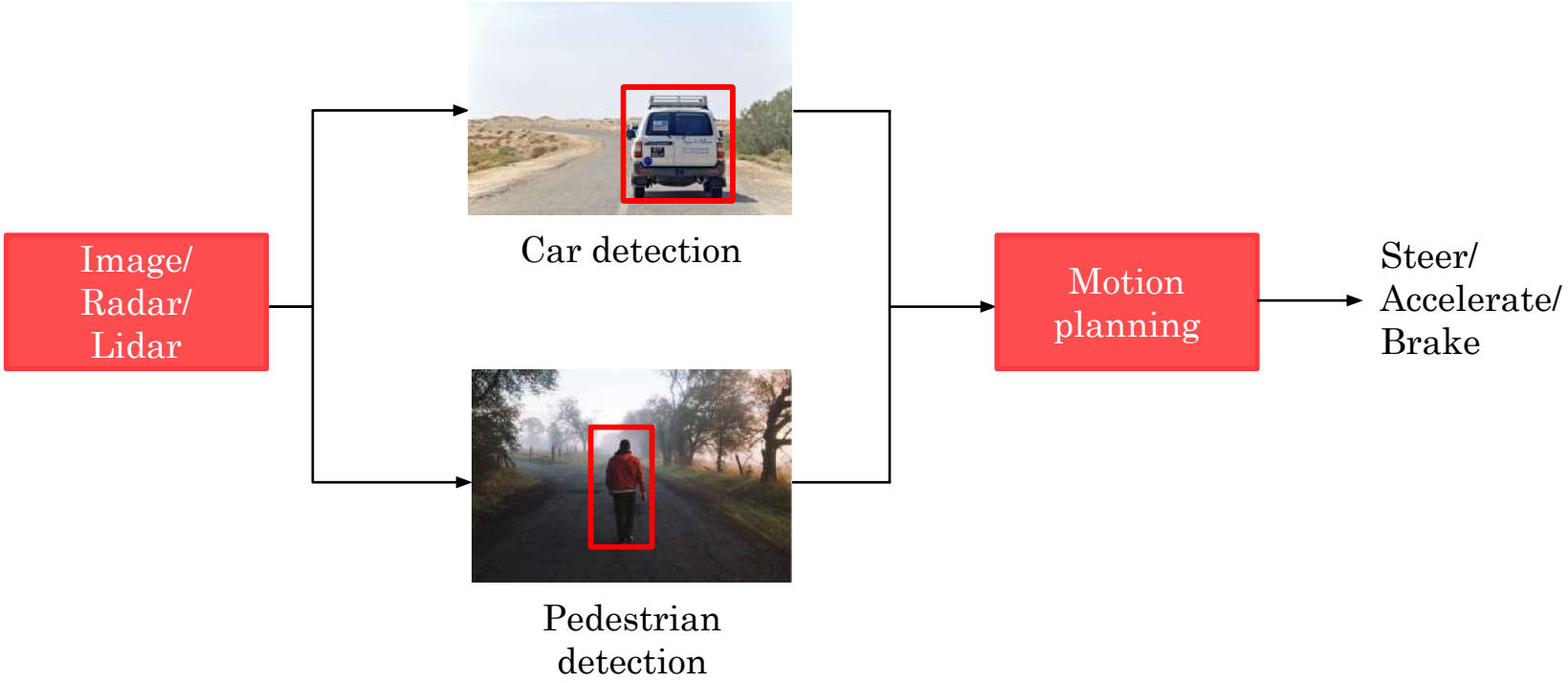
Building AI in Your Company

Case study: Self-driving car

Andrew Ng

Steps for deciding how to drive



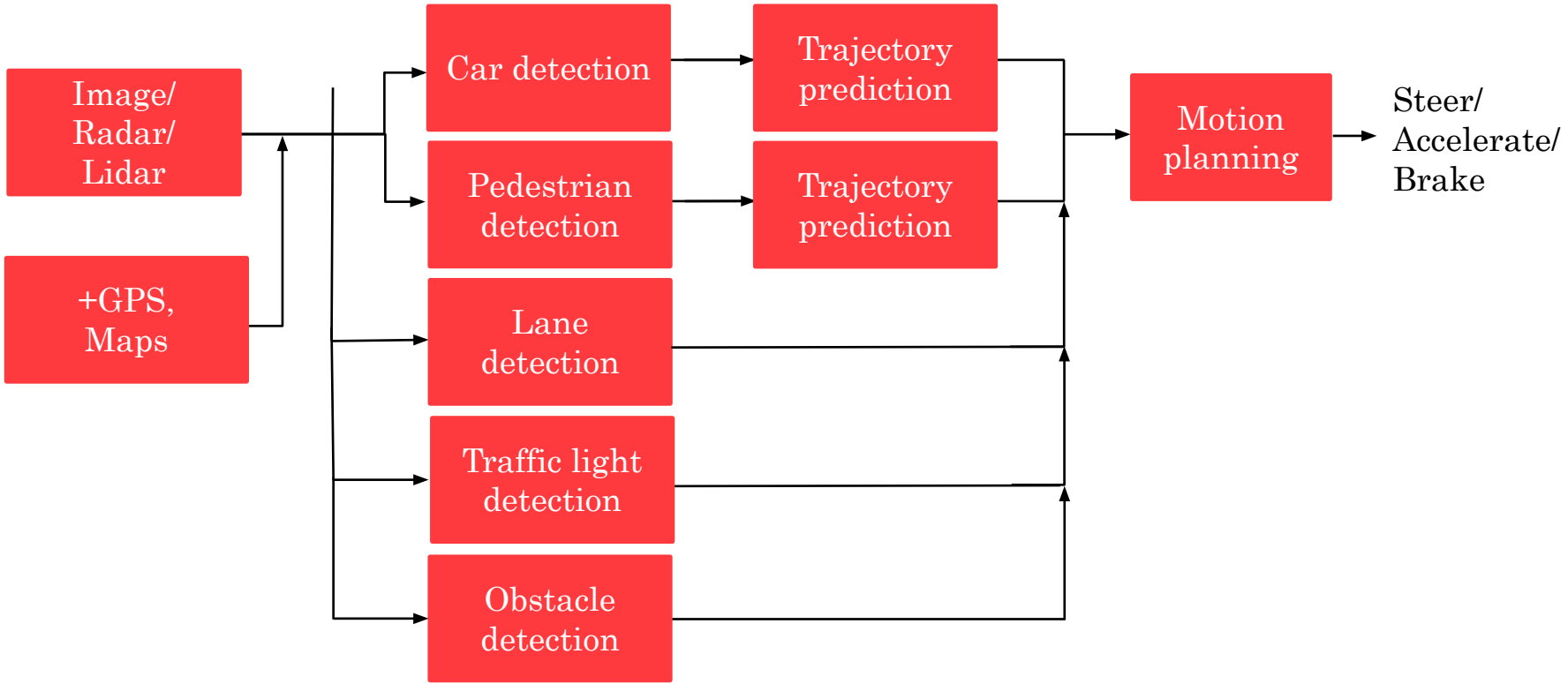
Key steps:

1. Car detection

2. Pedestrian detection

3. Motion planning

Steps for deciding how to drive



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Building AI in Your Company

Example roles of an AI team

Andrew Ng

Example roles

- Software Engineer
  - E.g., joke execution, ensure self-driving reliability, …
- Machine Learning Engineer

Applied ML Scientist

- Machine Learning Researcher
  - Extend state-of-the-art in ML

Example roles

- Data Scientist
  - Examine data and provide insights
  - Make presentation to team/executive
- Data Engineer
  - Organize data
  - Make sure data is saved in an easily accessible, secure and cost effective way

1 MB (megabyte)
1,000 MB = GB (gigabyte)
1,000,000 MB = TB (terabyte)
1,000,000,000 MB = PB (petabyte)

- AI Product Manager
  - Help decide what to build; what's feasible and valuable

Getting started with a small team

- 1 Software Engineer , or
- 1 Machine Learning Engineer/Data Scientist , or
- Nobody but yourself

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Building AI in Your Company

AI Transformation Playbook (Part I)

Andrew Ng

AI Transformation Playbook

1. Execute pilot projects to gain momentum
2. Build an in-house AI team
3. Provide broad AI training
4. Develop an AI strategy
5. Develop internal and external communications

1. Execute pilot projects to gain momentum

- More important for the initial project to succeed rather than be the most valuable
- Show traction within 6-12 months
- Can be in-house or outsourced

2. Build an in-house AI team

BU= Business Unit

AI function can be under CTO, CIO, CDO, etc. or a new CAIO

3. Provide broad AI training

Role	What they should learn
Executives and senior business leaders	• What AI can do for your enterprise • AI strategy • Resource allocation
Leaders of divisions working on AI projects	• Set project direction (technical and business diligence) • Resource allocation • Monitor progress
AI engineer trainees	• Build and ship AI software • Gather data • Execute on specific AI projects

The smart CLO knows they should *curate* rather than *create* content

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Building AI in Your Company

AI Transformation Playbook (Part II)

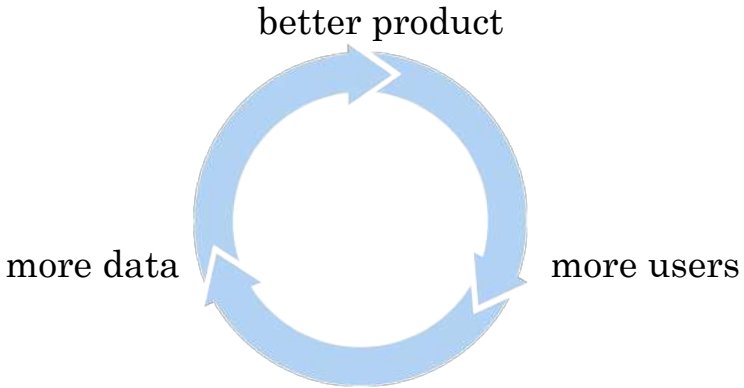
Andrew Ng

AI Transformation Playbook

1. Execute pilot projects to gain momentum
2. Build an in-house AI team
3. Provide broad AI training
4. Develop an AI strategy
5. Develop internal and external communications

4. Develop an AI strategy

- Leverage AI to create an advantage specific to your industry sector
- Design strategy aligned with the “Virtuous Cycle of AI”



4. Develop an AI strategy

- Consider creating a data strategy
  -Strategic data acquisition
  -Unified data warehouse
- Create network effects and platform advantages
  -In industries with “winner take all” dynamics, AI can be an accelerator

5. Develop internal and external communications

- Investor relations
- Government relations
- Customer/user education
- Talent/recruitment
- Internal communications

Detailed AI Transformation Playbook: https://landing.ai/ai-transformation-playbook/

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Building AI in Your Company

AI pitfalls to avoid

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AI pitfalls to avoid

Don't:

- Expect AI to solve everything
- Hire 2-3 ML engineers and count solely on them to come up with use cases

Do:

- Be realistic about what AI can and cannot do given limitations of technology, data, and engineering resources
- Pair engineering talent with business talent and work cross-functionally to find feasible and valuable projects

AI pitfalls to avoid

Don't:

- Expect the AI project to work the first time
- Expect traditional planning processes to apply without changes
- Think you need superstar AI engineers before you can do anything

Do:

- Plan for AI development to be an iterative process, with multiple attempts needed to succeed
- Work with AI team to establish timeline estimates, milestones, KPIs, etc.
- Keep building the team, but get going with the team you have

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Taking your first step in AI

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Some initial steps you can take

- Get friends to learn about AI
  - -This course
  - -Reading group
- Start brainstorming projects
  - -No project is too small
- Hire a few ML/DS people to help
- Hire or appoint an AI leader (VP AI, CAIO, etc.)
- Discuss with CEO/Board possibilities of AI Transformation
  - -Will your company be much more valuable and/or more effective if it were good at AI?

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Building AI in Your Company

Survey of major AI application areas (optional)

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Computer Vision

- Image classification/Object recognition

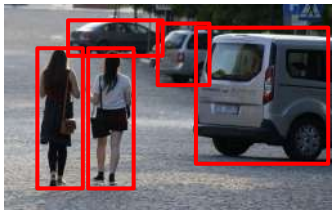
cat

-Face recognition

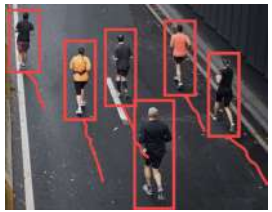
register

new

- Object detection



- Image segmentation
- Tracking



Natural Language Processing

- Text classification
  - Sentiment recognition
- Information retrieval
  - E.g., web search
- Name entity recognition
- Machine translation

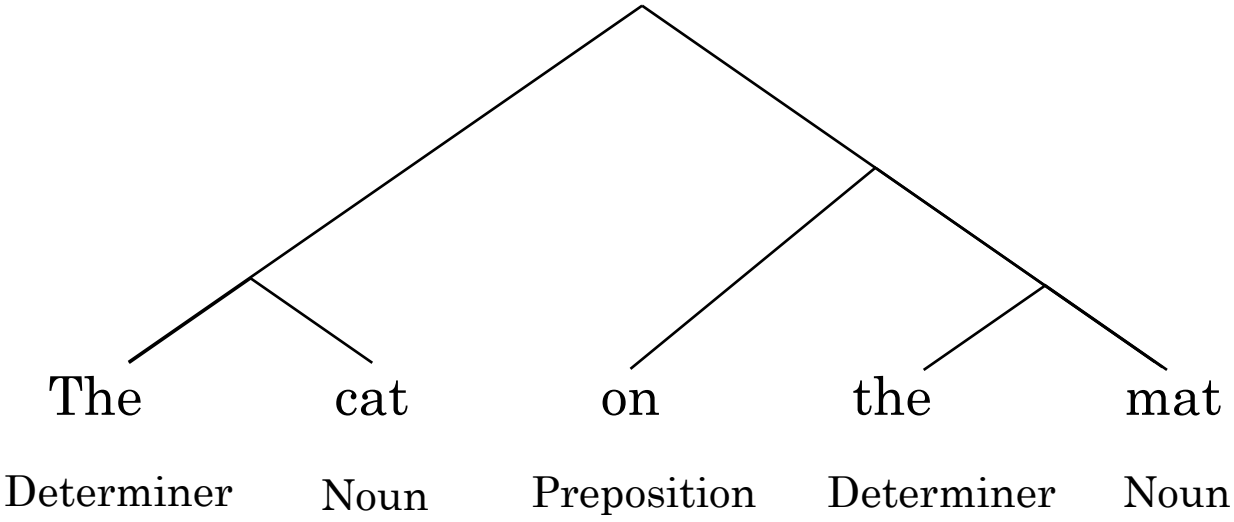
Email	Spam/Non-Spam
Product description	Product category
“The food was good”	★★★★
“Service was horrible”	★

“Queen Elizabeth II knighted Sir Paul McCartney for his services to music at the Buckingham Palace”

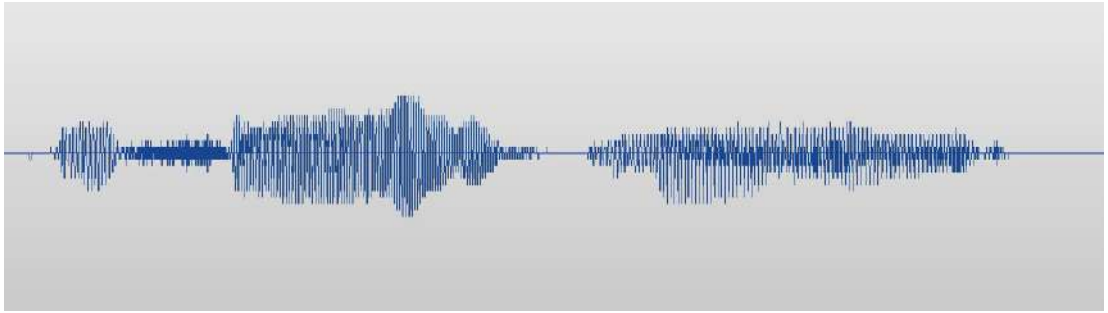
AIは、新たな電気だ
AI is the new electricity

Natural Language Processing

- Others: parsing, part-of-speech tagging



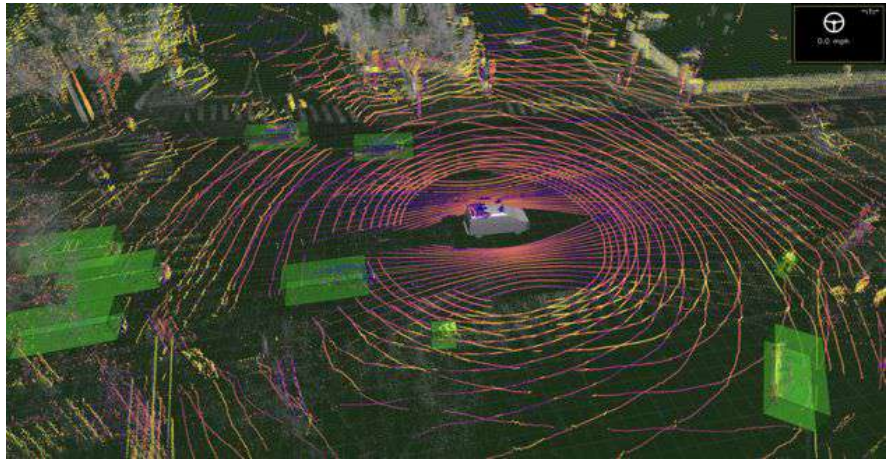
Speech



- Speech recognition (speech-to-text)
- Trigger word/wakeword detection
- Speaker ID
- Speech synthesis (text-to-speech, TTS)
  The quick brown fox jumps over the lazy dog.

Robotics

- Perception: figuring out what's in the world around you
- Motion planning: finding a path for the robot to follow
- Control: sending commands to the motors to follow a path



General machine learning

- Unstructured data (images, audio, text)

 image

 audio

AIは、新たな電気だ
AI is the new electricity text

- Structured data

House size (square feet)	# of bedrooms	Price (1000$)
523	1	100
645	1	150
708	2	200

Clay batch #	Supplier	Mixing time (minutes)
001	ClayCo	35
034	GooClay	22
109	BrownStuff	28

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Building AI in Your Company

Survey of major AI techniques (optional)

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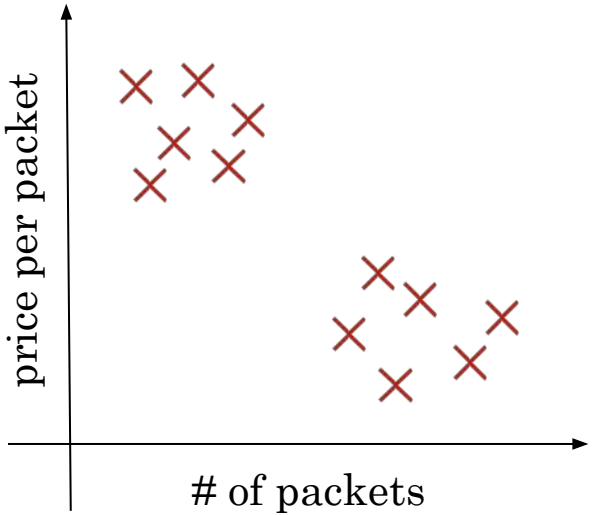
Unsupervised learning

Clustering
Potato chip sales



Given data (without any specific desired output labels), find something interesting about the data

Finding cats from unlabeled YouTube videos

Transfer learning

Car detection

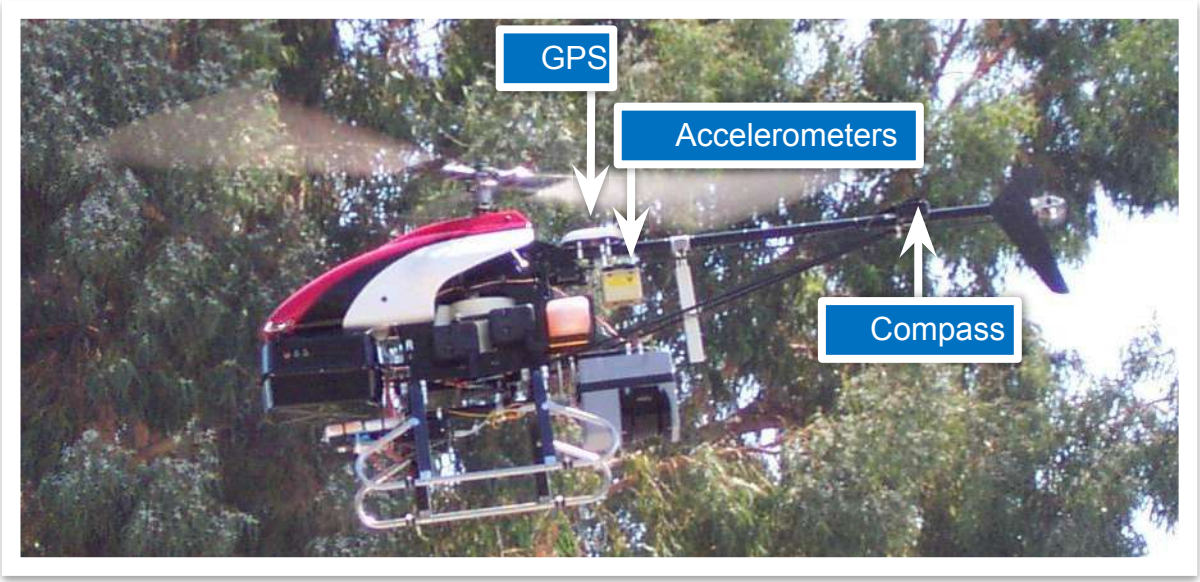
100,000 images

Golf cart detection

100 images

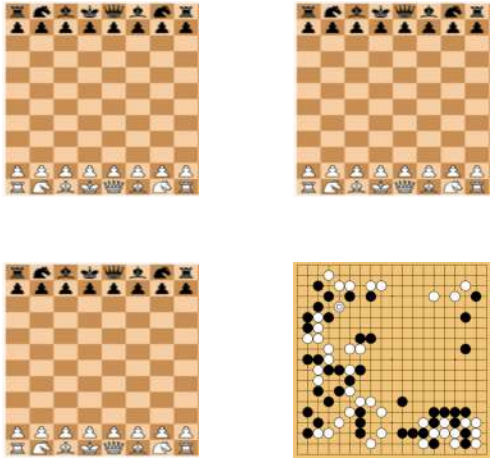
Learn from task A, and use knowledge to help on task B

Reinforcement learning



Use a “reward signal” to tell the AI when it is doing well or poorly. It automatically learns to maximize its rewards.

Reinforcement learning



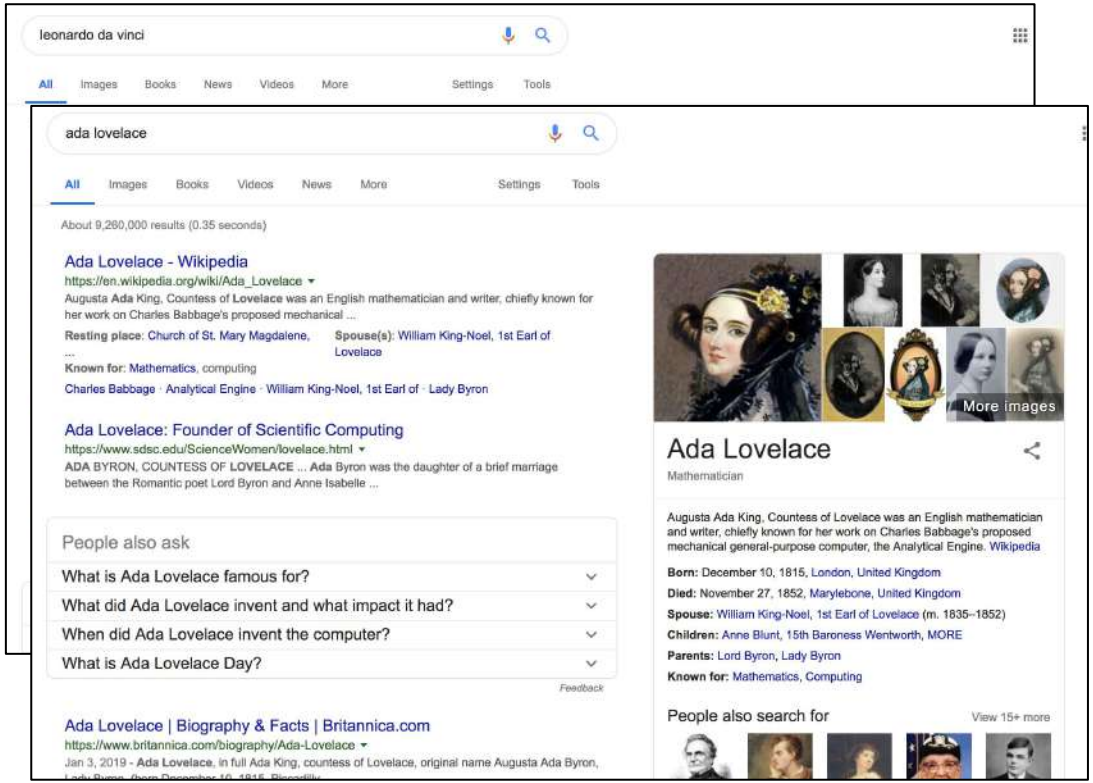
Use a “reward signal” to tell the AI when it is doing well or poorly. It automatically learns to maximize its rewards.

GANs (Generative Adversarial Network)

Synthesize new images from scratch

[Source: Karras et al. (2018). Progressive Growing of GANs for Improved Quality, Stability, and Variation]

Knowledge Graph



Ada Lovelace	
Born	Dec 10, 1815
Died	Nov 27, 1852
Bio	English mathematician and writer...

Northern Rooster Hotel	
Address	45 Rooster St, LA
Phone	(650) 555-3992
Wifi	yes
Pool	no

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AI and Society

Introduction

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AI and society

- AI and hype
- Limitations of AI

  -Bias

  -Adversarial attacks

  AI and Ethics
- AI, developing economies, and jobs
- Conclusion

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AI and Society

A realistic view of AI

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Goldilocks rule for AI

- Too optimistic: Sentient / super-intelligent AI killer robots coming soon
- Too pessimistic: AI cannot do everything, so an AI winter is coming
- Just right: AI can't do everything, but will transform industries

Limitations of AI

- Performance limitations
- Explainability is hard (but sometimes doable)

Right-sided Pneumothorax (collapsed lung)

[Rajpurkar et al. (2018). CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays with Deep Learning.]
[Wang et al. (2017). ChestX-ray8: Hospital-scale Chest X-ray Database and Benchmarks on Weakly-Supervised Classification and Localization of Common Thorax Diseases. IEEE CVPR]
[Images source: NIH Clinical Center Image dataset: https://nihcc.app.box.com/v/ChestXray-NIHCC]

Limitations of AI

- Biased AI through biased data
- Adversarial attacks on AI

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AI and Society

Discrimination / Bias

Andrew Ng

AI learning unhealthy stereotypes

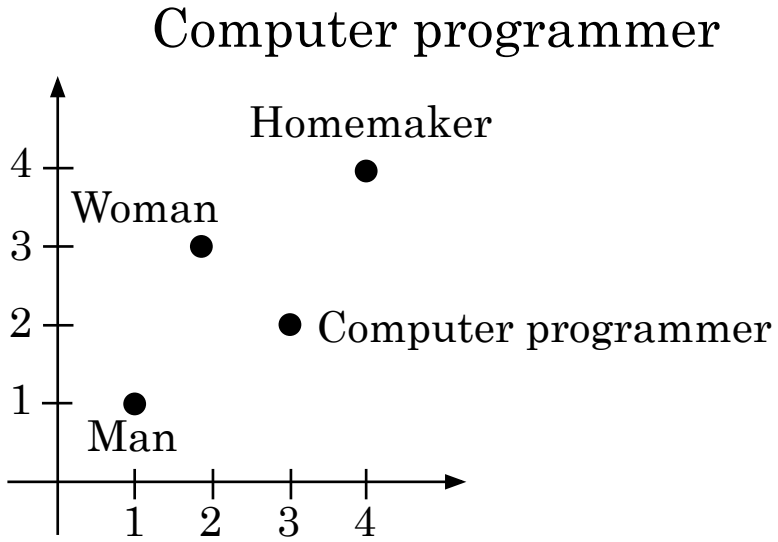
- Man : Woman as Father : Mother
- Man : Woman as King : Queen
- Man : Computer programmer as Woman : Homemaker

Man: (1,1)

Computer programmer: (3,2)

Woman: (2,3)

Homemaker: (4,4)



Bolukbasi et al. (2016). Man is to Computer Programmer as Woman is to Homemaker? Debiasing Word Embeddings.

Why bias matters

- Hiring tool that discriminated against women
- Facial recognition matching dark skinned individuals to criminal mugshots
- Bank loan approvals
- Toxic effect of reinforcing unhealthy stereotypes

Combating bias

- Technical solutions:
  - E.g., “zero out” the bias in words
  - Use less biased and/or more inclusive data
- Transparency and/or auditing processes
- Diverse workforce
  - Creates less biased applications

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AI and Society

Adversarial attacks on AI

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Adversarial attacks on AI

Hummingbird

Minor perturbation

Hammer

Hare

Minor perturbation

Desk

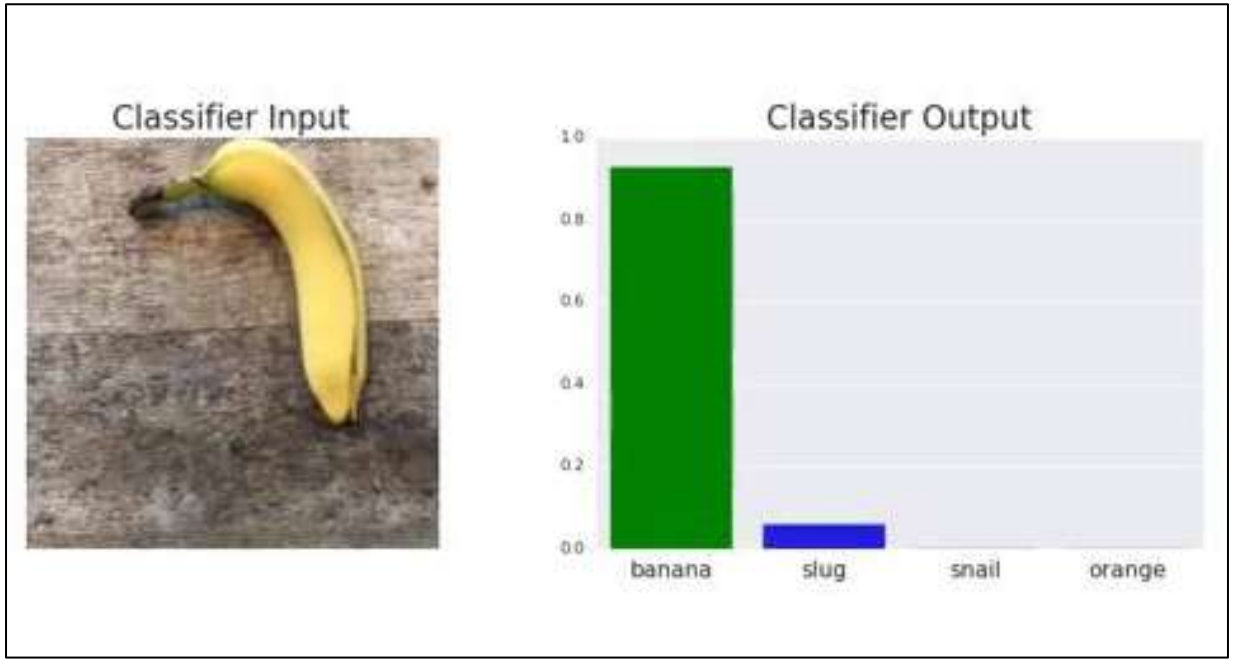
Physical attacks

"Milla Jovovich"

Fails to see stop sign

Banana

Physical attacks



[Sharif et al. (2016). Accessorize to a Crime: Real and Stealthy Attacks on State-of-the-Art Face Recognition.]
[Eykholt et al. (2018). Physical Adversarial Examples for Object Detectors.]
[Brown et al. (2018). Adversarial Patch.]

Adversarial defenses

- Defenses do exist, but incur some cost
- Similar to spam vs. anti-spam, we may be in an arms race for some applications

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AI and Society

Adverse uses of AI

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Adverse uses of AI

- DeepFakes
  - Synthesize video of people doing things they never did
- Undermining of democracy and privacy
  - Oppressive monitoring of individuals
- Generating fake comments
- Spam vs. anti-spam and fraud vs. anti-fraud

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AI and Society

AI and developing economies

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Developing economies

"leapfrog"

-Mobile phones

-Mobile payments

-Online education

How developing economies can build AI

- US and China are leading, but all AI communities are still immature
- Focus on AI to strengthen a country's vertical industries
- Public-private partnerships to accelerate development

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AI and Society

AI and jobs

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AI's impact on jobs worldwide

Jobs replaced by 2030

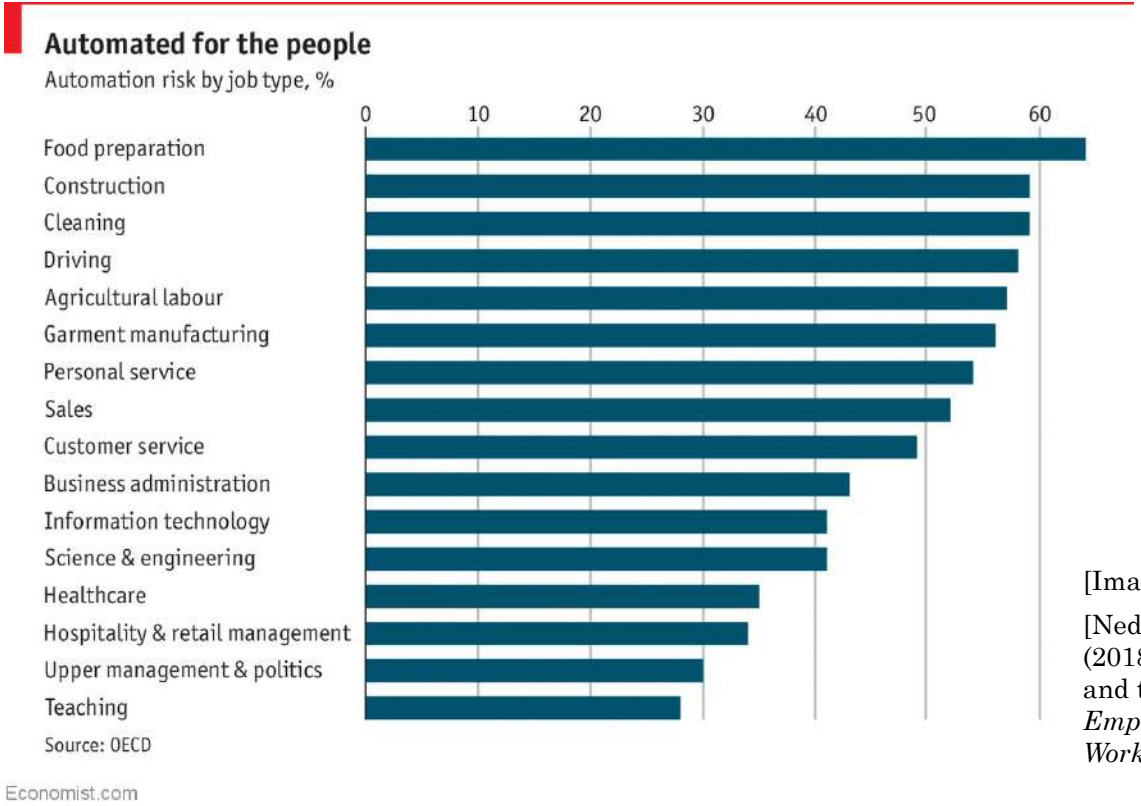
400-800 mil

Jobs created by 2030

555-890 mil

[Source: McKinsey Global Institute.]

AI's impact on jobs worldwide



[Image credit: Economist.com]

[Nedelkoska, L. and G. Quintini. (2018). Automation, skills use and training. *OECD Social, Employment and Migration Working Papers*, No. 202.]

Some solutions

- Conditional basic income: provide a safety net but incentivize learning
- Lifelong learning
- Political solutions

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AI for Everyone

Conclusion

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What you've learned

- What is AI?
- Building AI projects
- Building AI in your company
- AI and society

Keep learning!

- Online courses, books, blogs, ...
- deeplearning.ai mailing list

Thank you!