Introduction

AI value creation by 2030

$13 trillion

Retail	$0.8T
Travel	$480B
Transport & Logistics	$475B
Automotive & Assembly	$405B
Basic Materials	$300B
Advanced Electronics/Semiconductors	$291B
Healthcare Systems and Services	$267B
High Tech	$267B
Telecom	$174B
Oil & Gas	$173B
Agriculture	$164B
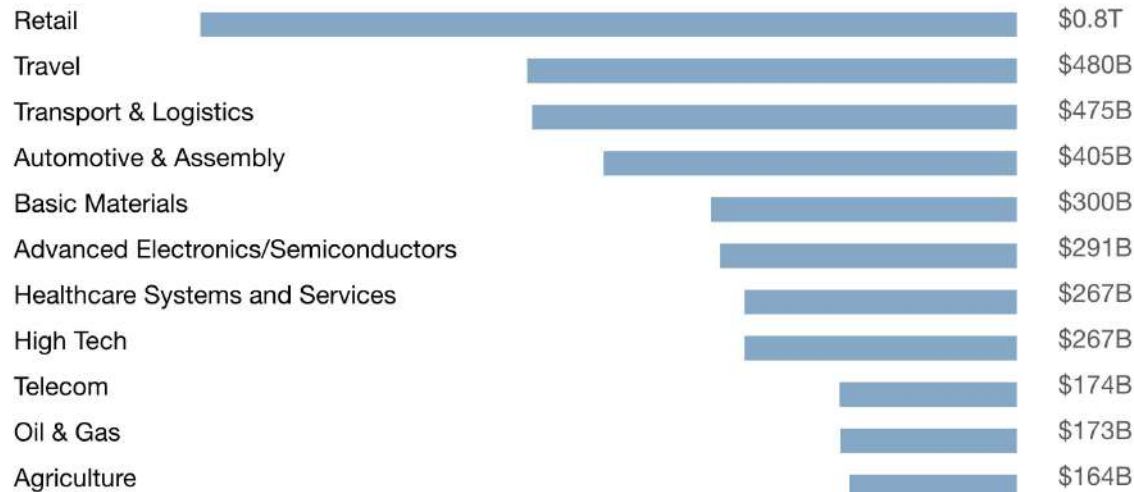
[Source: McKinsey Global Institute.]

Demystifying AI

AI

ANI
(artificial narrow intelligence)

E.g., smart speaker, self-driving car, web search, AI in farming and factories

AGI
(artificial general intelligence)

Do anything a human can do
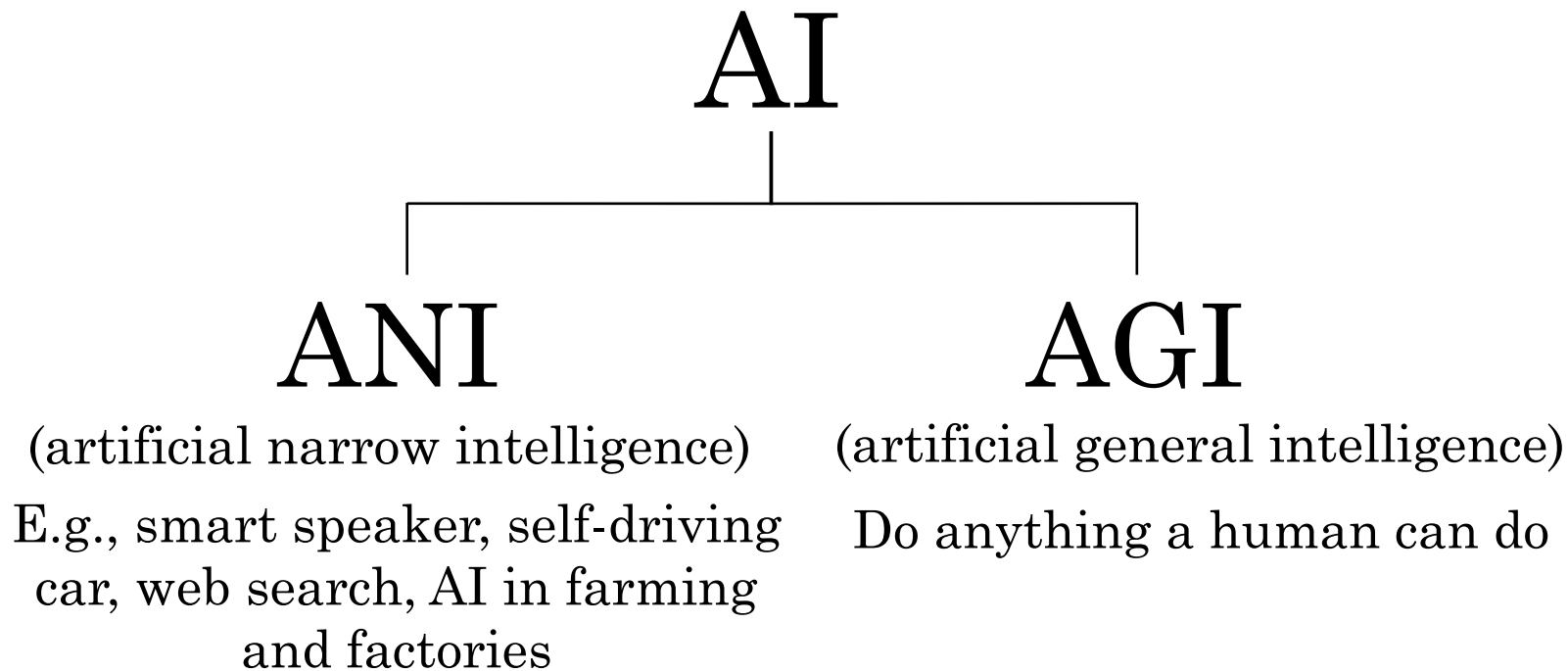
What you'll learn

- ## 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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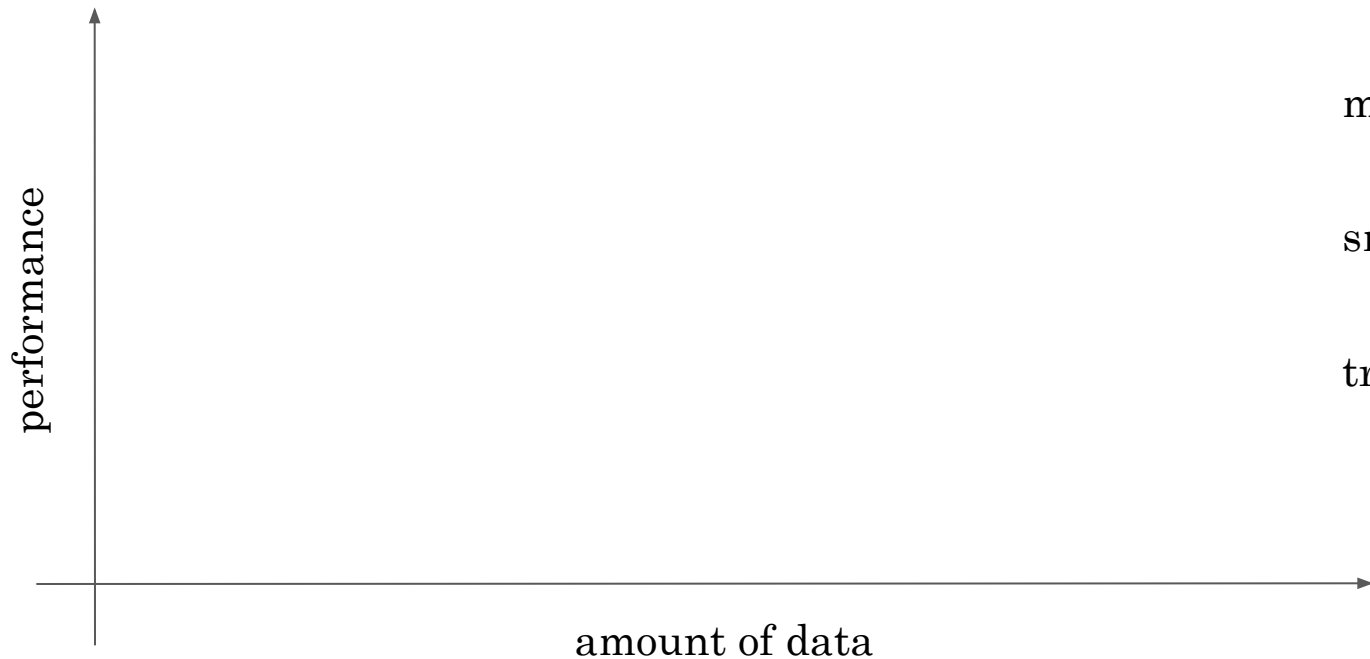
What is AI

Machine Learning

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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

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

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.

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

Newly renovated homes have a 15% premium.

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

neuron

big mathematical equation

size

# of bedrooms

# of bathrooms

newly renovated
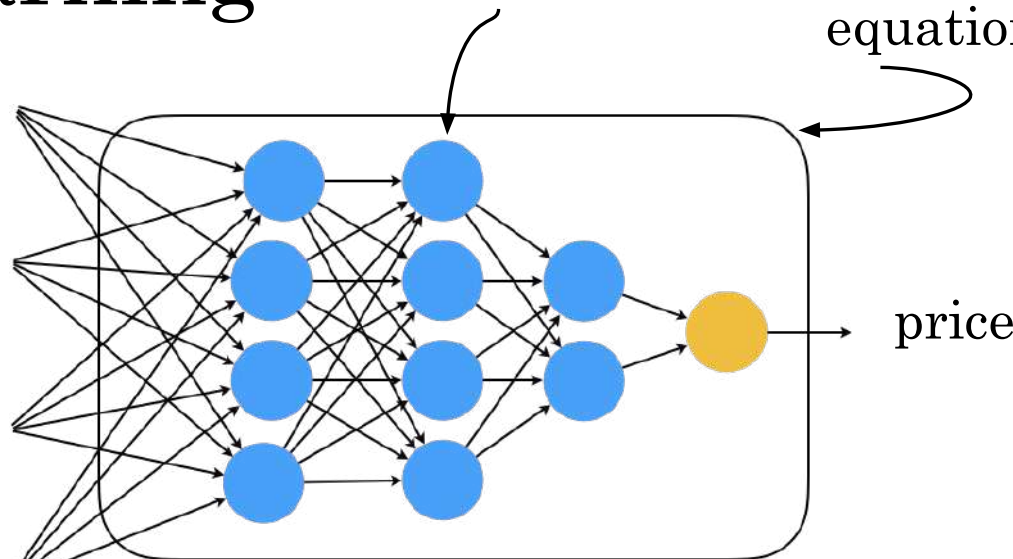
price

(Artificial) Neural Network

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

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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?

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

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

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

Demand prediction

price   demand

"neuron"

Demand prediction

price

shipping cost

demand

marketing

material

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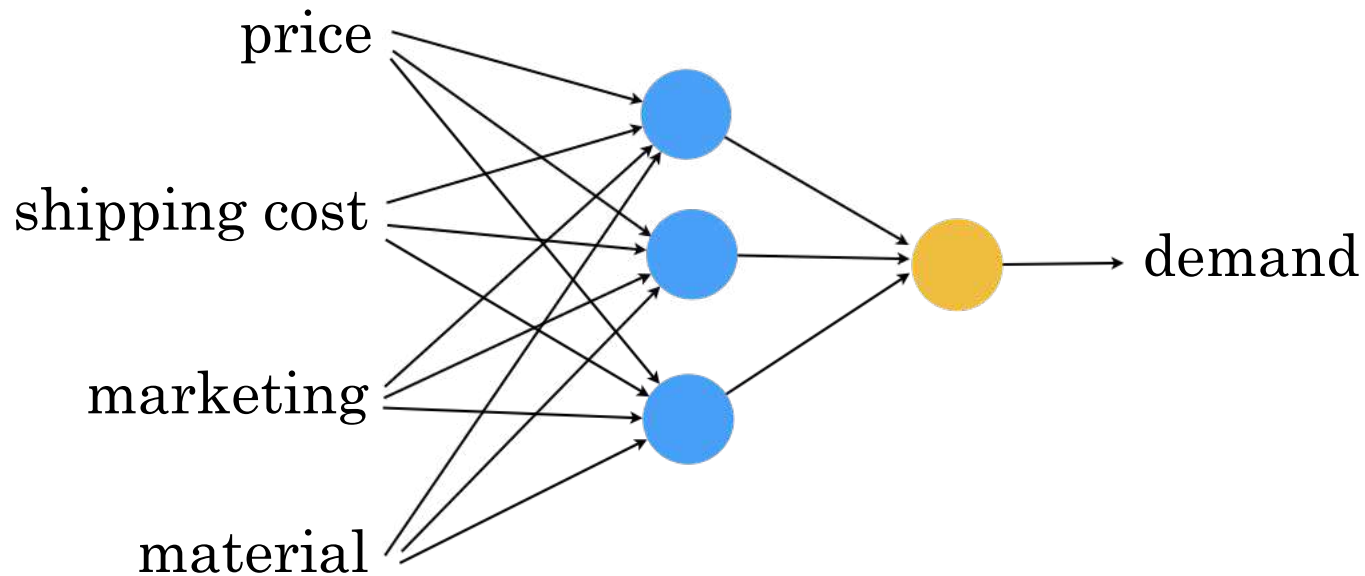
Face recognition
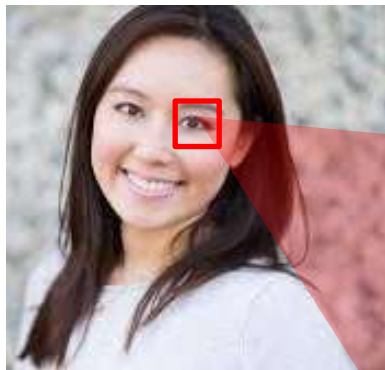
30	32	22	12	10	10	12	33	35	30
12	11	12	234	170	176	13	15	12	12
234	222	220	230	200	222	230	234	56	78
190	220	186	112	110	110	112	180	30	32
49	250	250	250	4	2	254	200	44	6
55	250	250	250	3	1	250	245	25	3
189	195	199	150	110	110	182	190	199	55
200	202	218	222	203	200	200	208	215	222
219	215	220	220	222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

Face recognition
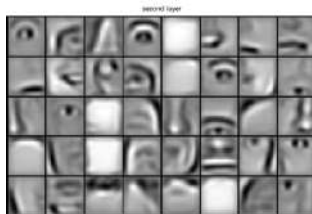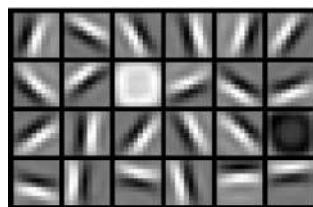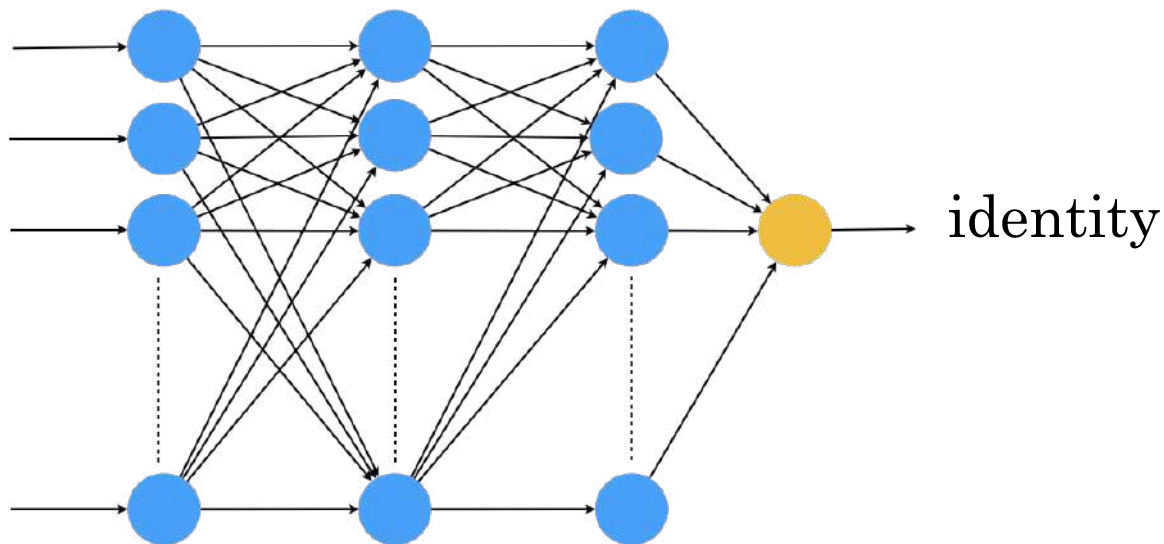
identity

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Building AI Projects

Starting an AI project

Starting an AI project

- Workflow of projects

- Selecting AI projects

- Organizing data and team for the projects

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
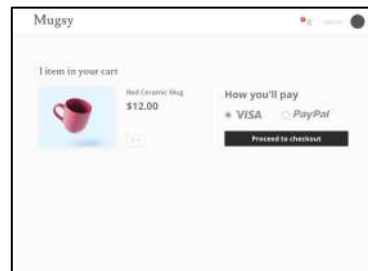
Example: Optimizing a sales funnel
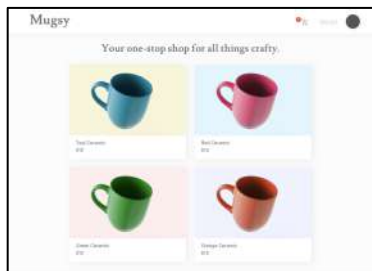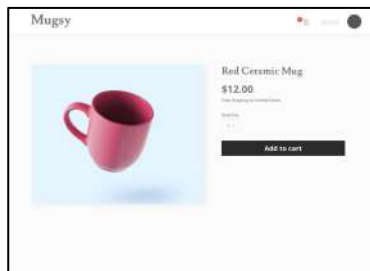
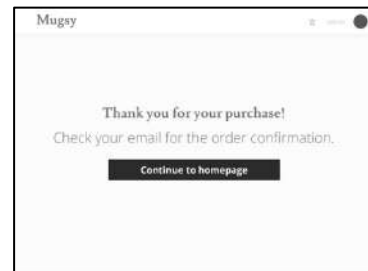Visit website   Product page   Shopping cart   Checkout

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

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Key steps of a data science project

Manufacturing line

Final
inspection

Mix clay   Shape mug   Add glaze   Fire kiln

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%	1410°	22
302	USA	0.003%	1520°	24
303	Malaysia	0.002%	1420°	22

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Sales

Data science

Visit website
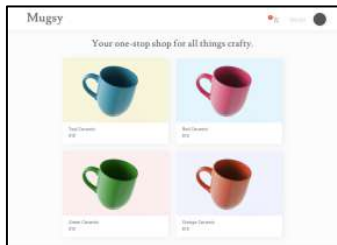
Product page
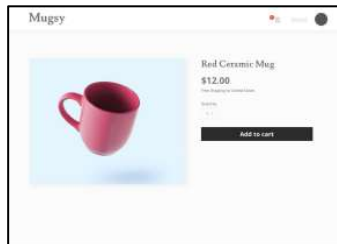
Shopping cart
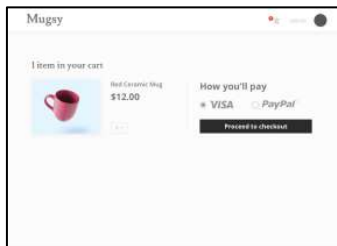
Checkout
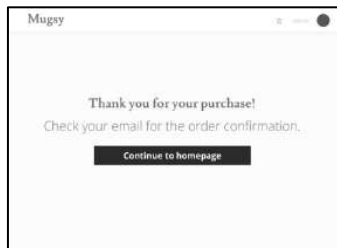
Optimize sales funnel

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
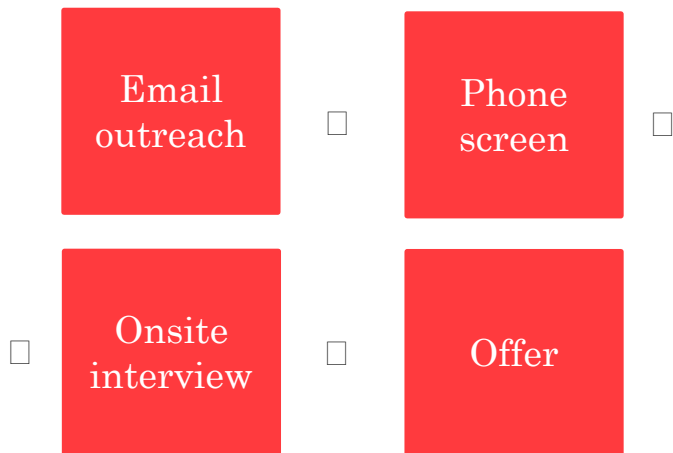

Optimize sales funnel

Machine learning

ok   ok   defect
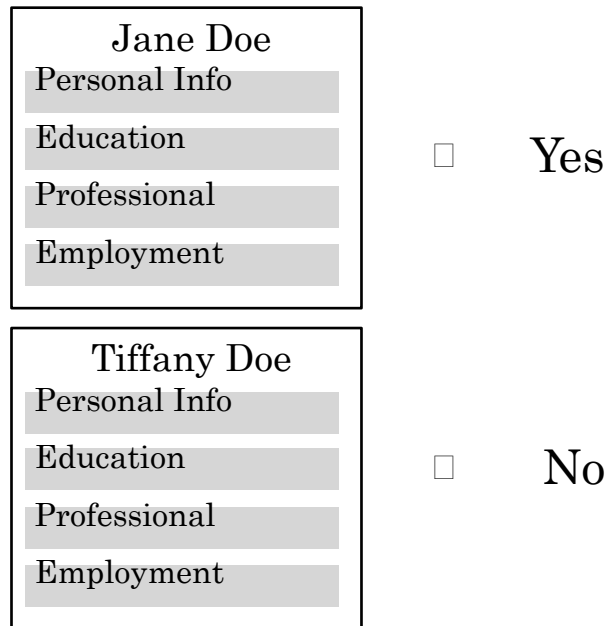
Automated visual inspection
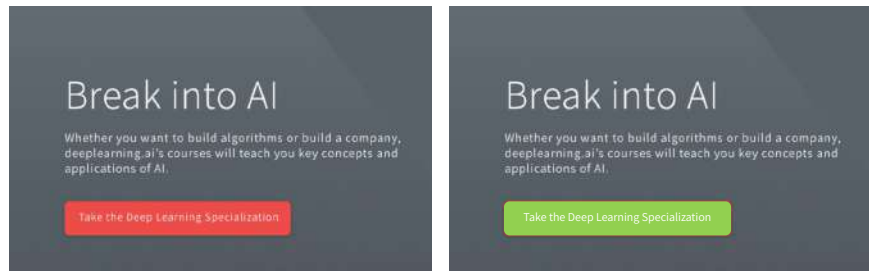
Recuiting

Data science

Optimize recruiting funnel

Machine learning

Automated resume screening

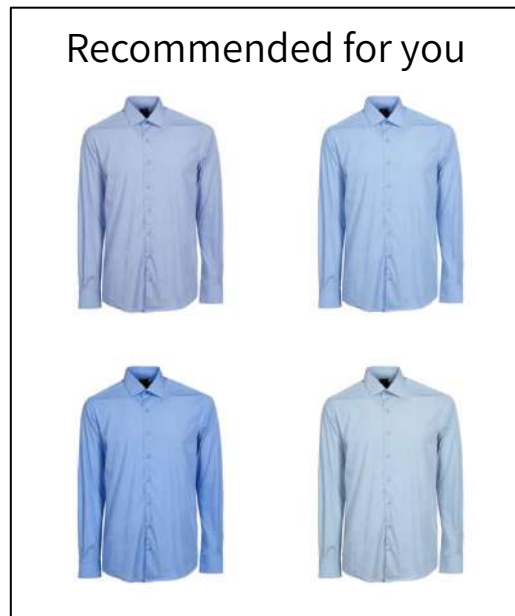# Marketing

Data science

A

B

A/B testing

Machine learning

Recommended for you

Customized product recommendation

Agriculture

Data science

Crop analytics

Machine learning

Precision weed killing

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.

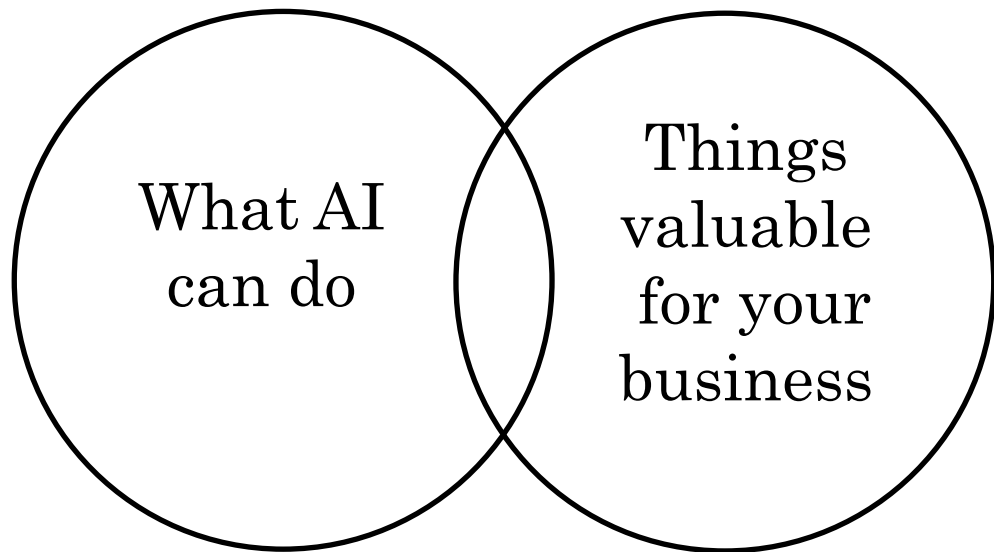- But with small datasets, you might still make progress.

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Building AI Projects

How to choose an AI project II

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Due diligence on project

What AI can do

Things valuable for your business

Technical diligence

Business diligence

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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

- Launch new product or business

current 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.

Specify your acceptance criteria

ok

ok

defect

Goal: detect defects
with 95% accuracy

Provide AI team a dataset on
which to measure their
performance

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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)

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

- 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

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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

Trigger word detection	☐	Speech recognition	☐	Intent recognition	☐	Execution
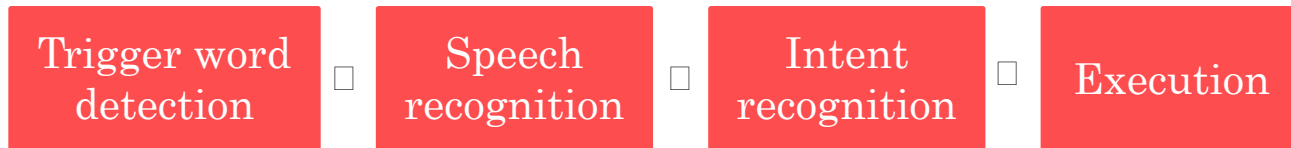
"*Hey device, set timer for 10 minutes*"

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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Steps for deciding how to drive

Image/
Radar/
Lidar

Car detection

Pedestrian
detection

Motion
planning

Steer/
Accelerate/
Brake
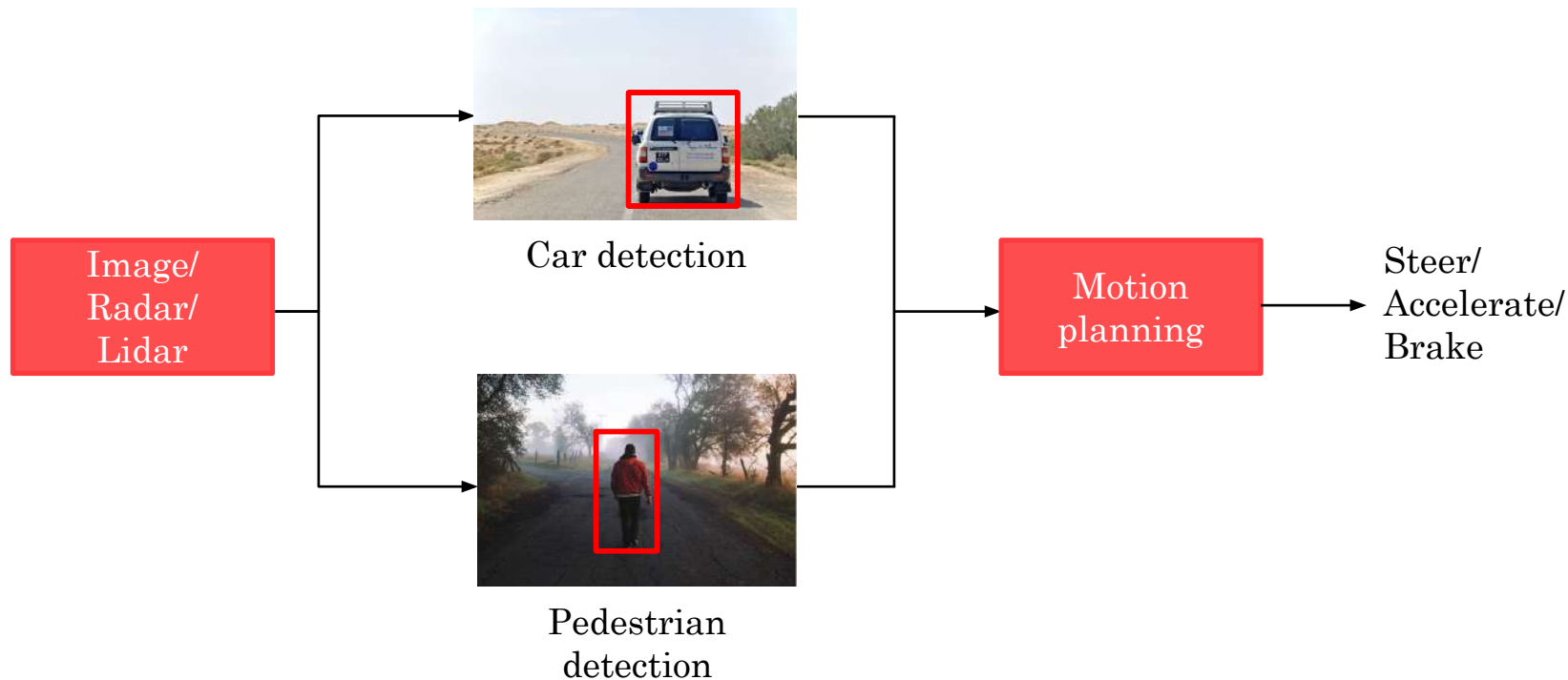
Key steps:

1. Car detection

2. Pedestrian detection

3. Motion planning

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Steps for deciding how to drive

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Building AI in Your Company

Example roles of an AI team

Example roles

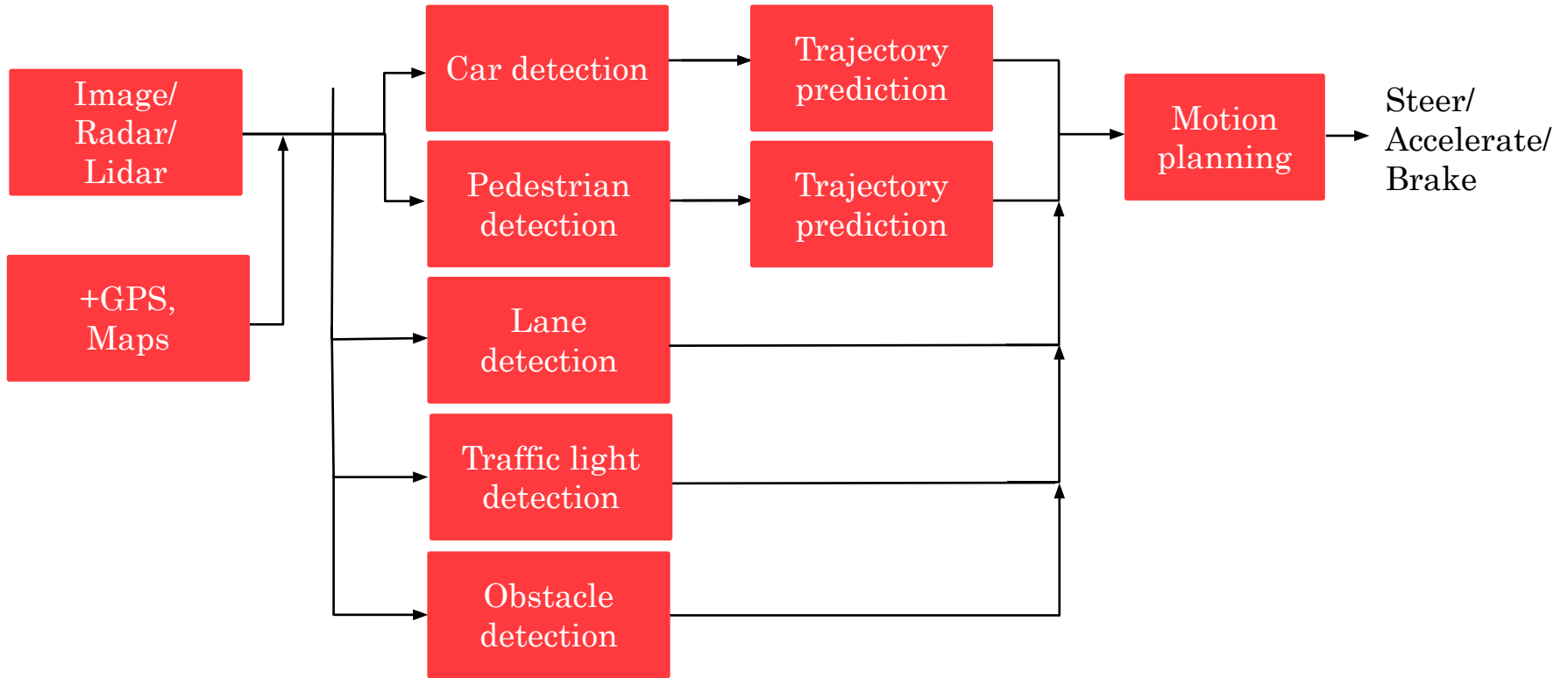- Software Engineer
  - E.g., joke execution, ensure self-driving reliability, …

- 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

- AI Product Manager

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

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

Getting started with a small team

- 1 Software Engineer , or

- 1 Machine Learning Engineer/Data Scientist , or

- Nobody but yourself

Building AI in Your Company

AI Transformation Playbook
(Part I)

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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

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"

better product

more data   more users
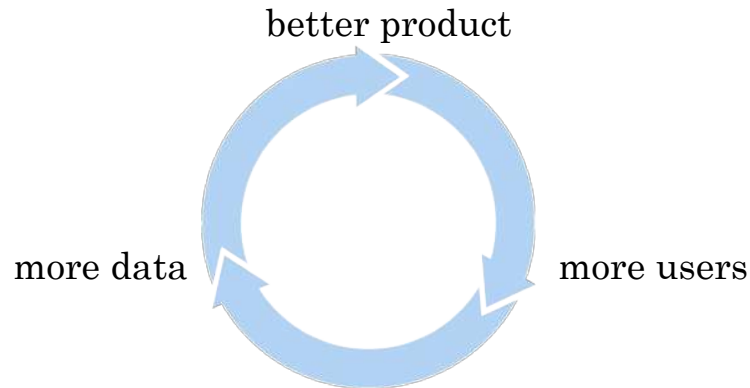
4. Develop an AI strategy

- 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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Building AI in Your Company

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?

Computer Vision

- Image classification/Object recognition   cat
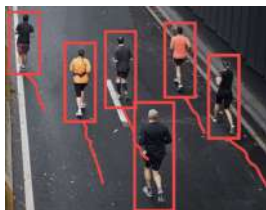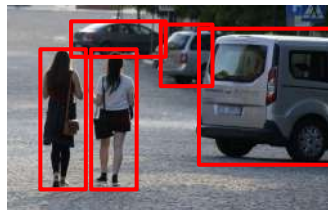
  -Face recognition

  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

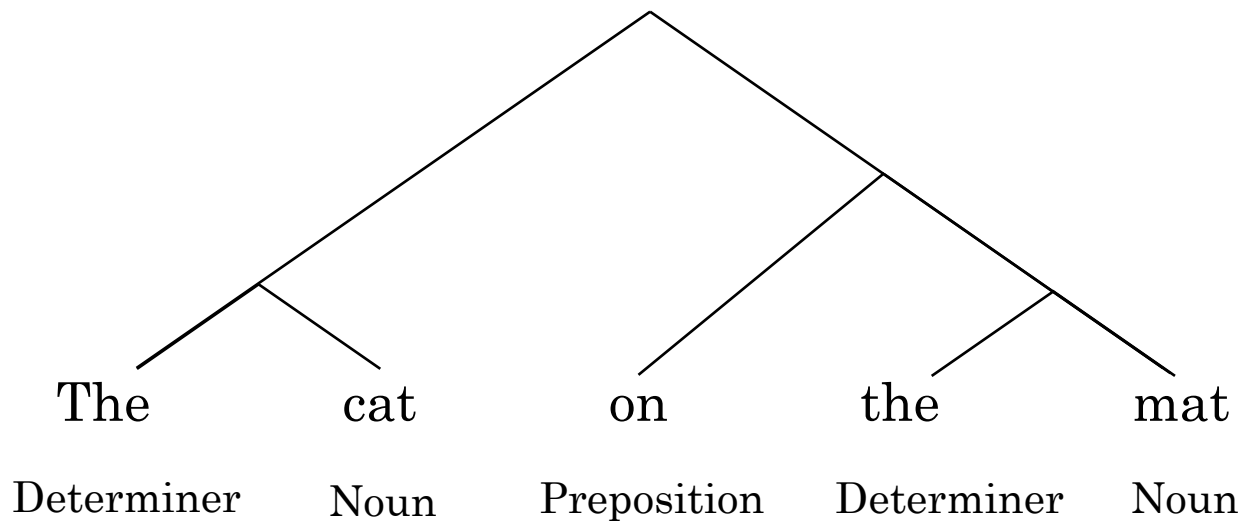| Email	Spam/Non-Spam
Product description	Product category
"The food was good"	★ ★ ★ ★
"Service was horrible"	★

"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

```
                              /\
                             /  \
                            /    \
                           /      \
                          /        \
                         /          \
                        /          /\
                       /          /  \
                      /          /    \
                     /\         /    /\
                    /  \       /    /  \
                   /    \     /    /    \
                 The    cat  on  the    mat
```

The   cat   on   the   mat

Determiner   Noun   Preposition   Determiner   Noun

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.

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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
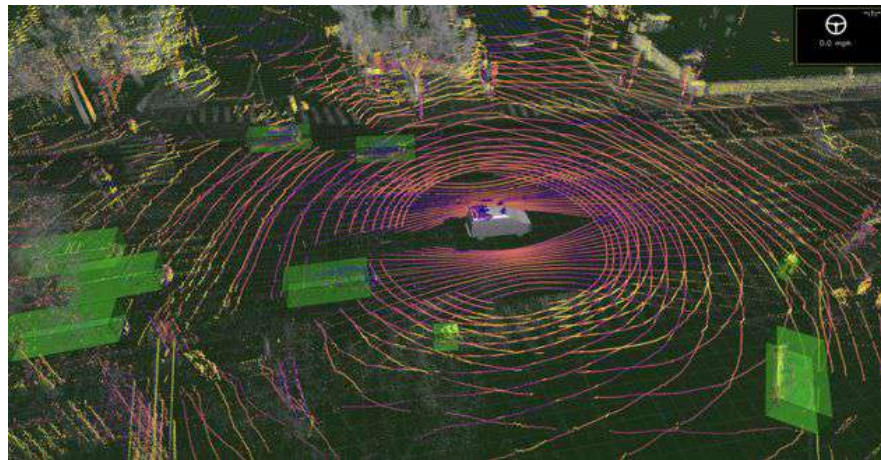
General machine learning

- Unstructured data (images, audio, text)

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

- 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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Unsupervised learning

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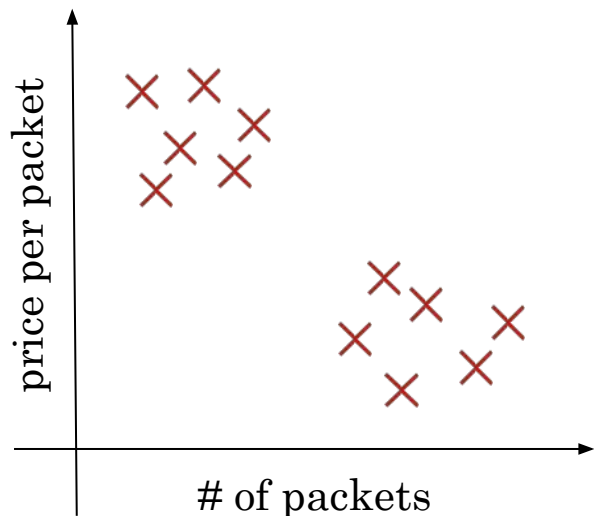
Given data (without any specific desired output labels), find something interesting about the data

Finding cats from unlabeled YouTube videos

Transfer learning
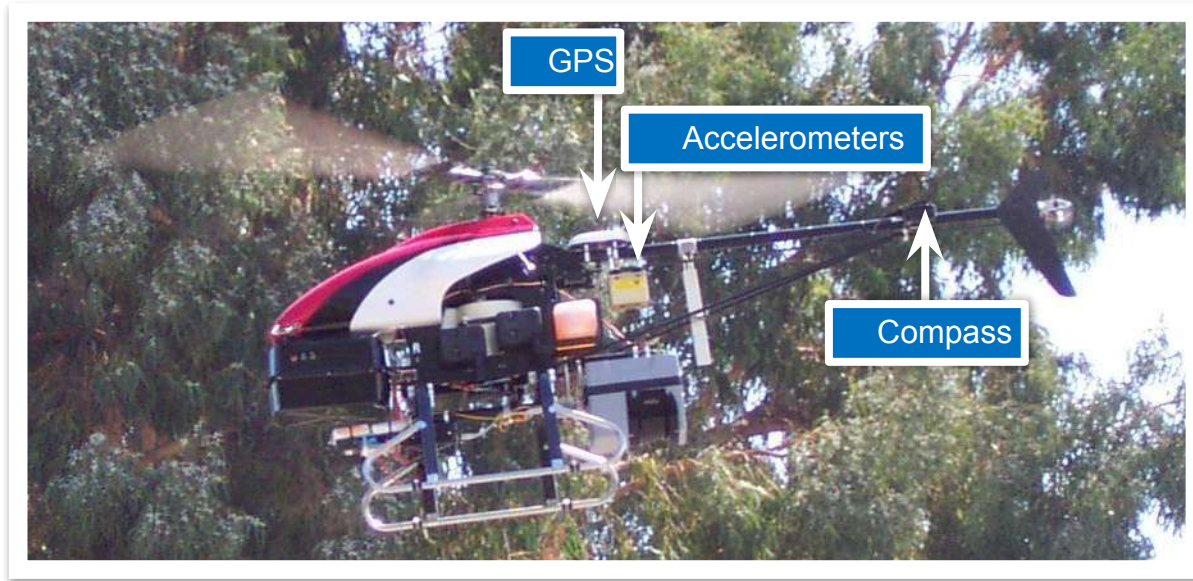
Car detection

100,000 images

Golf cart detection

100 images

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

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Reinforcement learning

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

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Reinforcement learning

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

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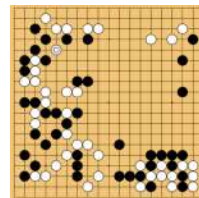
GANs (Generative Adversarial Network)

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   AI and Ethics
  -Adversarial attacks

- AI, developing economies, and jobs

- Conclusion

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]

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Limitations of AI

- Biased AI through biased data
- Adversarial attacks on AI

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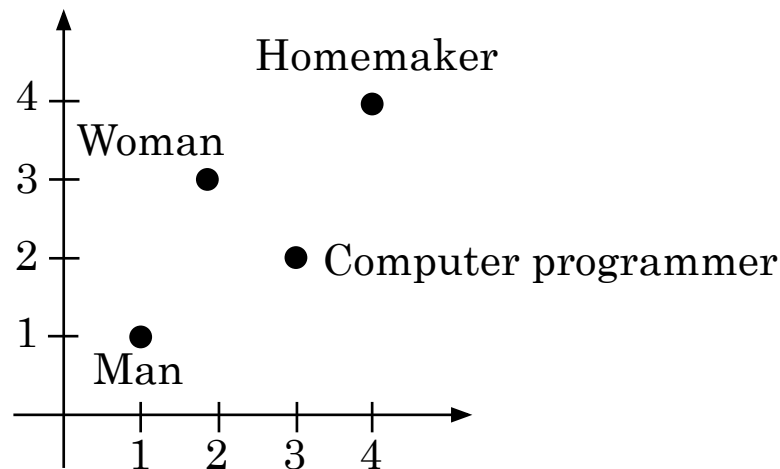
Bolukbasi et al. (2016). Man is to Computer Programmer as Woman is to Homemaker? Debiasing Word Embeddings.

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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

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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

Adversarial attacks on AI

Hummingbird → Minor perturbation → Hammer

Hare → Minor perturbation → Desk

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Physical attacks

"Milla Jovovich"

Fails to see stop sign

Banana

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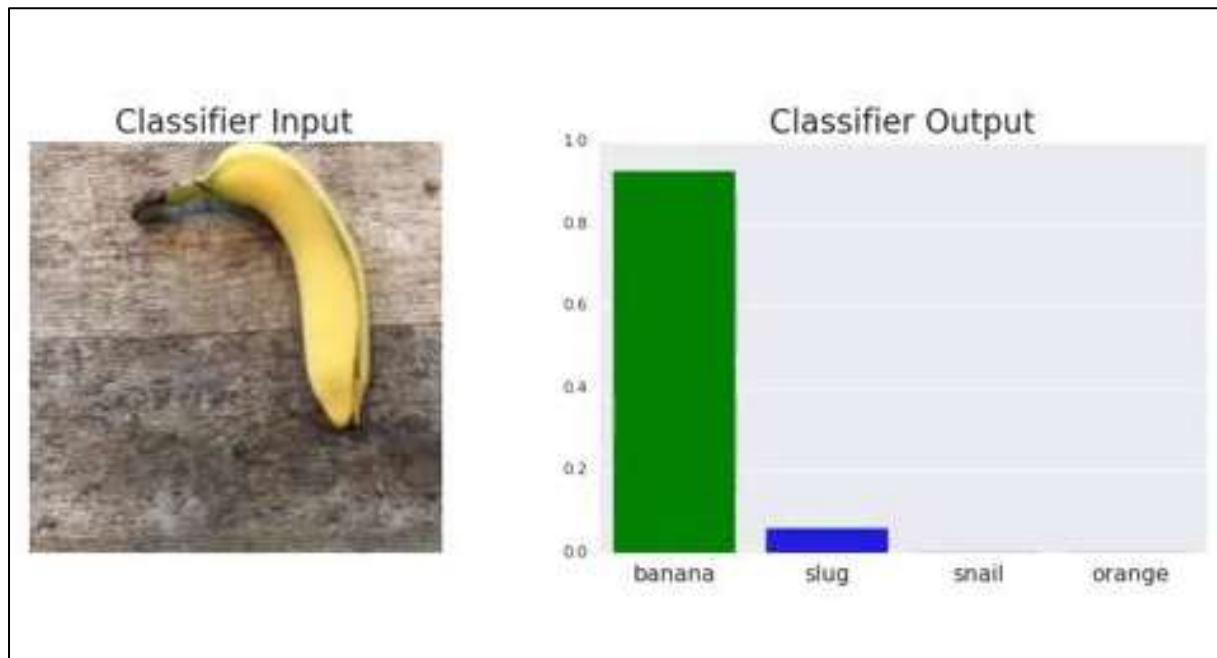# Physical attacks

[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

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

AI's impact on jobs worldwide

Jobs replaced
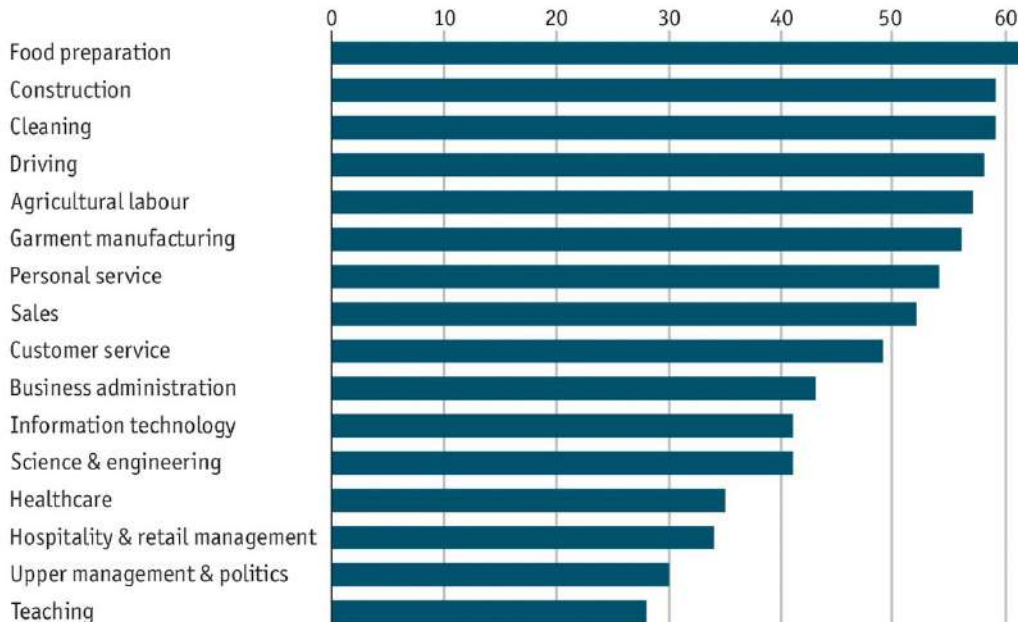### by 2030

Jobs created
by 2030

400-800mil

555-890mil

[Source: McKinsey Global Institute.]

AI's impact on jobs worldwide

Automated for the people
Automation risk by job type, %

	0	10	20	30	40	50	60
Food preparation							
Construction							
Cleaning							
Driving							
Agricultural labour							
Garment manufacturing							
Personal service							
Sales							
Customer service							
Business administration							
Information technology							
Science & engineering							
Healthcare							
Hospitality & retail management							
Upper management & politics							
Teaching							

Source: OECD

Economist.com

[Image credit: Economist.com]

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

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Some solutions

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

- Lifelong learning

- Political solutions

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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!