Deep learning

UNDERSTANDING MACHINE LEARNING

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What is deep learning?

- AKA: Neural Networks
  - Basic unit: neurons (nodes)
- Special area of Machine Learning
- Requires more data
- Best when inputs are images or text

Predicting box office revenue

Predicting box office revenue

Budget

Advertising

Star Power

Timing

Predicting box office revenue

Star Power

Timing

Predicting box office revenue

Predicting box office revenue

Predicting box office revenue

Predicting box office revenue

Predicting box office revenue

Predicting box office revenue

Deep learning

- Neural networks are much larger
- Deep learning: neural network with many neurons
- Can solve complex problems

When to use deep learning?

- Lots of data
- Access to processing power
- Lack of domain knowledge
- Complex problems
  - Computer vision
  - Natural language processing

The process

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Computer vision

Helps computers see and understand the content of digital images

Image data

157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

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180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

Image data

color image
(RGB)

3 channels
(RGB)

28 pixels
(height)

28 pixels
(width)

Identity
Lis
Hadrien
Sara

Identity
Lis
Hadrien
Sara

Training the neural network

Mary
William
Michael
Anny
Lynn
Johnny
James
Robert
Louise
David
Lee
Richard
Daniel
Friedrich
Frederick
Mark
Albert
Edward
Elizabeth
Jean
Emil
Thomas
Carl
Jeffrey
Arthur
Paul
Donald
Harold
Henry
Charles
Patricia
Suzanne
Josephine
Douglas
Johann
Christopher
Anna
Wilhelm
Diane
Alan
Todd
August
Andrew
Martha
Barbara
Eugene
Jane
Roger
Carol
Kenneth
Margaret
Karen
Kathleen
Samuel
Bertha
Steven
kai
Allen
Brian
Scott
Otto
Herbert
Walter
Warren
Laura
Craig
Timothy
Ronald
Susan
Harlan
George
Mae
Lisa
Ruth
Martin
Ryan
Ida
Jo
Rae
Loy
Howard
Julius
Rustin
Leroy
Emma
Amanda
Adam
Larry
Renee
Jacob
Kevin
Cynthia
Adolph
Peter
Matthew
Michel
Rudolph
Patrick
Rodney
Ruben
Heinrich
Glenn
Louis
Keith
Lori
June
Dean
Dale
Jon
Herman
Gene
Claire
Linda
Alvina
Karl
Dana
Lara
Lloyd
Lorraine
Augusta
Caroline
Amy
Grace
Emily
Duane
Julie
Edwin
Alice
Joel
Alma
Elmer
Eileen
Irene
Leonard
Anne
Esther
Melvin
Sandra
Cheryl
Renee
Larry
Jacob
Kevin
Cynthia
Adolph
Warren
Nicholas
Randal
Virginia
Raymond
Gregory
Bruce
Jessica
Jonathan
Kristin
Patrick
Rudolph
Marta
Kathleen
Janice
Stephen
Julie
Edwin
Alma
Gary
Joanne
Caroline
Duane
Emily
Grace
Glen
Sara
Dana
Karl
Kurt
Louis
Keith
Lori
June
Dean
Dale
Jon
Herman
Gene
Claire
Linda
Alvina
Karl
Kurt
Rodney
Ruben
Heinrich
Glenn
Susan
Harlan
Ronald
Timothy
Craig
Laura
Peter
Matthew
Michel
Rudolph
Patrick
Kathleen
Janice
Kathleen
Bradley
Rebecca
Helen
Jennifer
Christine
Lydia
Margaret
Kenneth
Ernestine
Sharon
Karen
Thomas
Friedrich
Daniel
Frederick
Carol
Bruce
Roger
Mark
William
Michael
Anny
Lynn
Johnny
James
Robert
Louise
David
Lee
Richard
Daniel
Emil
Jean
Elizabeth
Edward
Albert
George
Steven
Bertha
kai
Brian
Scott
Allen
Otto
Carl
Jeffrey
Herbert
Walter
Arthur
Charles
Patricia
Suzanne
Paul
Donald
Harold
Henry
Douglas
Josephine
Johann
Christopher
Anna
Wilhelm
Diane
Alan
Todd
August
Andrew
Martha
Barbara
Eugene
Jane
Louise
Robert
Mae
Lisa
Ruth
Martin
Ryan
Ida
Jo
Rae
Loy
Howard
Julius
Rustin
Leroy
Emma
Amanda
Adam
Larry
Renee

Applications

- Facial recognition
- Self-driving vehicles
- Automatic detection of tumors in CT scans
- Deep fake
- ...

Natural Language Processing

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Natural Language Processing (NLP)

The ability for computers to understand the meaning of human language

Bag of words

It is a period of civil war. Rebel spaceships, striking from a hidden base, have won their first victory against the evil Galactic Empire.

During the battle, Rebel spies managed to steal secret plans to the Empire's ultimate weapon, the DEATH STAR, an armored space station with enough power to destroy an entire planet.

Pursued by the Empire's sinister agents, Princess Leia races home aboard her starship, custodian of the stolen plans that can save her people and restore freedom to the galaxy....

the	7
to	4
rebel	2
plans	2
of	2
her	2
empire's	2
an	2
...	...

Bag of words

"U2 is a great band"

Word	Count
U2	1
Queen	0
is	1
a	1
great	1
band	1

"Queen is a great band"

Word	Count
U2	0
Queen	1
is	1
a	1
great	1
band	1

Bag of words: n-grams

"That book is not great"

Word	Count
That	1
book	1
is	1
not	1
great	1

2-gram (bi-gram)

Word	Count
That book	1
book is	1
is not	1
not great	1

Bag of words: limitations

- Word counts don't help us consider synonyms
- Example: "blue"
  - "sky-blue"
  - "aqua"
  - "cerulean"
- Want to group as a single feature

Word embeddings

Word embeddings

- Create features that group similar words
- Features have a mathematical meaning:

```
king - man + woman = queen
```

Language translation

Applications

- Language translation
- Chatbots
- Personal assistants
- Sentiment analysis
- ...

Deep learning

- Two types of problems
  - Computer vision
  - Natural language processing
- Why deep learning?
  - Complex problems
  - Automatic feature extraction
  - Lots of data

Limits of machine learning

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Data quality

- Garbage in garbage out
- Output quality depends on input quality

How it can go horribly wrong

Amazon's gender-biased recruiting tool

- Recruiting software to help review resumes
- Preferred men because it learned from historic data when more men were hired
- It downgraded resumes that
  - contain the word "women"
  - implied the applicant was female

How it can go horribly wrong

Microsoft's AI chatbot

Beware

- Don't blindly trust your model
- Awareness is key
- Pay attention to your data

A machine learning model is only as good as the data you give it

Quality assurance

- High-quality data requires:
  - Data analysis
  - Review of outliers
  - Domain expertise
  - Documentation

Explainability

Explainability

- Transparency to increase trust, clarity, and understanding
- Use cases: business adoption, regulatory oversight, minimizing bias

Explainable AI

Black box

- Deep learning
- Better for "What?"
- Highly accurate predictions

Explainable AI

- Traditional machine learning
- Better for "Why?"
- Understandable by humans

Example: Explainable AI

1. **Prediction:** Will the patient get diabetes?
2. **Inference:** Why will this happen

Example: Inexplicable AI

Prediction only: Which letter is this likely to be?

Congratulations!

UNDERSTANDING MACHINE LEARNING

Chapter 1

- What is machine learning?
- Machine learning concepts and workflow

Chapter 2

- Different types of machine learning
- How we evaluate and improve machine learning models

Chapter 3

- Deep learning, including computer vision and natural language processing
- Limits of machine learning

What's next?

- Machine Learning Scientist
- Machine Learning Fundamentals
- Supervised Machine Learning
- Unsupervised Machine Learning