

Machine Learning

Introduction

Carl Henrik Ek - carlhenrik.ek@bristol.ac.uk

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<http://www.carlhenrik.com>





\$20 Off Baby Coupon



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- *"My daughter got this in the mail!. She's still in high school, and you're sending her coupons for baby clothes and cribs? Are you trying to encourage her to get pregnant?"*



\$20 Off Baby Coupon

- "*My daughter got this in the mail!. She's still in high school, and you're sending her coupons for baby clothes and cribs? Are you trying to encourage her to get pregnant?*"
- "*I had a talk with my daughter, It turns out there's been some activities in my house I haven't been completely aware of. She's due in August. I owe you an apology*"

"artificial intelligence is our biggest existential threat"
– Elon Musk, The Guardian Oktober 2014

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*"I agree with Elon Musk and some others on this and
don't understand why some people are not concerned."*

– Bill Gates, January 2015

"artificial intelligence is our biggest existential threat"

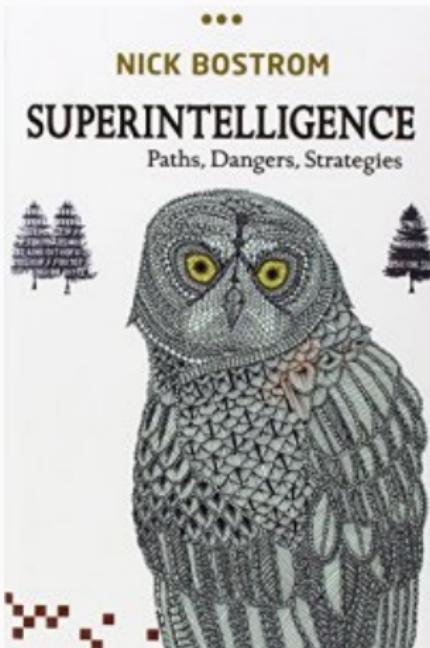
– Elon Musk, The Guardian Oktober 2014

*"I agree with Elon Musk and some others on this and
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*"Artificial intelligence could wipe out humanity when it
gets too clever as humans will be like ants."*

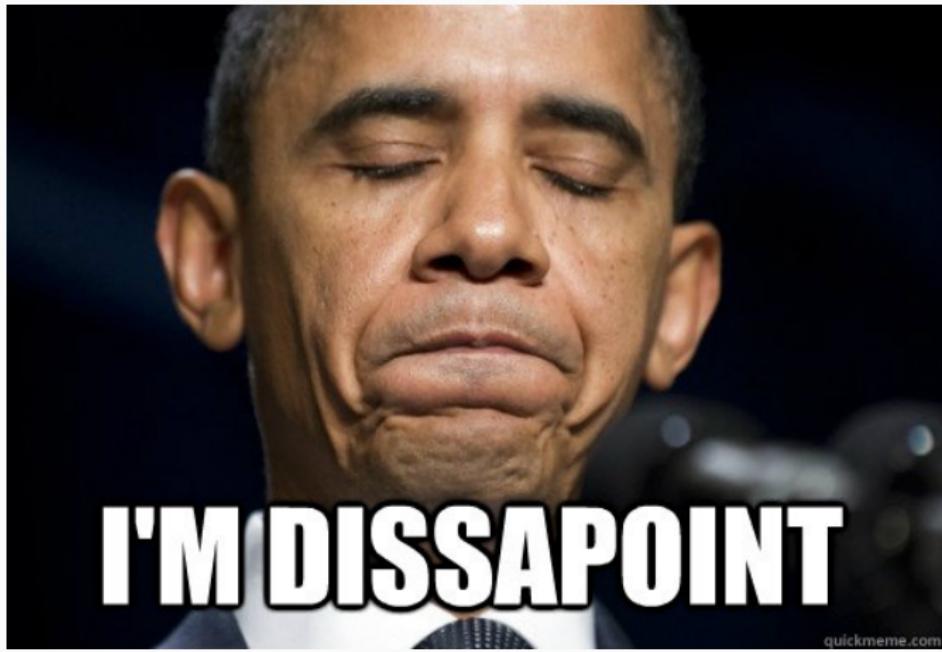
– Prof. Steven Hawking, The Independent, October 2015



Nick Bostrom







I'M DISSAPPOINT

quickmeme.com



*Artificial Intelligence is just what statistics is called by statisticians
who are not clever enough to understand what they do*

Work



- 1990
- 36.0×10^9 USD
- 1.2 million

Work



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11% of the Detroit workforce is generating 30 times as much wealth in SF



Machine Learning

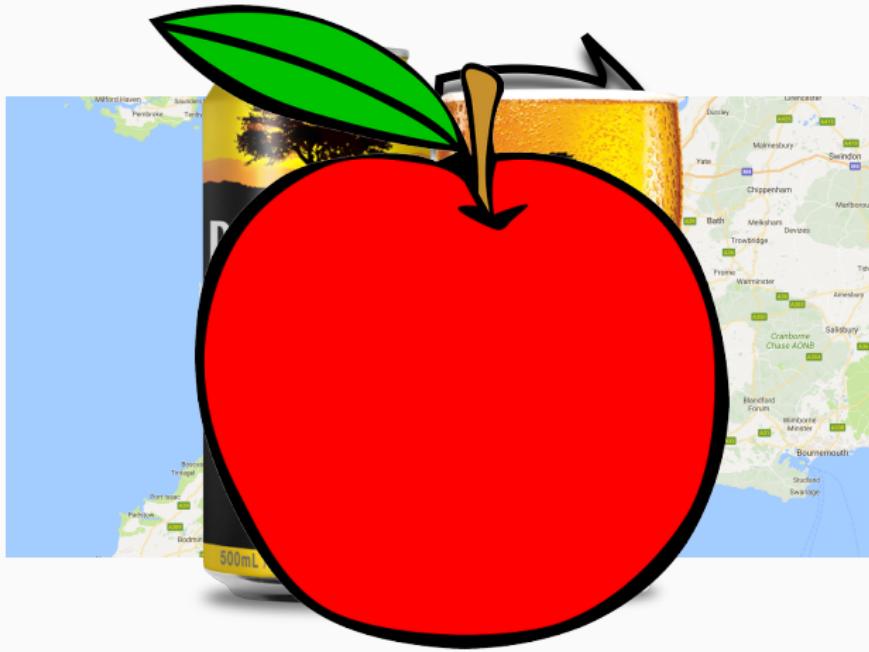
Me

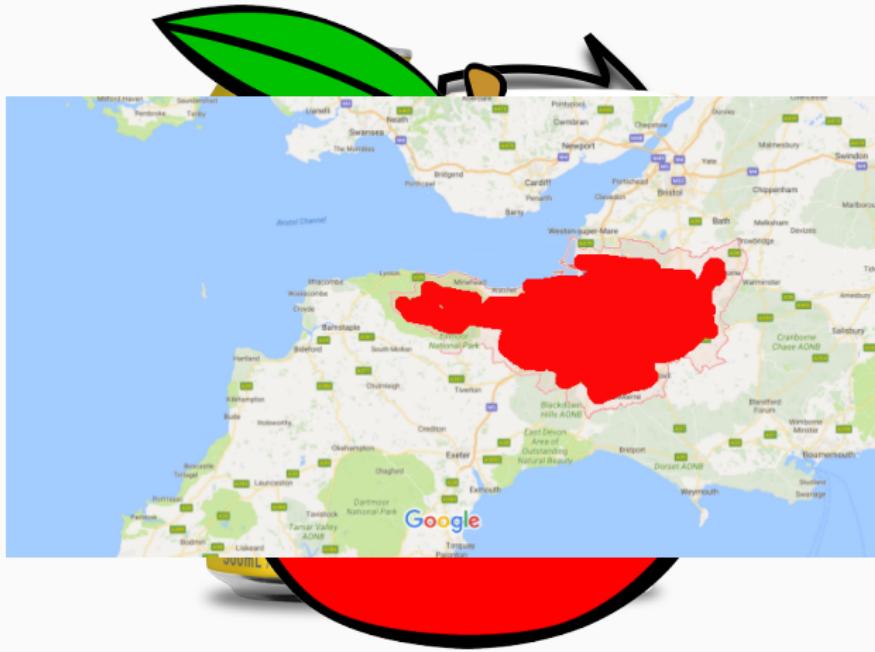


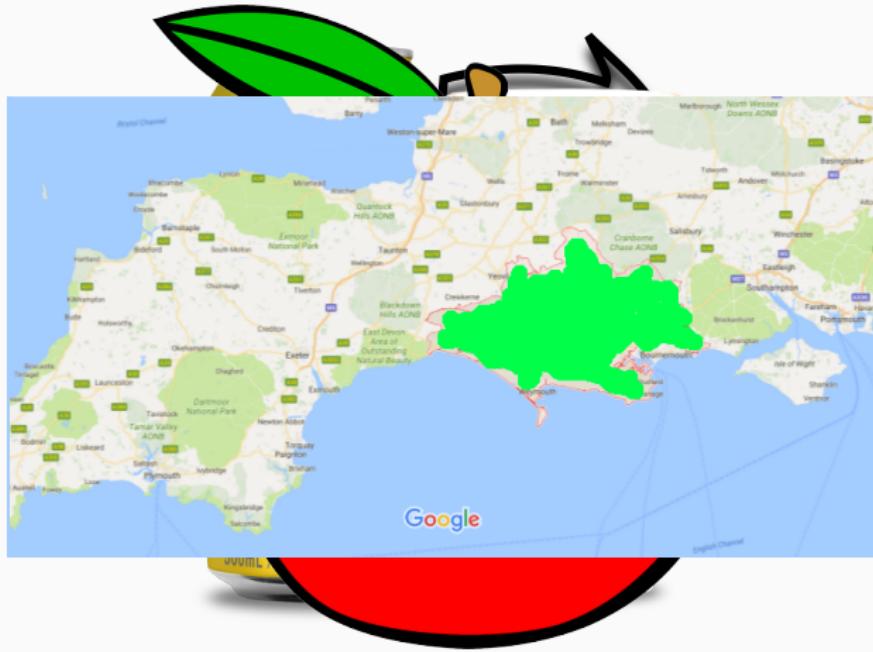


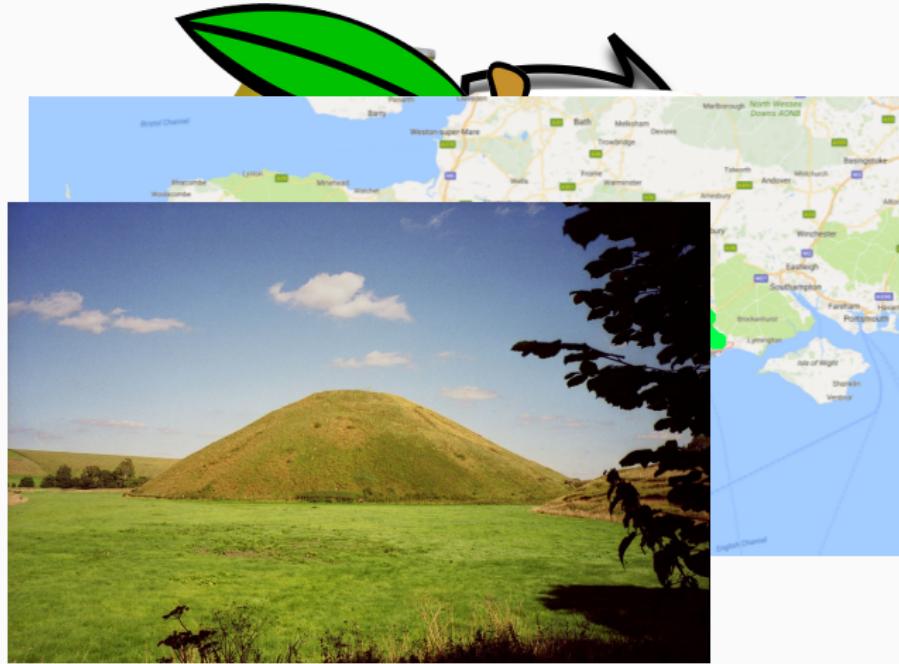


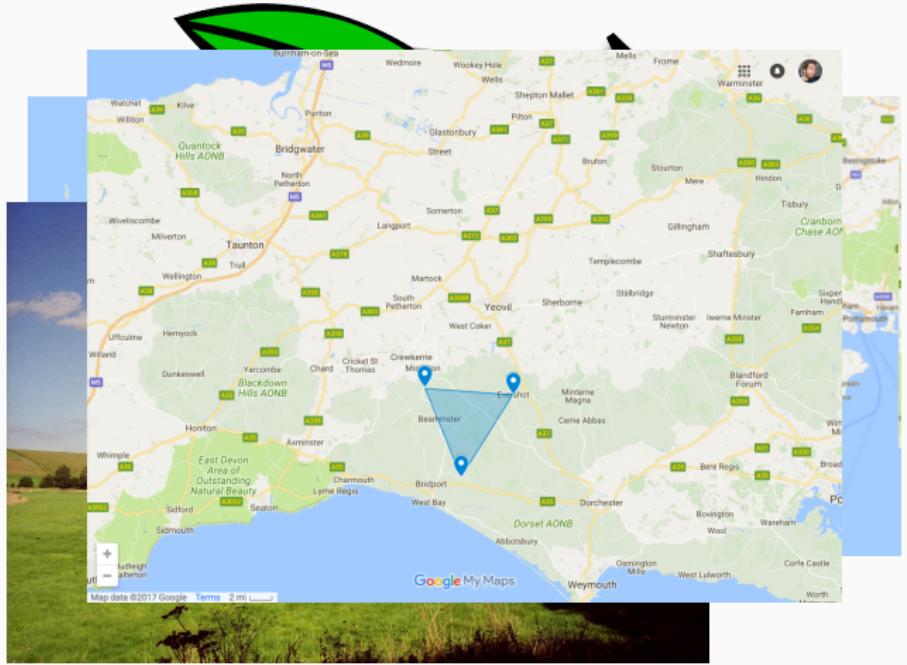




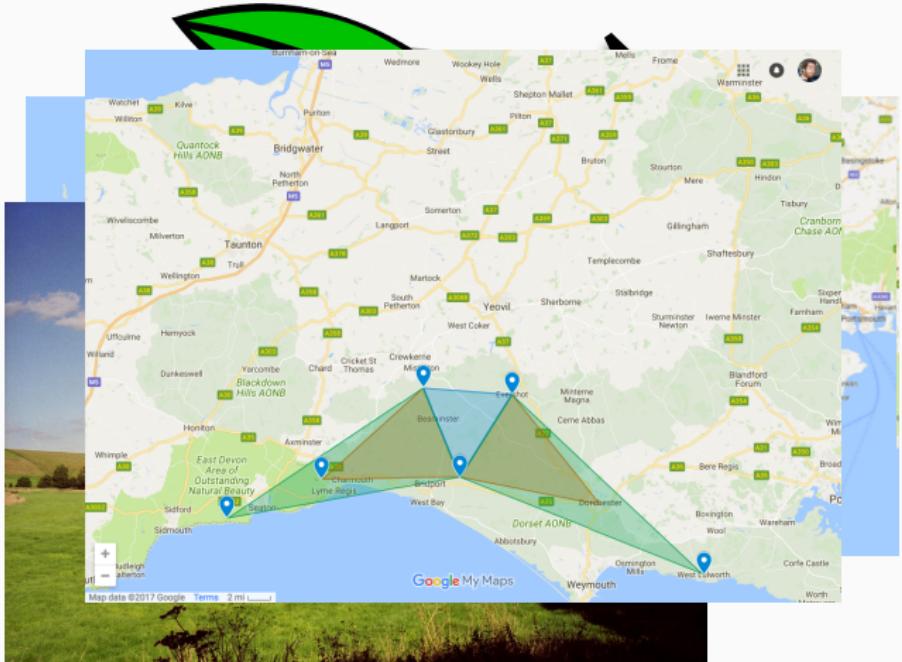


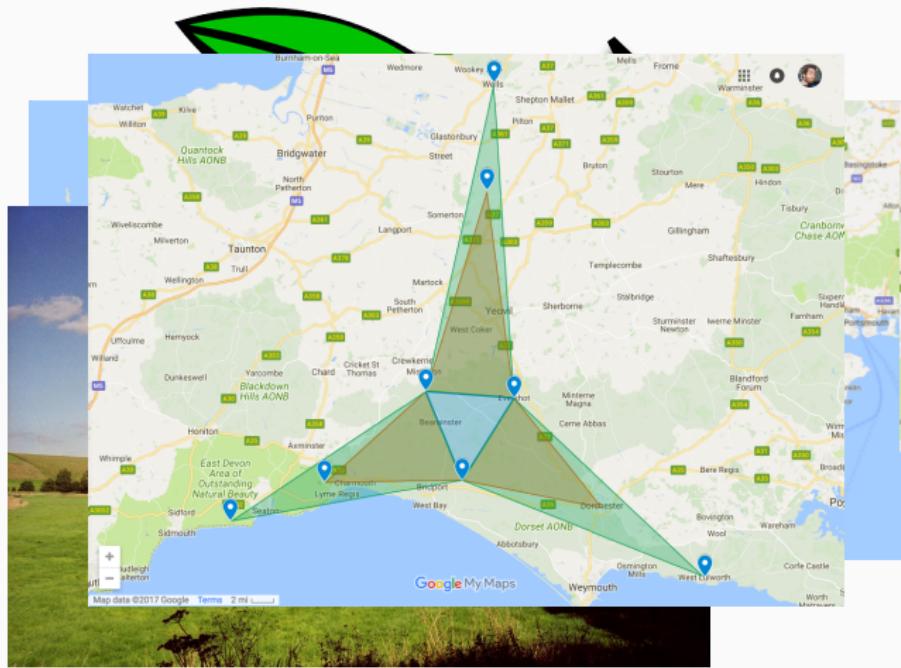


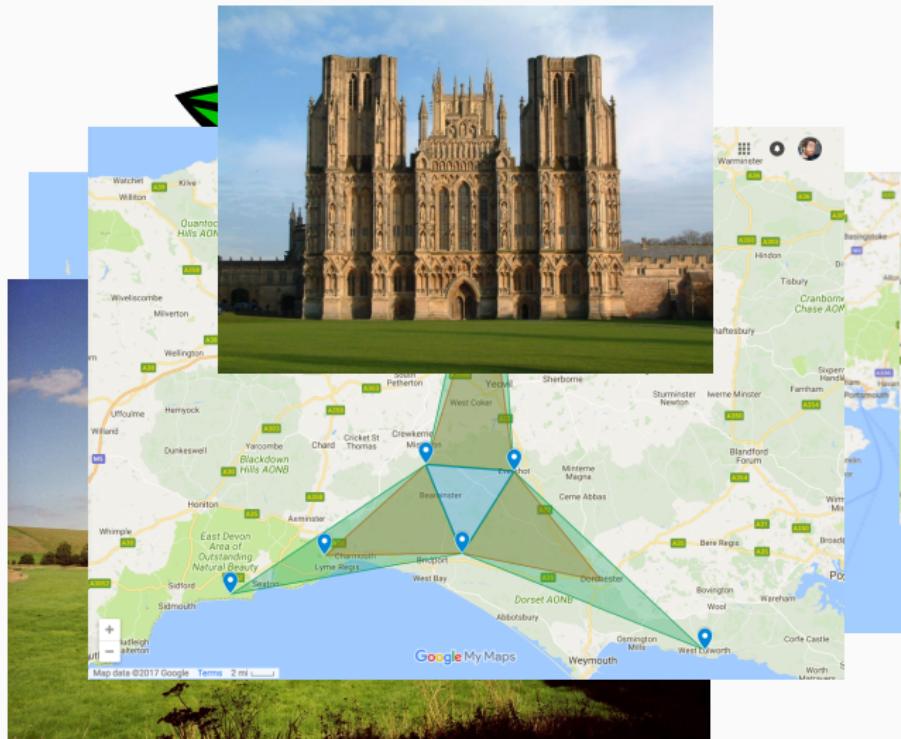


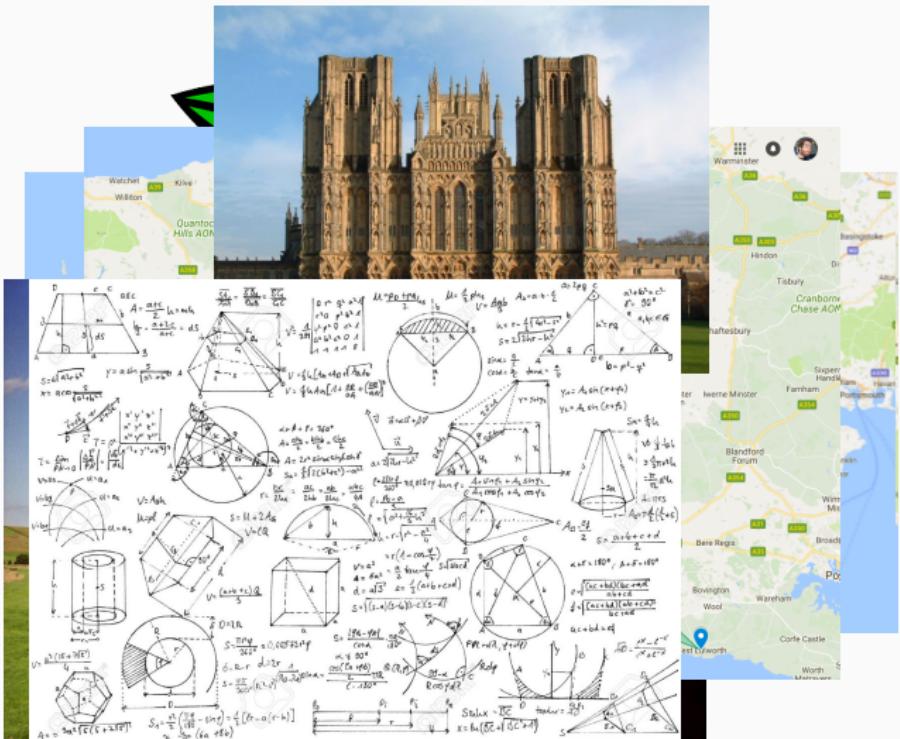


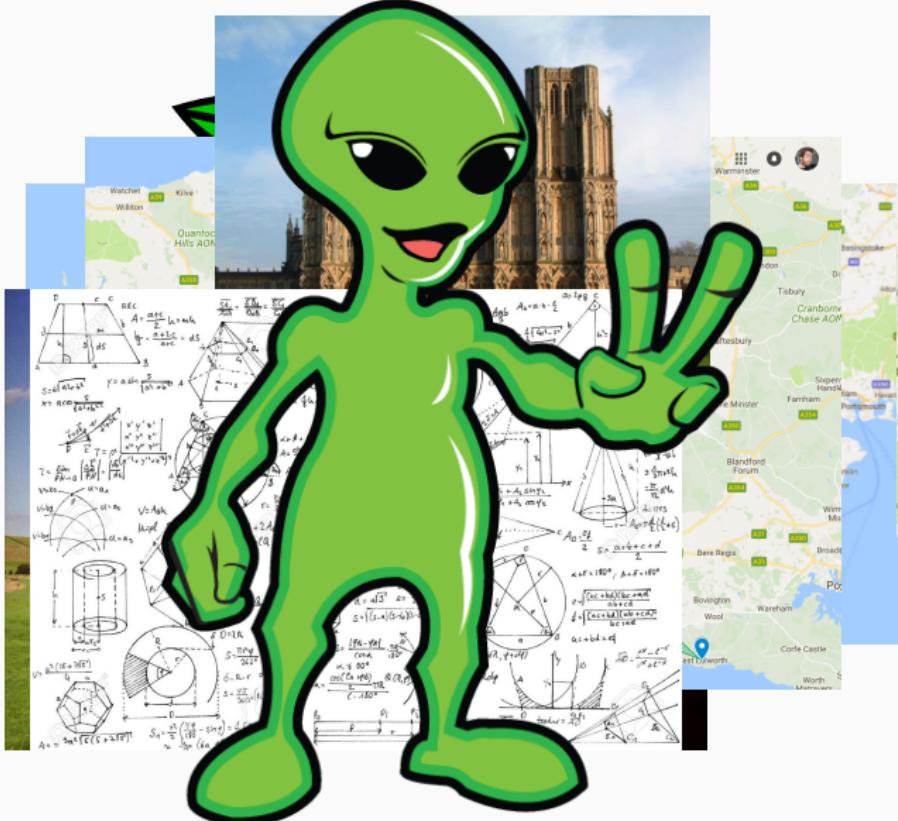






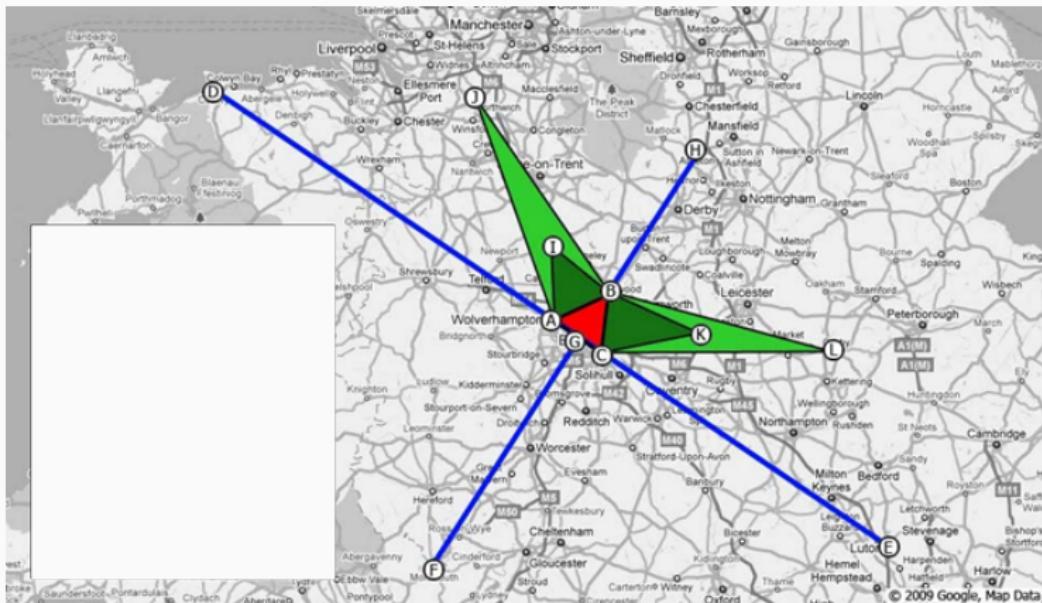








"Brooks has proved, he explains, that there were keen mathematicians here 5,000 years ago, millennia before the Greeks invented geometry: "Such is the mathematical precision, it is inconceivable that this work could have been carried out by the primitive indigenous culture we have always associated with such structures . . . all this suggests a culture existing in these islands in the past quite outside our expectation and experience today." He does not rule out extraterrestrial help." – The Guardian





"We know so little about the ancient Woolworths stores," he explains, "but we do still know their locations. I thought that if we analysed the sites we could learn more about what life was like in 2008 and how these people went about buying cheap kitchen accessories and discount CDs"

– Matt Parker, The Guardian



Inductive Reasoning

"In inductive inference, we go from the specific to the general. We make many observations, discern a pattern, make a generalization, and infer an explanation or a theory"

– Wassertheil-Smoller

¹https://en.wikipedia.org/wiki/Inductive_reasoning

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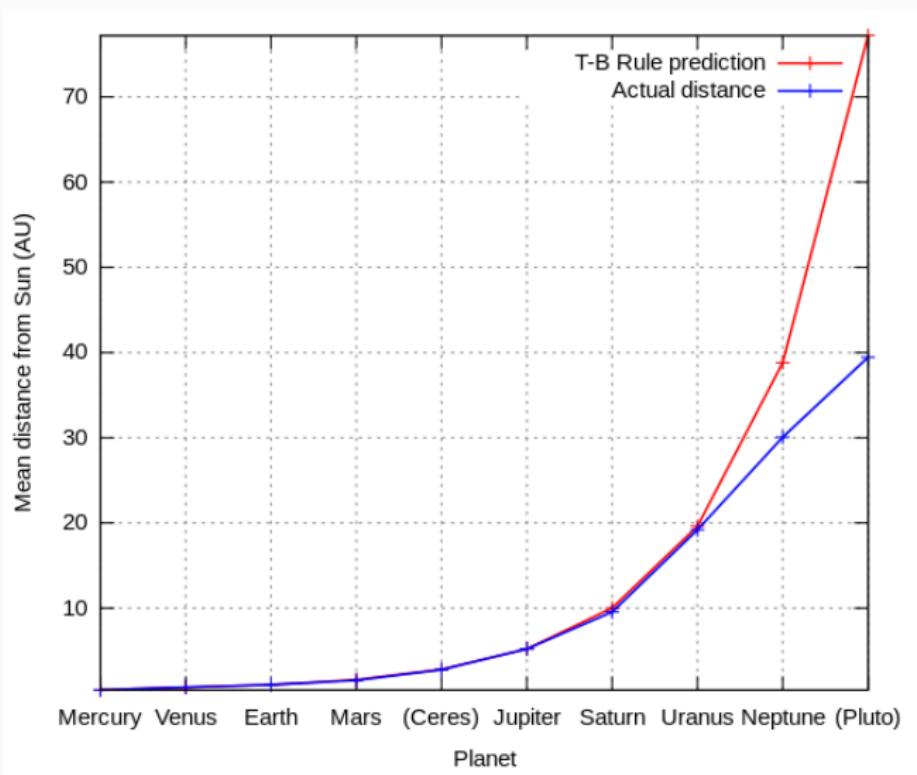
Inductive reasoning

Unlike deductive arguments, inductive reasoning allows for the possibility that the conclusion is false, even if all of the premises are true.¹

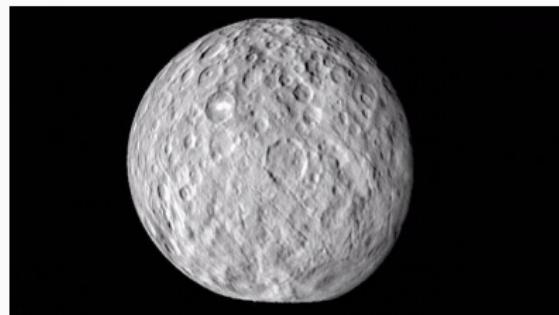
¹https://en.wikipedia.org/wiki/Inductive_reasoning



Titus-Bode



Ceres

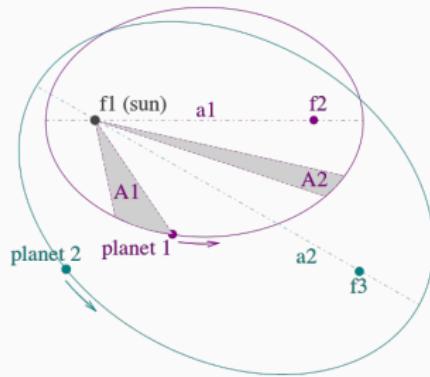


Piazzi Measurements

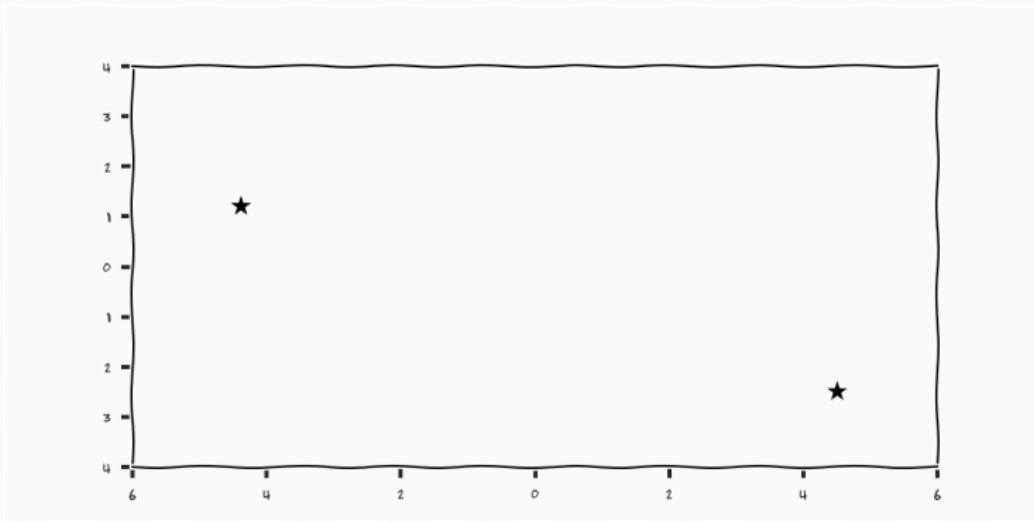
Beobachtungen des zu Palermo d. 1^{ten} Jan. 1801 von Prof. Piazzi neu entdeckten Gestirns.

1801	Mittlere sonnen- Zeit	Grade Aufstieg in Zeit	Grade Auf- steigung in Grad.	Nördl. Abweich.	Geocentr. iche Länge	Geocentr. Breite	Ort der Sonne + 20° Aberration	Logar. d. Distanz ⊙ ☿
Jan.	St ,	St ,	,	,	Z ,	Z ,	Z ,	
1	8 43 27,8	3 27 11,25	51 47 48,8	15 37 43,5	1 23 22 58,3	3 6 42,1	9 11 1 30,9	9,9926156
2	8 39 24,6	3 26 53,5	51 43 27,8	15 41 55,5	1 23 19 44,3	3 2 24,9	9 12 2 18,6	9,9926317
3	8 34 53,3	3 26 38,4	51 39 36,0	15 44 31,6	1 23 16 58,6	2 58 9,9	9 13 3 16,6	9,9926324
4	8 30 42,1	3 26 23 15,51	35 47,4	15 47 57,6	1 23 14 75,5	2 53 55,6	9 14 4 14,9	9,9926418
10	8 6 15,8	3 25 32,1	51 28 1,5	16 10 32,0	1 23 7 59,1	2 29 0,6	9 20 10 17,5	9,9927641
11	8 2 17,5	3 25 29,7	51 22 26,6	16 10 32,0	1 23 7 59,1	2 29 0,6	9 20 10 17,5	9,9927641
13	7 34 26,2	3 25 30,5	51 22 34,5	16 22 49,5	1 23 10 37,6	1 16 59,7	9 23 12 13,8	9,9928490
14	7 50 31,7	3 25 31,7	51 22 55,8	16 27 5,7	1 23 12 1,2	2 12 56,7	9 24 14 13,5	9,9928809
17	16 40 13,0
18	7 35 11,3	3 25 55,1	51 28 45,0	16 40 13,0
19	7 31 28,5	3 26 8,15	51 32 2,3	16 49 16,1	1 23 25 59,2	1 53 38,2	9 29 19 53,6	9,9930607
21	7 24 2,7	3 26 34,2	51 38 34,1	16 58 35,9	1 23 34 21,3	1 46 6,0	10 1 20 40,3	9,9931434
22	7 20 21,7	3 26 49,4	51 41 21,3	17 3 18,5	1 23 39 1,8	1 42 28,1	10 2 21 32,0	9,9931886
23	7 16 46,5	3 27 16,9	51 46 43,5	17 8 5,5	1 23 44 15,7	1 38 52,1	10 3 22 22,7	9,9932348
28	6 58 51,3	3 28 54,5	52 13 38,3	17 32 54,1	1 24 15 15,7	1 21 6,9	10 8 26 20,1	9,9935061
30	6 51 52,9	3 29 48,14	52 27 2,1	17 43 11,0	1 24 30 9,0	1 14 16,0	10 10 27 46,2	9,9936332
31	6 48 26,4	3 30 17,25	52 34 18,8	17 48 21,5	1 24 38 7,3	1 10 54,6	10 11 28 18,5	9,9937007
Febr.	1 6 44 59,9	3 30 47,2	52 41 48,0	17 53 36,3	1 24 46 19,3	1 7 30 9	10 12 29 9,6	9,9937703
2	6 41 35,8	3 31 19,06	52 49 45,9	17 58 57,5	1 24 54 57,9	1 4 12 5	10 13 29 49,9	9,9938423
5	6 31 31,5	3 33 2,70	53 15 49,5	18 15 1,0	1 25 22 43,4	0 54 23,9	10 16 31 45,5	9,9940751
8	6 21 39,2	3 34 58,50	53 44 37,5	18 31 23,2	1 25 53 29,5	0 45 5,0	10 19 33 33,3	9,9943276
11	6 11 58,2	3 37 6,54	54 16 38,1	1 26 47 58,8	1 26 26 30,0	0 36 2,9	10 22 35 13,4	9,9945823

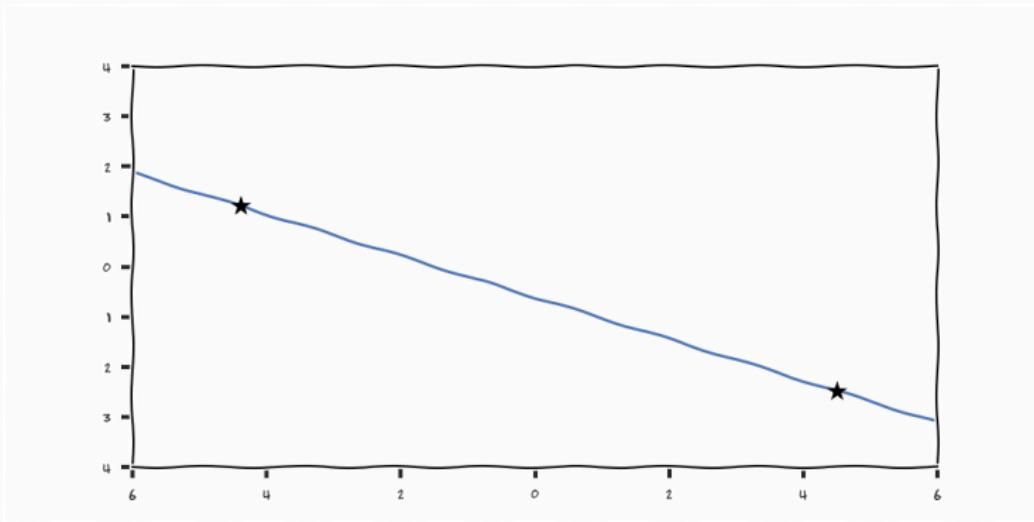
Keplers Law's



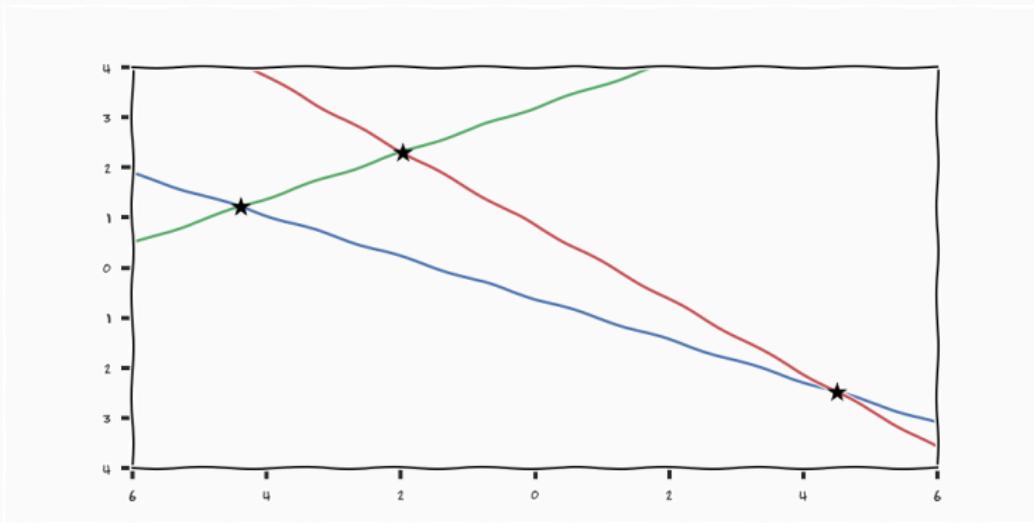
Data



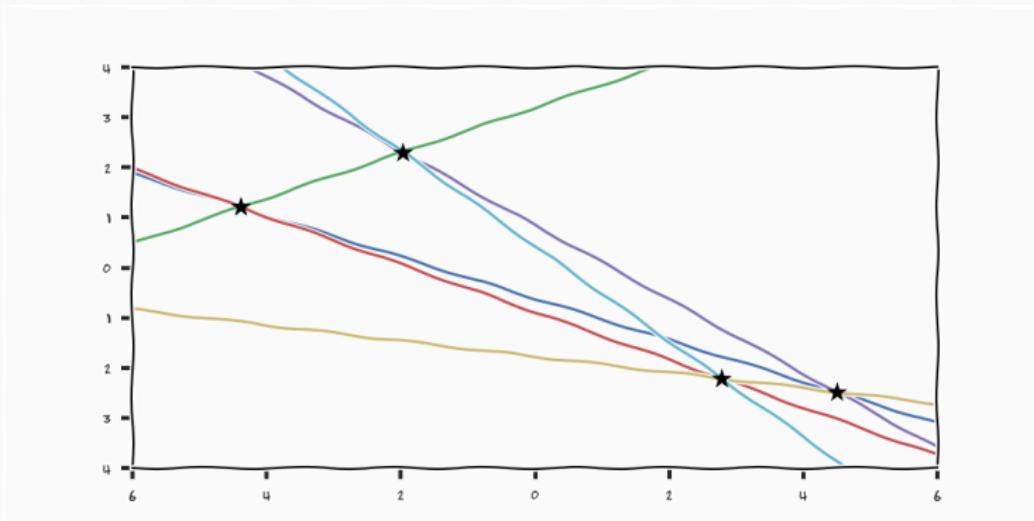
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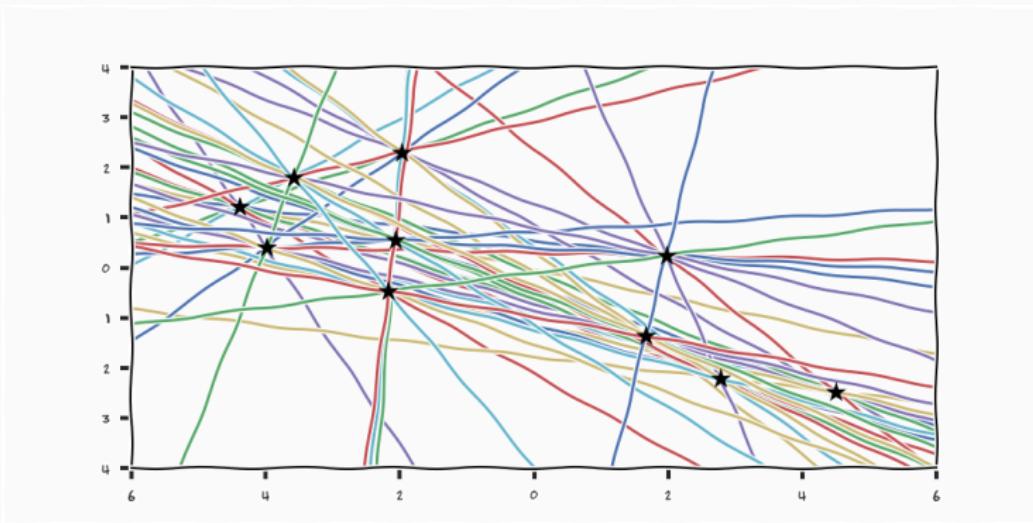
Model



Model



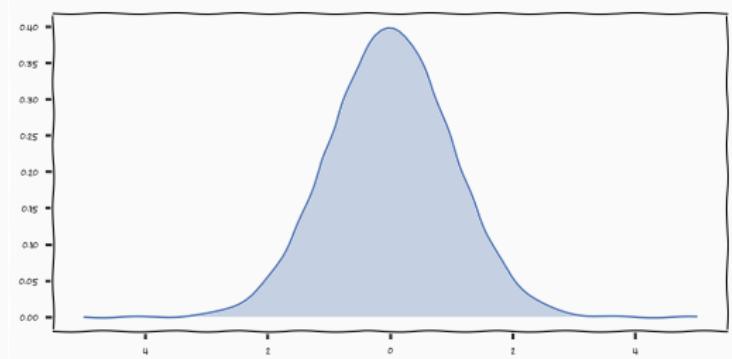
Model



Gauss



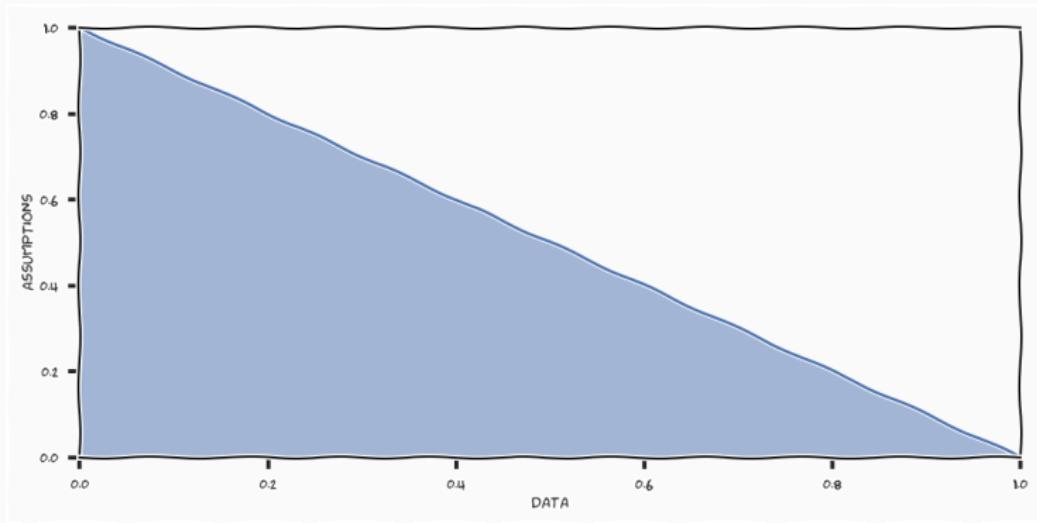
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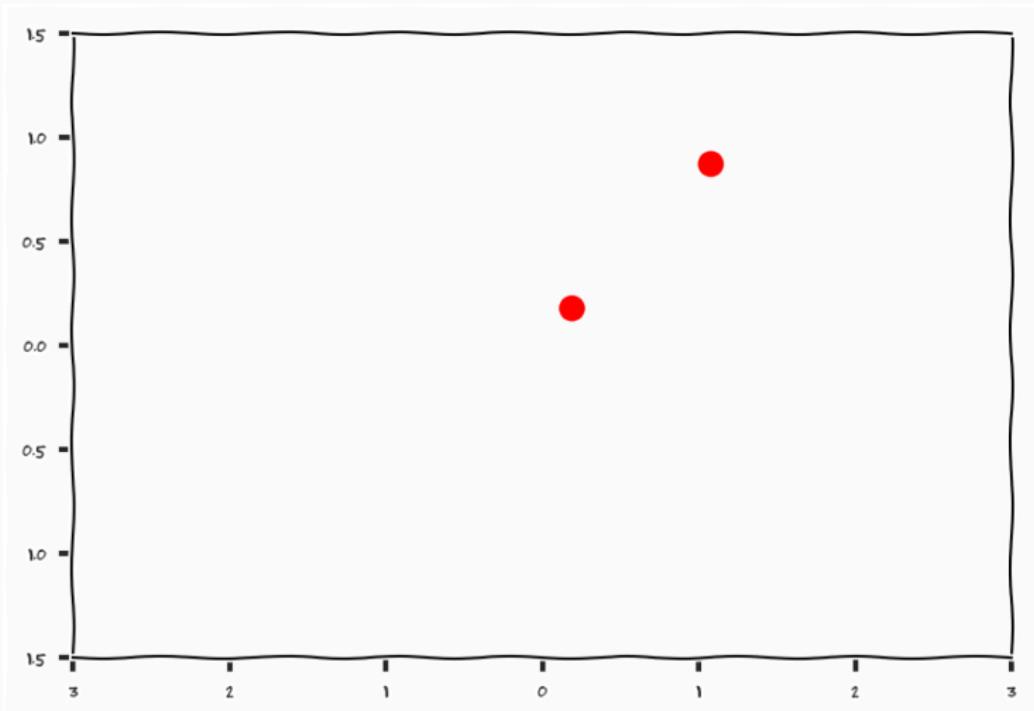
$$\text{measurement} = \text{truth} + \epsilon$$

$$\epsilon \sim \mathcal{N}(0, I)$$

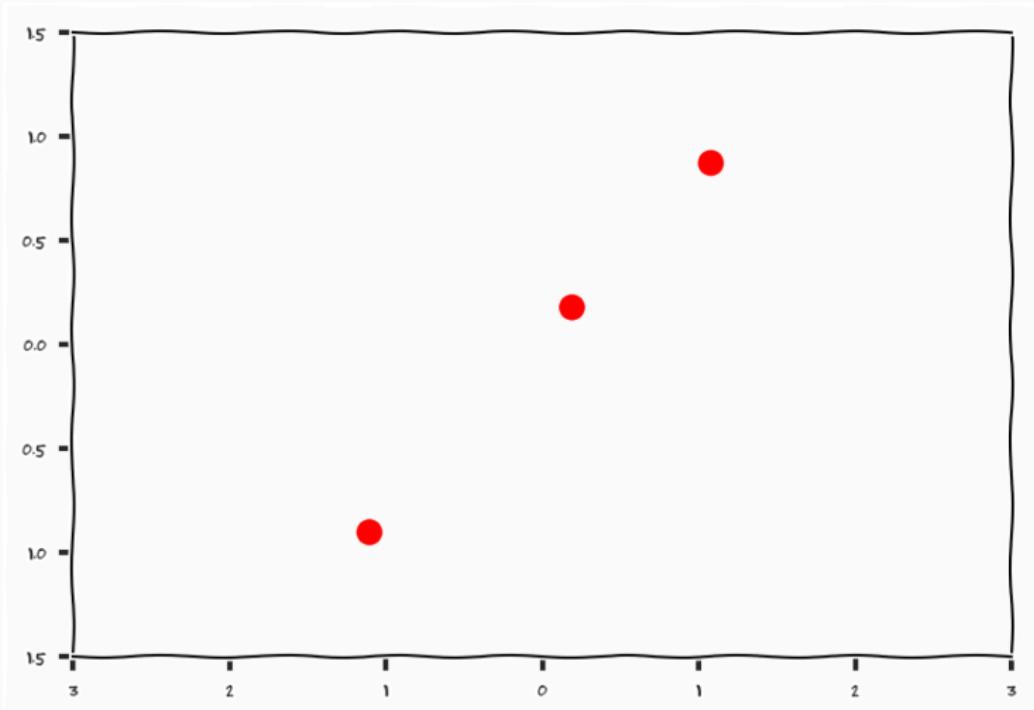
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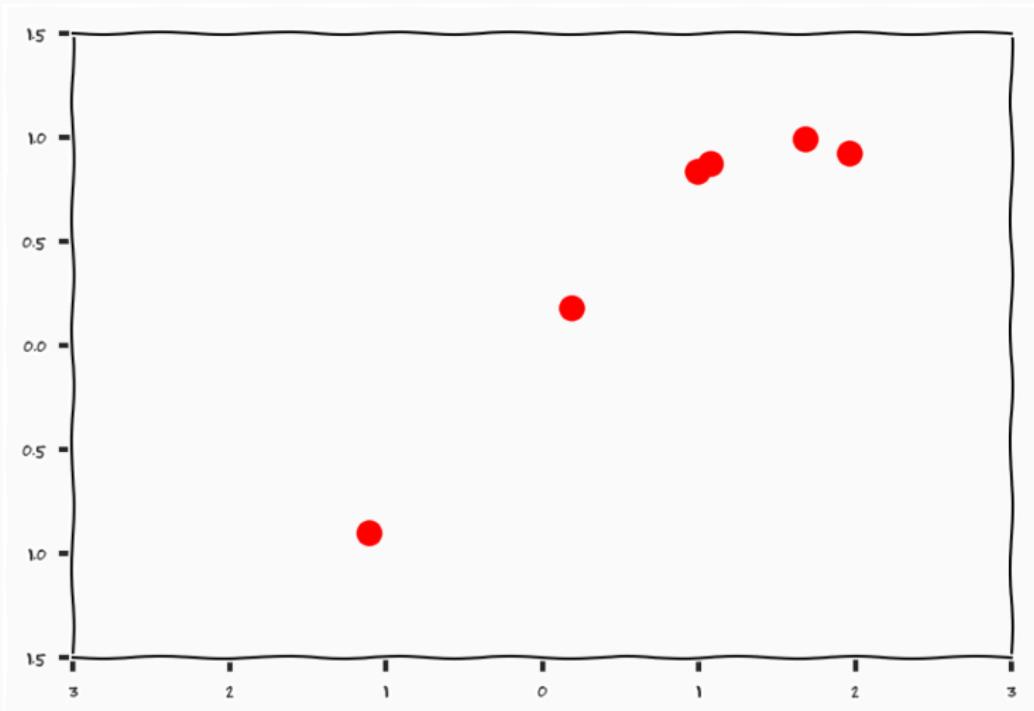
Data



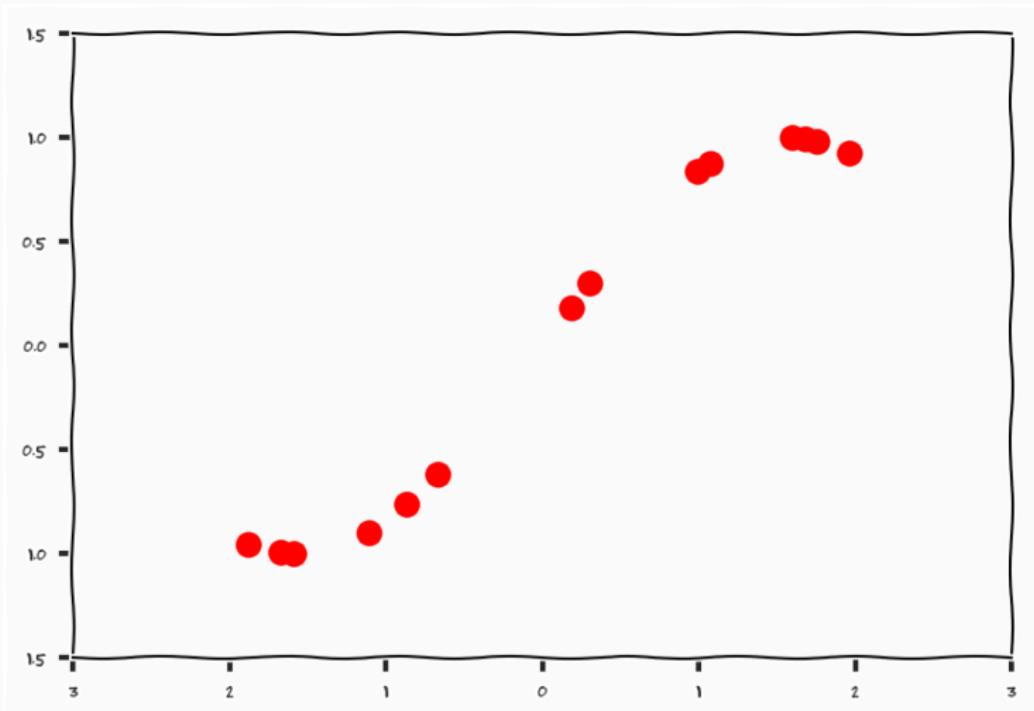
Data



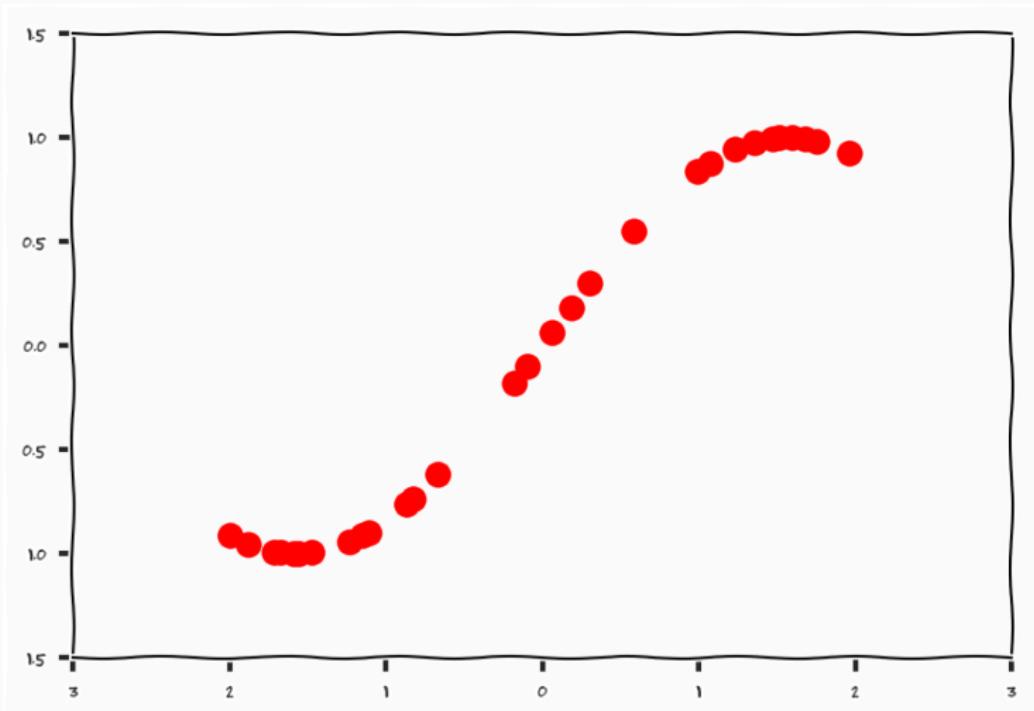
Data



Data



Data





- 16, 1066, 1456

Halley's Comet



- In 1705 predicted 1758
- Died 1742

The digital age

- 90% of all *stored* information was created the last two years

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- Every other day we create as much *stored* information that was created during the whole human civilisation till the year 2003

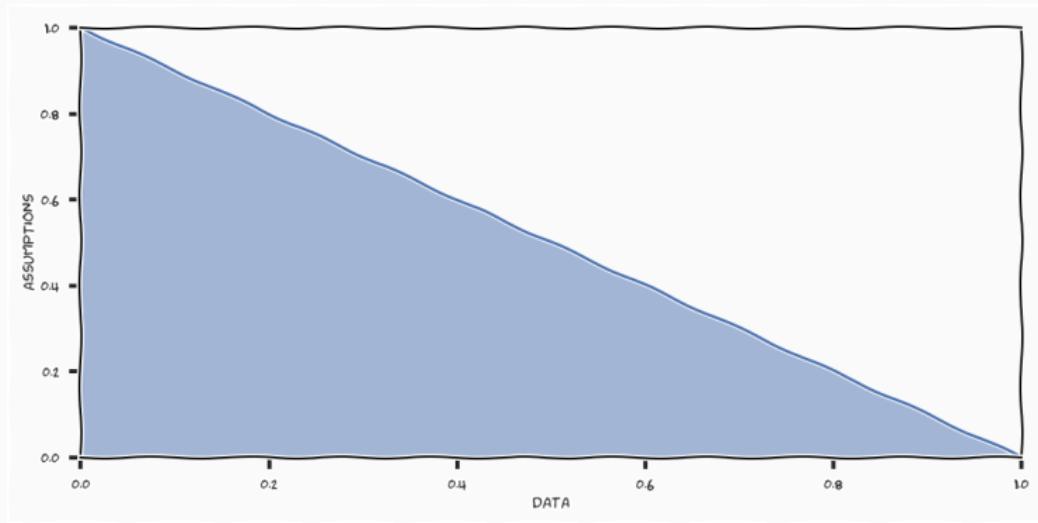
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- We create 10^{19} bytes of "data" every day

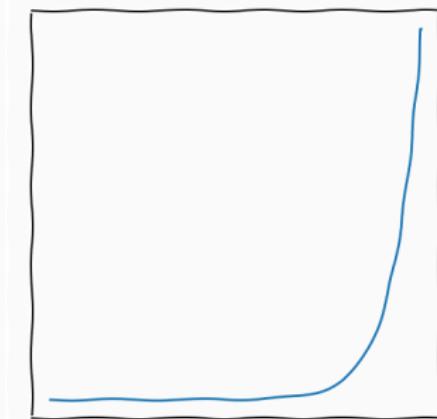
The digital age

- 90% of all *stored* information was created the last two years
- Every other day we create as much *stored* information that was created during the whole human civilisation till the year 2003
- We create 10^{19} bytes of "data" every day
- *more facts that are beyond grasp*

Data



Compute



The perfect storm



Machine Learning

- There is infinitely many equal explanations of a finite sample from infinite sample space
- We can only ever learn by choosing explanation based on assumptions
- You can falsify but not prove your assumptions
- Anything that you learn can only ever be reasoned about relative your assumptions

Assumptions is intelligence



Assumptions is intelligence²



²[https://www.economist.com/game-theory/2012/04/23/
in-the-blink-of-an-eye](https://www.economist.com/game-theory/2012/04/23/in-the-blink-of-an-eye)

The Task of Machine Learning

1. How can we formulate beliefs and assumptions mathematically
2. How can we connect our assumptions with data
3. How can we update our beliefs

Society



Machine Learning and Society



Machine Learning and Society



Ethnography



Kate Byron

Kate Byron

COMS30007



Lectures

Part I (4 lectures)

- What is learning
- Basic probability theory

Part II (10 lectures)

- modelling
- mathematical formulation of assumptions

Part III (4 lectures)

- Inference
- How do we fit models to data?
- Three different approaches

Part IV (2 lectures)

- Ethical Dilemmas and Machine Learning
- Summary of unit

Lectures



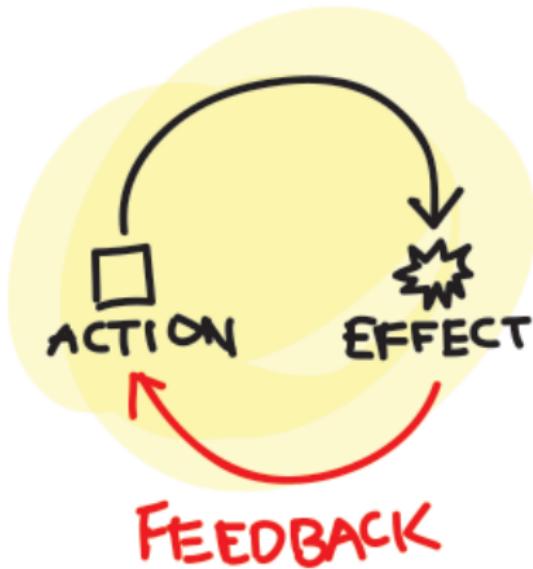
[summary.pdf](#)



reddit

<http://www.reddit.com/r/coms30007/>

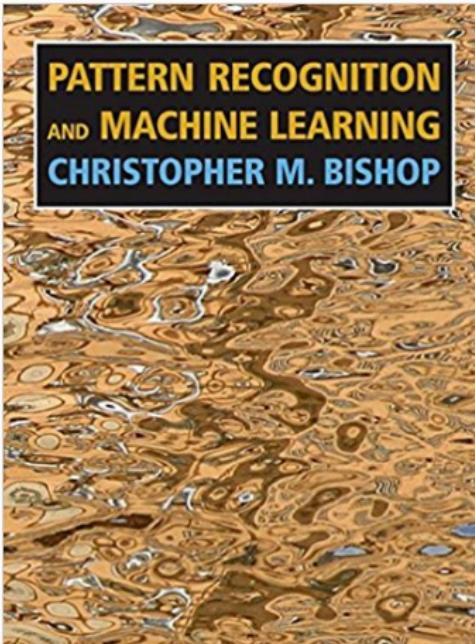
Feedback





<http://carlhenrik.com/COMS30007/>

The Book [1]



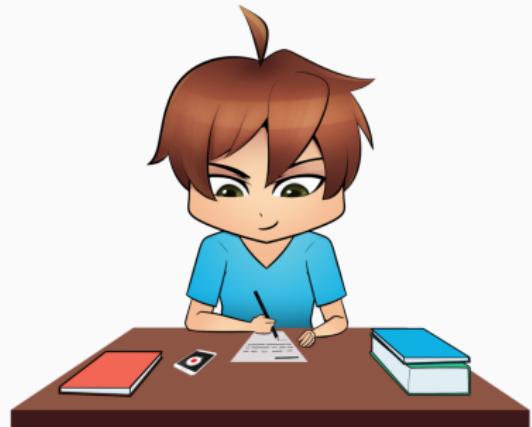
Bishop, C. M., Pattern recognition and machine learning
(information science and statistics) (2006)

Labs



Exam

- Multiple choice
- understanding
- conceptual aspects
- 100% of grade



Summary

Summary

- Learning can only be done by assumptions
- Machine learning is the science for making "handles" to incorporate assumptions
- We will learn mathematical formulations of assumptions
- We will learn mathematical tools for updating assumptions from data
 - *this is learning*

eof

References

 Christopher M. Bishop.

*Pattern Recognition and Machine Learning (Information
Science and Statistics).*

Springer-Verlag New York, Inc., Secaucus, NJ, USA, 2006.