

Philip Avchinnikov - My notes

Bad way

How we need to do on lectures

CHALK+TALK

ink+think

1 listening

2 first way of processing

3 Writing, incl. sth., you're not quite sure about

Walking in Oxford on a cold and rainy day

With prof. Matthias Winkel

DEPARTMENT OF STATISTICS

University of Oxford

difference in school and university logic terms

School $\rightarrow$ gravity $\rightarrow$ MOTION $\Rightarrow$ formalism $\Rightarrow$ University $E=MC^2$ $\nabla \cdot \vec{J} = \rho$ $\oint \vec{J} \cdot d\vec{s}$

CONCRETE AND ABSTRACT THINKING

Newton - ideas

Einstein - formulas creation (laws)

gravity

Why falling?

MOTION

Acceleration

ISAAC NEWTON

Albert Einstein

$E=MC^2$

$W=2\pi f$

$\beta = \frac{\Delta T_c}{\Delta T_a}$

$E = \frac{1}{2} h \sqrt{k/m}$

$\nabla \cdot \vec{J} = \rho$

$\lambda = \frac{h}{\sqrt{2em_0c}}$

$E = \frac{1}{2} N \sqrt{k/m}$

$\vec{S} = \frac{1}{\mu_0} (\vec{E} \times \vec{B})$

$m_e = N \cdot M_0 \cdot \frac{Q}{V_e} \cdot \frac{N_0}{N_0}$

$I = \frac{V_0}{R + R_0}$

$(\vec{E} \times \vec{B})$

$\oint \vec{J} \cdot d\vec{s}$

$\vec{S} = \frac{1}{\mu_0} (\vec{E} \times \vec{B})$

GAUSS

ALBERT EINSTEIN

founder of modern high math

Motivation: 80% chance of rain

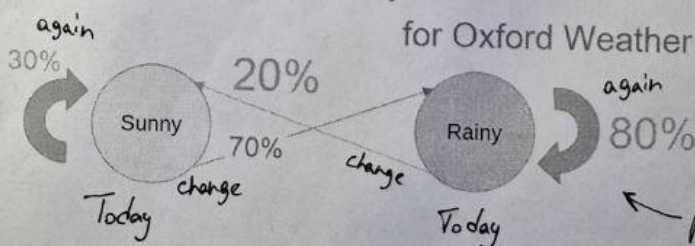
Let A_j be the event of rain at 9am on day j of this term, $1 \leq j \leq n$

Suppose the events A_j are independent

Oxford

Tue 12th	Wed 14th	Thu 15th	Fri 16th
10° 9° 70%	13° 10° 70%	13° 8° 70%	11° 7° 100%

Markoff Chain Probability Model



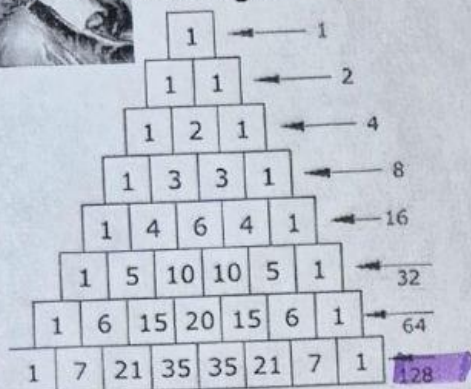
Philosophy: is weather random?

like Bean machine
50/50 chance right/left)

next is a sum
of two upper



Pascal's triangle



was invented to
solve

$$\begin{aligned}
 (a+b)^0 &= 1 \\
 (a+b)^1 &= a+b \\
 (a+b)^2 &= a^2 + 2ab + b^2 \\
 (a+b)^3 &= a^3 + 3a^2b + 3ab^2 + b^3 \\
 (a+b)^4 &= a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4 \\
 (a+b)^5 &= a^5 + 5a^4b + 10a^3b^2 + 10a^2b^3 + 5ab^4 + b^5 \\
 (a+b)^7 &= a^7 + 7a^6b + 21a^5b^2 + 35a^4b^3 + 35a^3b^4 + 21a^2b^5 + 7ab^6 + b^7 \\
 (a+b)^9 &= a^9 + 9a^8b + 36a^7b^2 + 84a^6b^3 + 126a^5b^4 + 126a^4b^5 + 84a^3b^6 + 36a^2b^7 + 9ab^8 + b^9
 \end{aligned}$$

Newton's Binomial

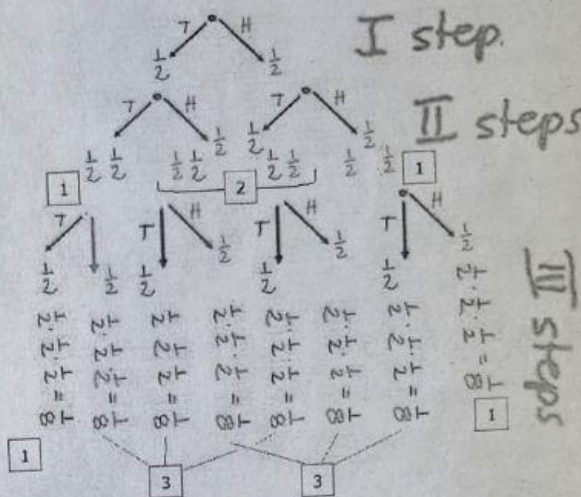


here is chance of final
position of ball

$$\begin{array}{r}
 1/8 \ 28/56 \ 70/56 \ 28/8 \ 1 \\
 \hline
 1/9 \ 36/92 \ 126/126 \ 92/36 \ 9/1
 \end{array}$$



ball $\Rightarrow$ it has 50% prob. to go left
& 50% prob. to go right
and then the same



Events & probabilities

11.02

Experiment: Ω of outcomes

$\omega \in \Omega$ - sample space

coin($\Omega = \{H, T\}$); dice($\Omega = \{1, 2, 3, 4, 5, 6\}$)

A - event, A^c - compliment

Union: $A \cup B$ (both); Intersection: $A \cap B$ (smth in A and B)

$A \setminus B = A \cap B^c$ (A-occur; B - doesn't occur)

Disjoint: $A \cap B = \emptyset$ (doesn't have smth in common)

P - probability; Ω - finite (all outcomes equally likely)

$$P(A) = \frac{|A|}{|\Omega|}$$

Elementary combinatorics

n - distinguishable objs    3!

GALOIS

C_m^n - binominal coefficient

$$(a+b)^6 = a^6 + 6a^5b + 15a^4b^2 + 20a^3b^3 + 15a^2b^4 + 6ab^5 + b^6$$

$$e^{j\pi} = -1$$

УВ: Laplace's rule, матожидание, багунное

Boolean algebra = Boolean logic what
= Syllogism

Без спогоні зник → чужеземч
Погресивчє → ср. змч
Погресивчє → чужеземч



Massachusetts Institute of Technology (MIT)

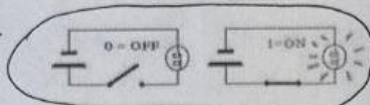


Lecture by Pr. Bob Gallagher

Boole (1815-1864) & Shannon (1916-2001)



Shannon



Logical addition
(disjunction)

A	B	F = A ∨ B
0	0	0
0	1	1
1	0	1
1	1	1

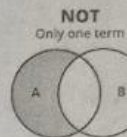
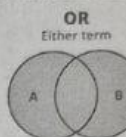
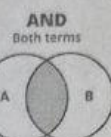
A	B	A ∨ B
True	True	True
True	False	True
False	True	True
False	False	False

Logical disjunction



Definition
Truth table
Logic gate

BOOLEAN LOGIC



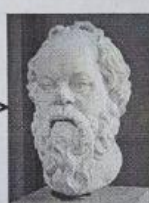
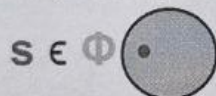
it's great
but Boole
is famous
for
Boolean
algebra

Boole => true/false
Aristotelian => all men/some men/
no men

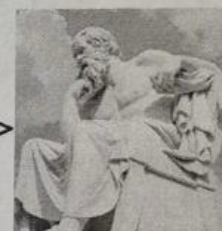
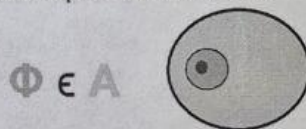
Good logic



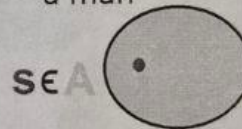
Socrates was
a philosopher



philosophers are men



Socrates was
a man



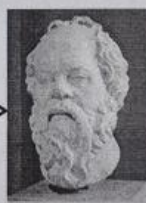
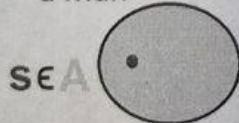
For ancient
Greece
(not Germany
and modern)

because of
Mannah Arendt (woman)

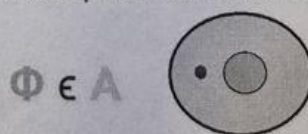
Bad logic



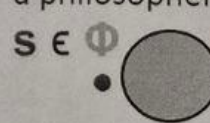
Socrates was
a man



philosophers are men



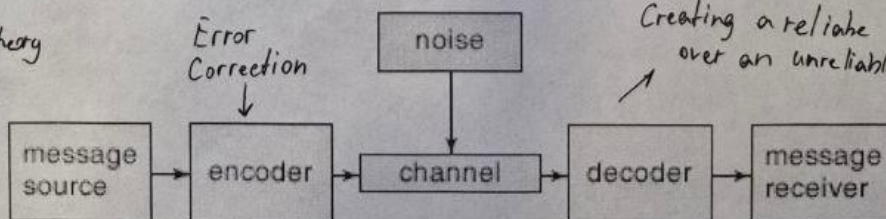
Socrates was
a philosopher



Because work
for all

This is what
classical Info Theory
about

Shannon
did this



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S

t - coded transmission

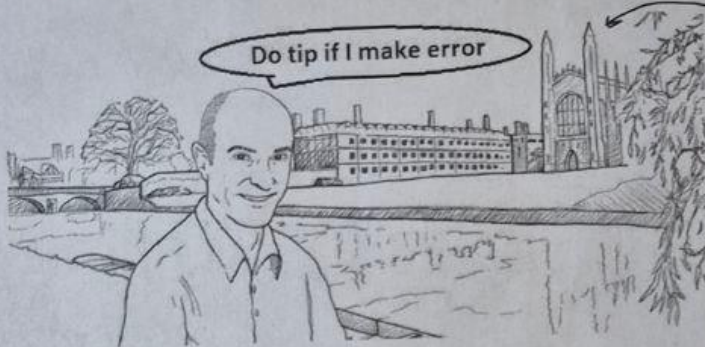
r - received

n - noise

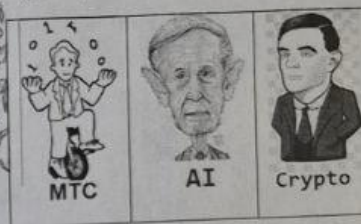
infers
S ≠ n

Creating a reliable connection
over an unreliable (noisy) channel

+0.1

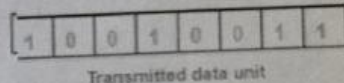


Sir Dr. D. MacKay,
University of Cambridge
(22 April 1967 – 14 April 2016)



if odd number of "1" $\downarrow$ 1

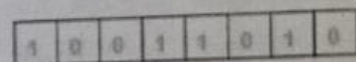
"I believe in clean energy,
but I also believe in mathematics"



Transmitted data unit

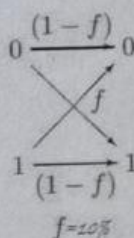
Parity bit

if even number of "1" $\downarrow$ 0



Transmitted data unit

Parity bit



f = probab of error

$f = 10\%$

R-3 $\Rightarrow$ 96, 3%

simple $\Rightarrow$ 90%

picture without noise



representation of R-3 logic (more copies $\Rightarrow$ less data loss)

Source sequence s	Transmitted sequence t
0	000
1	111

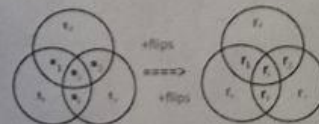
The repetition code R_3



SOURCE MESSAGE s	0	0	1	0	1	1	0
t	000	000	111	000	111	111	000
n	000	001	000	000	101	000	000
r	000	001	111	000	010	111	000
corrected errors	*						*
undetected errors							

7.4. Hamming code.

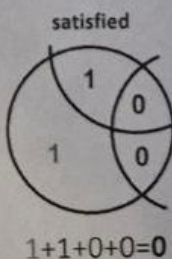
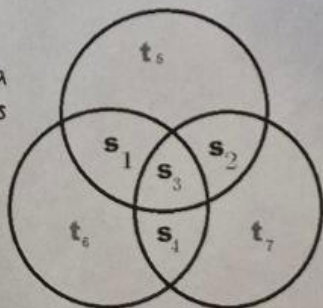
$$\frac{4}{\Sigma} \rightarrow \frac{7}{t}$$



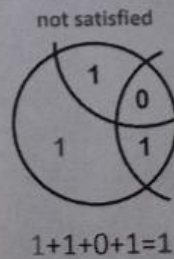
7 = total num of bits

4 = num of data bits

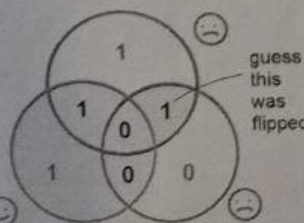
3 = 7 - 4
 $\downarrow$
parity bits



$$1+1+0+0=0$$



$$1+1+0+1=1$$



guess this was flipped

6	0	1	1	0	0	1	0
s_1	s_2	s_3	s_4	t_5	t_6	t_7	



Hamming code: $n = 2^m - 1$
 $m = 3$
 $n = 2^3 - 1 = 8 - 1 = 7$

Spoke more about Shannon because old as he didn't quite overlap with Boole

Resume of Lecture by Pr. Bob Gallager from MIT

MIT Massachusetts Institute of Technology (MIT)

Inventor of Boolean logic

George Boole (1815-1864) developed Boolean logic

The principles of logical thinking have been understood (and occasionally used) since the Hellenic era.

Boole's contribution was to show how to systemize these principles and express them in equations (called Boolean logic or Boolean algebra).

Claude Shannon (1916-2001) showed how to use Boolean algebra as the basis for switching technology. This contribution systemized logical thinking for computer and communication systems, both for the design and programming of the systems and their applications.

Logic continues to be abused in politics, religion, and most non-scientific areas.

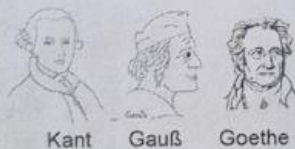
Logic continues to be abused in politics, religion and most non-scientific areas

Showed how to use Boolean log in techs

He invented Information theory

all spheres to understand themselves

some of people use bad logic and try to abuse the normal one



Kant Gauß Goethe

A little nationalistic, but this is an sample of right logic

Kant, Gauss, Goethe are great

Kant, Gauss, Goethe - Germans

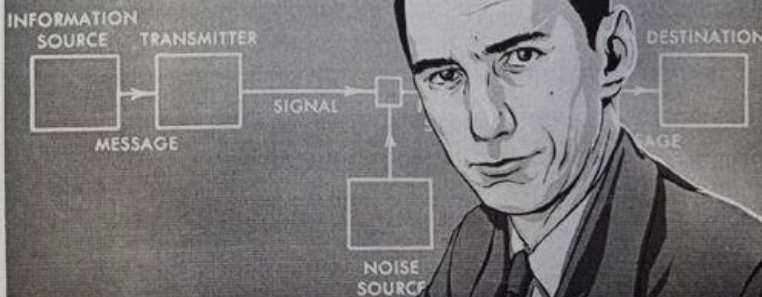
Germany Great



Bad logic (abuse of logic)

sample of right logic

The Mathematical Theory of Communication



Creating a reliable connection over an unreliable (noisy) channel that's what IT is about

and that's what Shannon did

Hedgehog in the fog = Information theory

Data => Facts
Information => organized data

1 channel $\Rightarrow$ huge noise problem } $\longrightarrow$ school problem (noise)

2 channel $\Rightarrow$ better (less mistakes)



For example, voice of actor in movie & subtitles of words he say

$\downarrow$ Richard Feynman
(you really like his style)



180 students $\Rightarrow$ 10-20 Successful (7-12%)

$(50 \cdot (7-12\%)) = 4-6$ stud from 453-454

Solution $\nearrow$ Physical
 $\searrow$ System $\checkmark$

$$\boxed{G^2 = npa} \quad = f = 0,1$$

10000 0.9

$$G^2 = 900 \quad G = 30$$

$$9000 \pm 30$$

$$R-3 \Rightarrow p = 0,972 ; f = 0,027 + 0,001 = 0,028$$

$$p(x) = \frac{n!}{(n-x)!x!} p^x q^{n-x}$$

x - success, n - trials

$+0,1$ 4,5 $+0,1$ Enter

logic of choosing a partner (according to the IT)



Say NO to the first



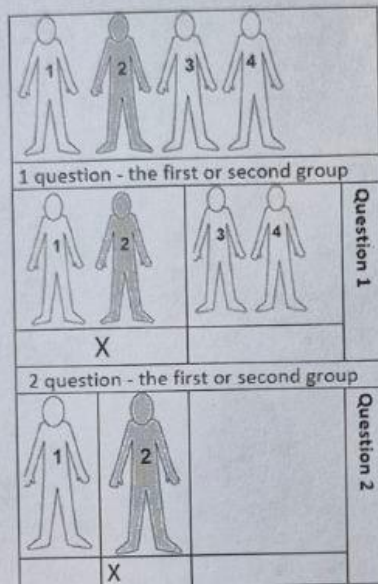
Say YES to the second if it is better than the first



Say NO to the third only if it is worse than all the others



number of questions to guess an element from the set (example, letter in alphabet)



Average number of questions =

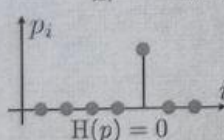
$$2 \cdot 0.25 + 2 \cdot 0.25 + 2 \cdot 0.25 + 2 \cdot 0.25 = 2$$

Average number of questions =

$1 \cdot 0.5 +$	$2 \cdot 0.25 +$	$3 \cdot 0.125 +$	$3 \cdot 0.125$

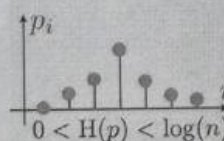
Question 1. Is this Zuckerberg?	50%	$1 \cdot 0.5$
Question 2. Is this Sergey Brin?	25%	$2 \cdot 0.25$
Question 3. Is this Stefan from BMW?	12,5%	$3 \cdot 0.125$
So Prince Saud	12,5%	$3 \cdot 0.125$
Average number of questions = 1,75		

$$H(X) = - \sum_{i=1}^n p(x_i) \log_2 \frac{1}{p(x_i)}$$



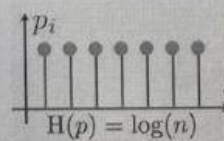
$$\sum_{i=1}^n p(i) \log_2 \frac{1}{p(i)}$$

Quantifying information



$$I(x_i) = \log_2 \left(\frac{1}{p_i} \right)$$

number of bits required to encode choice



$$\sum_{i=1}^n p(x_i) I(x_i)$$



information

sum

probability

$$H = - \sum_x p(x) \log p(x)$$

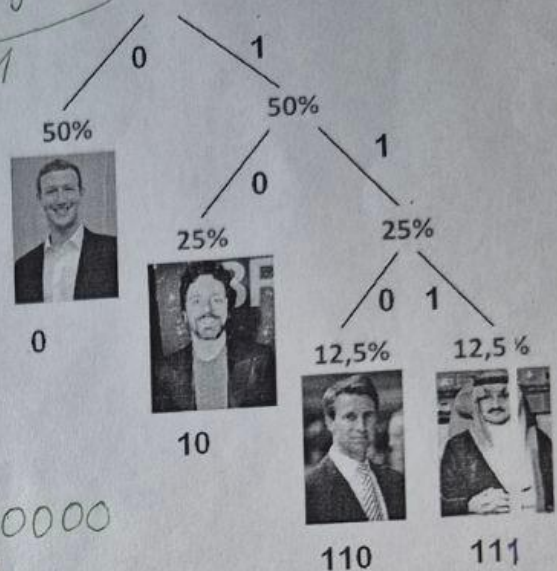
base 2 log

0000 - $N=1$ ← $\frac{1}{2} \log_2 2$
 00 ← $\frac{1}{4} \log_2 4$

Энтропия - $H = \sum_{i=1}^n p(x) \log\left(\frac{1}{p(x)}\right)$

Роль этого члена

0000000
 00
 00



First-order approximation (symbols independent but with frequencies of Belarusian txt).

Мама мыла ра	
М - 3 — 30%	1-3 М
а - 4 — 40%	4-7 а
ы - 1 — 10%	8 -ы
л - 1 — 10%	9 -л
р - 1 — 10%	10 -р
10	
лла	мам ма р

Мама мыла ра

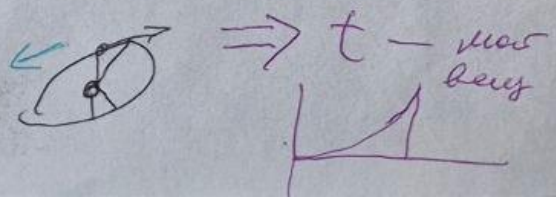
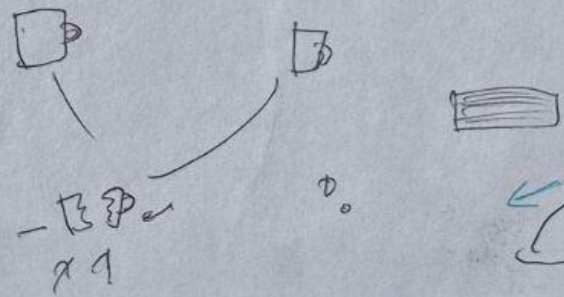
Ма - 2 22%	1-2 ма
ам - 2 22%	3-4 ам
мы - 1 11%	5 мы
ыл - 1 11%	6 ыл
ла - 1 11%	7 ла
ар - 1 11%	8 ар
ра - 1 11%	9 ра
9	

0. 4 6 7 3 1 9 1 6 7 3 5
 ам ыл ла ам ма ра ма ыл ла ам мы
 мылла рама



Second-order approximation (digram (2-symbols) structure as in Belarusian)

$R = \sigma t$



Q Wool Book

PAB

17.02.2020

Boolean logic:

$$1 + 1 = 1$$

$$0 + 1 = 1$$

$$1 + 0 = 1$$

$$0 + 0 = 0$$

$$1 \& 1 = 1$$

$$1 \& 0 = 0$$

$$0 \& 1 = 0$$

$$0 \& 0 = 0$$

Shannon created Information Theory

linguistic

philosophy

deals with data

data $\rightarrow$ braining $\rightarrow$ information

Claude Shannon (Father of Info. Age)

Main class in c# $\Rightarrow$ Object