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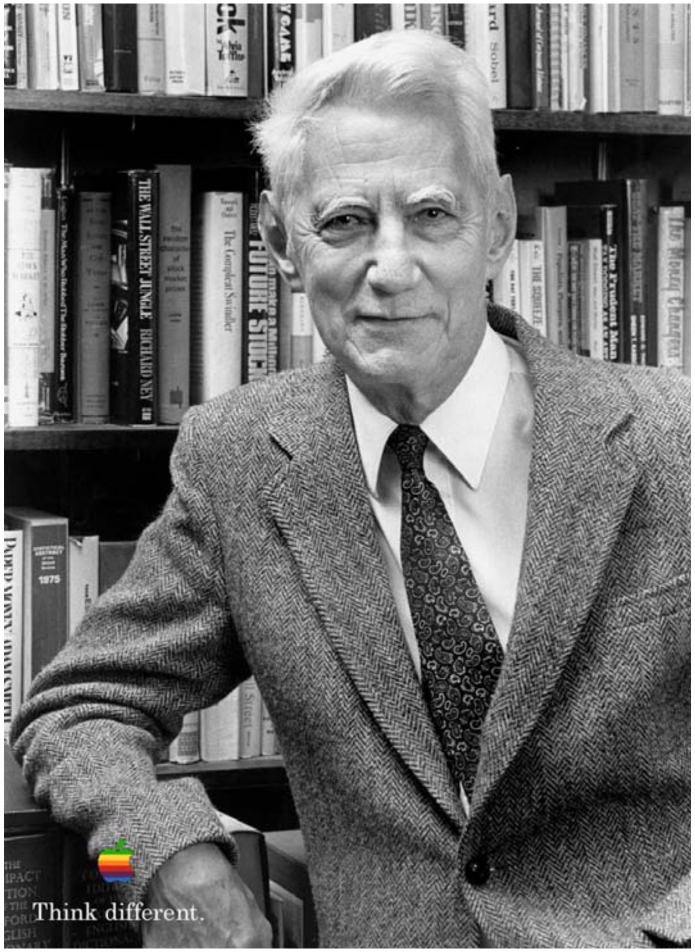
Informationstheorie



Claude Shannon 1916-2001

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- **Signal**
- **Nachricht**
- **Information**

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Signal

- analog
- digital

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Nachricht

- **Sprache**
- **Syntax**
- **Semantik**

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Syntax

- **Alphabet**
- **Code**

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Beispiele für Alphabete:

{ a | b | c | ... | z }

{ α | β | γ | ... | ω}

{ 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 }

{♈|♉|♊|♋|♌|♍|♎|♏|♐|♑|♒|♓}

{ ♣ | ♦ | ♥ | ♠ }

{ 🚺 | 🚹 }

{🔒|🔓}

{ + | - }

{ Ø | 1 }

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Binärcode

0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

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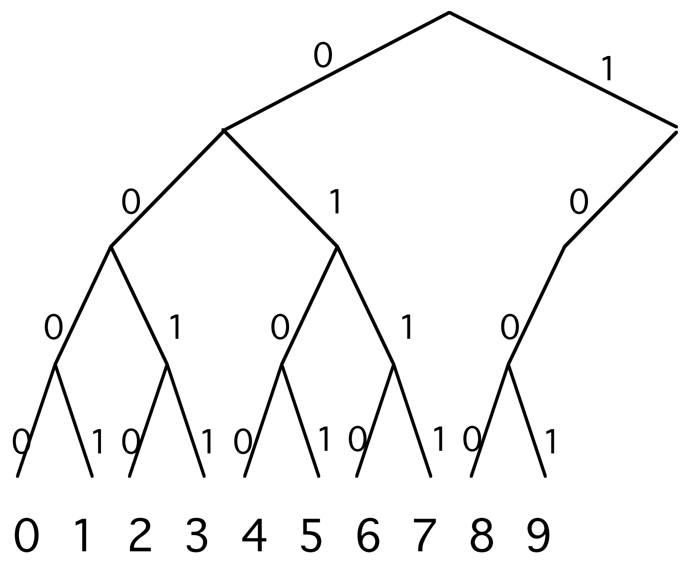
Codebaum



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$$n = 2^l$$

$$l = \mathrm{ld}\, n$$

l ... Wortlänge [bit]
n ... Anzahl der Zeichen

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Informationsgehalt h(p)

- unabhängig von der Codierung
- steigt wenn die Wahrscheinlichkeit p sinkt
- $h(p_1 * p_2) = h(p_1) + h(p_2)$
- $h(p) = ld\ (1/p)$ [bit]

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Beispiele für Informationsgehalt

- $h(1) = 0$ Nachricht wird immer erwartet
- $h(0) = \infty$ Nachricht wird nie erwartet
- $h(0.5) = 1$ Nachricht wird zu 50% erwartet
- $h(0.1) = 3.32$ Informationsgehalt einer Dezimalziffer

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Logarithmus dualis ld x

- $2^{\mathrm{ld}\ x} = x$
- ld (x*y) = ld x + ld y
- ld 2*x = 1 + ld x
- ld x^2 = 2*ld x
- ld x = ln x / ln 2 ~ 1.44*ln x
- ld x = log x / log 2 ~ 3.32*log x

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x	ld x
1	0.00
2	1.00
3	1.58
4	2.00
5	2.32
6	2.58
7	2.81
8	3.00
9	3.17
10	3.32

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Mittlerer Informationsgehalt $H = \sum p_i \, ld \, 1/p_i$ [bit]

Mittlere Wortlänge $L = \sum p_i \, l_i$ [bit]

Redundanz $R = L - H$ [bit]

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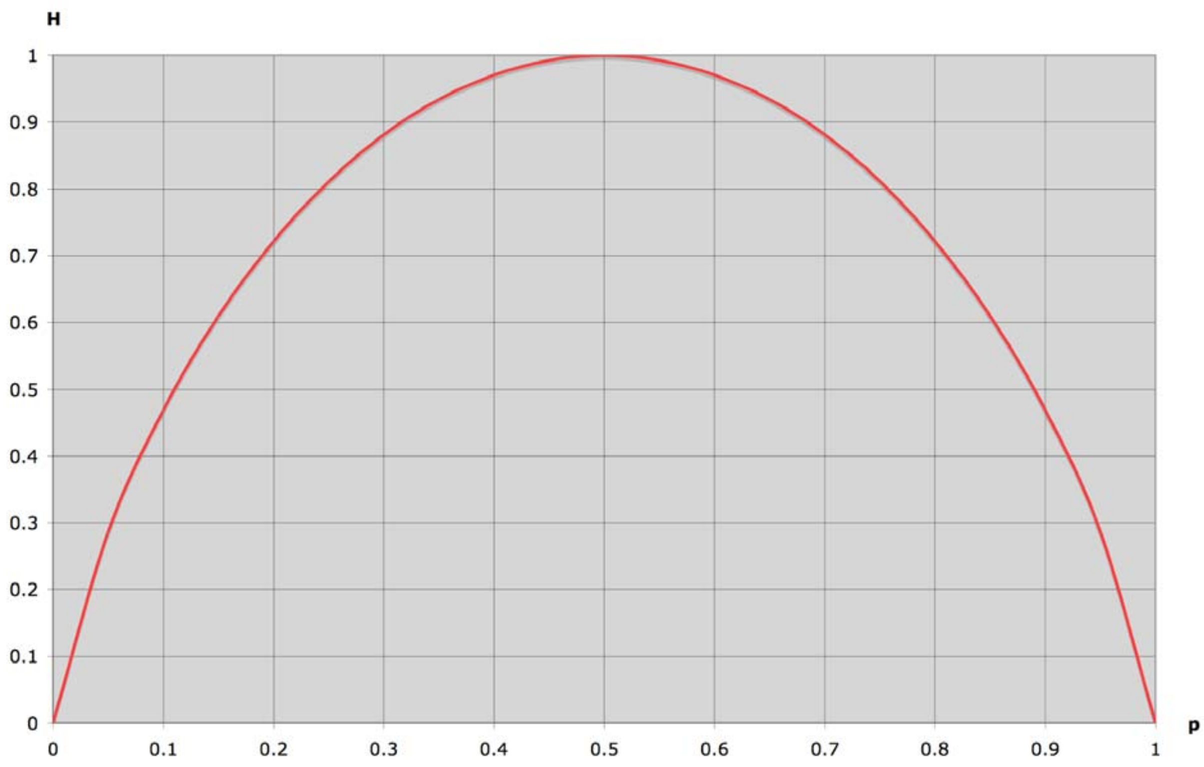
Shannon'sche Funktion

H = p ld 1 / p + (1-p) ld 1 / (1-p)



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Redundanz einer Dezimalziffer

(alle 10 Ziffern gleichwahrscheinlich)

Informationsgehalt H = ld 10 = 3.32 bit

Wortlänge L = 4 bit

Redundanz R = L - H = 0.68 bit

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Informationsgehalt eines Buchstabens

(alle 26 Buchstaben gleichwahrscheinlich)

Informationsgehalt H = ld 26 = 4.7 bit

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Informationsgehalt eines Buchstabens

(unterschiedliche Wahrscheinlichkeiten einzelner Buchstaben)

Mittlerer Informationsgehalt H = 4.1 bit

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Informationsgehalt eines Buchstabens

(unterschiedliche Wahrscheinlichkeiten aufeinanderfolgender Buchstaben)

Mittlerer Informationsgehalt H ~ 2 bit

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Informationsgehalt eines Wortes

**(10 Millionen Wörter
mit unterschiedlichen Wahrscheinlichkeiten)**

Mittlerer Informationsgehalt H ~ 11.8 bit
Mittlere Wortlänge L = 5.7 Buchstaben

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Informationsfluss beim Lesen

25 Buchstaben pro Sekunde entspricht 50 bit/s

(In 60 Jahren kann ein Mensch etwa $3*10^{10}$ bit aufnehmen)

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Speicherkapazität des Gehirns ~ 10^{12} bit

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Erbinformation ~ 10^{10} bit