Compression

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Netflix and chill



Lossless compression

"Today, by radio, and also on giant hoardings, a rabbi, an admiral notorious for his links to Masonry, a trio of cardinals, a trio, too, of insignificant politicians (bought and paid for by a rich and corrupt Anglo-Canadian banking corporation), inform us all of how our country now risks dying of starvation. A rumour, that's my initial thought as I switch off the radio, a rumour, or possibly a hoax..."

A void, George Perec, translated by Gilbert Adair.



$A \rightarrow 10, T \rightarrow 11, C = 001, G = 010, S = 0.11, B \rightarrow 0.010, Z = 0.0100, P = 0.0111$



Average code length $A \to 10, T \to 11, C = 001, G = 010, S = 011,$ $B \rightarrow 0000, Z = 0000, P = 0011$

 Conventional wisdom: 8 symbols requires 3 bits • Huffman: average code length is

 $L = 0.22^{2} + 0.2^{2} + 0.18^{3} + 0.15^{3} + 0.10^{3} + 0.08^{4} + 0.05^{5}$ + 0.02*5 = 2.8 bits

We saved 0.2 bits per symbol - something for nothing!

Is there a minimum code length?

- Yes!
- Let's imagine an symbol appeared with probability p
- In which case there would be N = 1/p possibilities • If we have a binary system, we might use I bits to represent N possibilities: $2^{I} = N$ *I* is called the *information* associated with *p* and

If 2' = N then $\log_2(2') = \log_2(N)$ or $I = \log_2(1/p)$ Or

 $I = - \log_2(p)$

SO

 $L = -0.22*\log_2(0.22) - 0.2*\log_2(0.2) - \dots -0.02*\log_2(0.02) = 2.7535$

Lossless codes that are optimal

- Not Huffman codes (only under certain rare circumstances)
- Arithmetic codes are though (nearly)

er certain rare circumstances) (nearly)

Arithmetic codes $> 0.101101_{9}$ Mesage=210



Foralorge daration of thesee (IC52) Ait matic country-Eangle #Inathenatic an ork https://www.outubecom/watch?=7.fctpo.//webist=RE12542EC857021Fonder=42

 $A = 012, p = p_0 p_1 p_2 = 02,04,04$

Find a briany number that sits completely in the mtrived Answar: 0.101101,

What can be achieved with lossless coding?

- Lossless compression critically depends on information redundancy
- No redundancy = no compression
- Some information sources are inherently redundant.

Run length coding

Ether 50 bitsperine o, hee fiverus does (41,2,(48,16,(175,114,(349,44,(48,50) o, hee aist of hericed argepirts 41 43 48 64 175 289 349 355 483

Burrows - Wheeler transformation

Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (ah-haa)~ aaeehho)~ aahh((c wrmmhnnnnnaa--Ttwwhww uu;;ene,,ggsggg

'Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (ah-haa) \sim ' '~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (ah-haa)' ')~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (ah-haa' 'a)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (ah-ha' 'aa)~Knowing mé, knowing you (ah-haa); There is nothing we can do; Knowing mé, knowing you (ah-h' 'haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (ah-' '-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (ah' 'h-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (a' 'ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (' '(ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you ' (ah-haa)~Knowing mé, knowing you (ah-haa); There is nothing we can do; Knowing mé, knowing you' 'u (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing yo' ou (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing y' 'you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing ' you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing' 'g you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowin' ng you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowi 'ing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, know 'wing you (ah-haa)~Knowing mé, knowing you (ah-haa); There is nothing we can do; Knowing mé, kno' 'owing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, kn' 'nowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, k' 'knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, ' knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me' knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing m 'me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing 'g mé, knowing you (ah-haa)~Knowing mé, knowing you (ah-haa); There is nothing we can do; Knowin' 'ng me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowi 'ing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Know' 'wing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Kno' 'owing mé, knowing you (ah-haa)~Knowing mé, knowing you (ah-haa); There is nothing we can do; Kn' 'nowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; K' 'Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do;' '; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do' 'o; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can d' 'do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can ' do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can' 'n do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we ca' 'an do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we c' 'can do; Knowing mé, knowing you (ah-haa)~Knowing mé, knowing you (ah-haa); There is nothing we ' can do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we' 'e can do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing w'

aiiiii KKkkdnyynnnneiooo oooo)

(ah-haa); There is nothing we can do; Knowing me, knowing you (ah-haa)~Kn (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Kn Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There There is nothing we can do; Knowing me, knowing you (ah-haa)~Knowing me, can do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa) do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); Th is nothing we can do; Knowing me, knowing you (ah-haa)~Knowing me, knowin knowing you (ah-haa); There is nothing we can do; Knowing me, knowing you knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing w ' me, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing ' me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothi ' nothing we can do; Knowing me, knowing you (ah-haa)~Knowing me, knowing y 'we can do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-h you (ah-haa); There is nothing we can do; Knowing me, knowing you (ah-haa you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do '(ah-haa); There is nothing we can do; Knowing me, knowing you (ah-haa)~Kno (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Kno '); There is nothing we can do; Knowing me, knowing you (ah-haa)~Knowing me ')~Knowing me, knowing you (ah–haa); There is nothing we can do; Knowing me knowing you (ah-haa); There is nothing we can do; Knowing me, knowing yo knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There is nothing '-haa); There is nothing we can do; Knowing me, knowing you (ah-haa)~Knowin '-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowin '; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There '; There is nothing we can do; Knowing me, knowing you (ah–haa)~Knowing me, 'Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing me, 'Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); There i 'There is nothing we can do; Knowing me, knowing you (ah-haa)~Knowing me, k 'a); There is nothing we can do; Knowing me, knowing you (ah-haa)~Knowing m 'a)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing m 'aa); There is nothing we can do; Knowing me, knowing you (ah-haa)~Knowing 'aa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Knowing 'ah-haa); There is nothing we can do; Knowing me, knowing you (ah-haa)~Know 'ah-haa)~Knowing me, knowing you (ah-haa); There is nothing we can do; Know 'an do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); 'can do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); 'do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa); The 'e can do; Knowing me, knowing you (ah-haa)~Knowing me, knowing you (ah-haa 'e is nothing we can do; Knowing me, knowing you (ah–haa)~Knowing me, knowi 'e, knowing you (ah-haa); There is nothing we can do; Knowing me, knowing y 'e, knowing you (ah-haa) Knowing me, knowing you (ah-haa); There is nothing 'ere is nothing we can do: Knowing me, knowing you (ah-haa)~Knowing me, kno

Tweedledee and Tweedledum

Lossy codes

200 Sinal

1%1611

1 in s

200 114

eye will not see

- Trick 1: discard pixels
- Trick 2: Split image into blocks and approximate them with equations
- Trick 3: Quantise the coefficients of the equations Trick 4: Scan them out to maximise runs
- Trick 5: Use Huffman coding to compress

At your PC - apply those in reverse order.

A series of "tricks" designed to reduce information that it is hoped the

JPEG Trick 1: discarding

Y	Y	Y	Y
Y	Y	Y	Y
Y	Y	Y	Y
Y	Y	Y	Y

G	G	G	G
G	G	G	G
G	G	G	G
G	G	G	G

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Ģ	Ģ	Ģ	Ģ
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			D		D		D		8
	`							G	В
F	२	ł	2		R		R	G	
F	२	F	२		R		R		

Y	Y	Y	Y
Y	Y	Y	Y
Y	Y	Y	Y
Y	Y	Y	Y

G	G
G	G
G	G
G	G

Ģ	G
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Y	Y	Y	Y
Y	Y	Y	Y
Y	Y	Y	Y
Y	Y	Y	Y

G	ß
G	G

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Trick 2: approximation

Trick 3: quantisation

Trick 4: zigzag scanning

172	173	172	171	173	174	176	177
171	171	170	172	177	175	173	175
170	172	172	173	175	173	175	177
169	170	173	173	177	177	174	173
172	171	173	172	175	176	173	170
172	174	176	173	173	173	172	174
172	172	173	173	172	174	174	174
171	171	168	171	168	172	176	174

60

JPEG pipeline (35 years on!)

GHdon, Aléger, BNissand, Sebestyén, "FRGet 25 Sill GingStrong" in IEEE MultiMedia, vol. 24 no 2 pp 96-103, Apr.-Ine 2017, dix 101109/MMI 2017.38

But what about movies?

- Solution 1: Code each frame as a JPEG (Motion JPEG)
- Solution 2: Model motion

Gideto MECFundmentals and Potocol Acetysis, Textronix, 2000

Measuring lossy quality

Fronfigure5ofGHudon, Aléger, BNissard. Sebestyén, "JPCGet25iSil CargStrong"in/EEE MultiMedia, vol. 24 ro2, pp.95-103, Apr.-J.ne2017, dia 101109/MNU.201738

Quality

Sæforeande, Nttflix Tech Bog https://retflixtechtlog.com/performance.comparison-of-viceo-cooling-standards-anactptivestræmingpæspective of 5001837285

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But what about?

- Audio?
- Other signals?

Compression

Mobile telephony, video conferencing, digital photography, drones, email, music, exploration, satellites, the internet, this lecture...

All rely on digital compression

Error Control Coding 1st February 6pm (UK time) 2022

Thanks and kudos to the Worshipful Company of Information Technologists who sponsor these lectures.