Simple structures in computation, statistics, and data acquisition

Simon Vary

people.maths.ox.ac.uk/vary/talk-exeter.pdf

Exeter Family Subject Dinner, 1/2/2021

Transferring analog signals

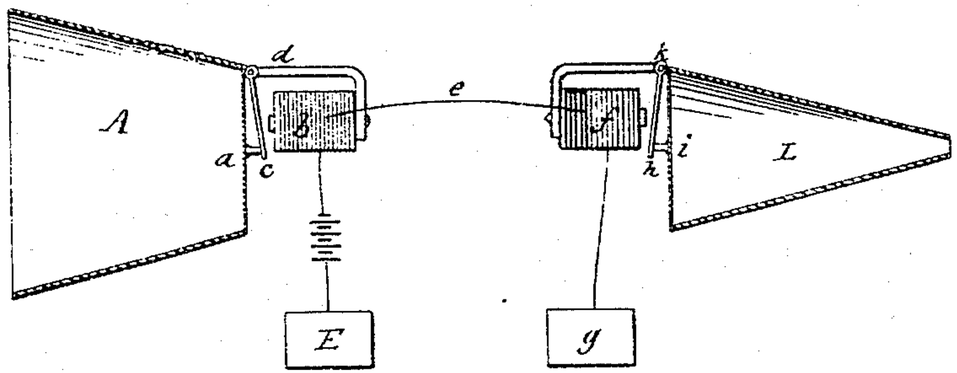
2 Sheets—Sheet 2.

A. G. BELL.

TELEGRAPHY.

No. 174,465. Patented March 7, 1876.

Fig. 7



Witnesses

Ewell & Dick.

H. J. Hutchinson

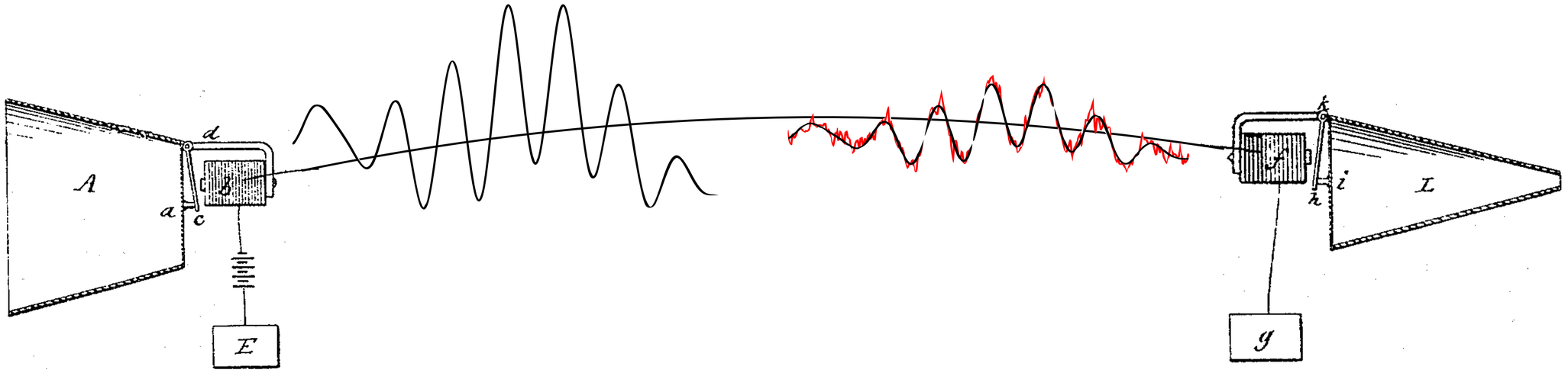
Inventor:

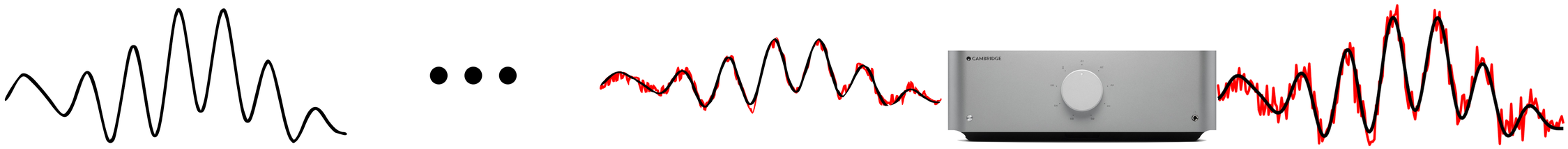
A. Graham Bell

by atty Pollock & Bailey

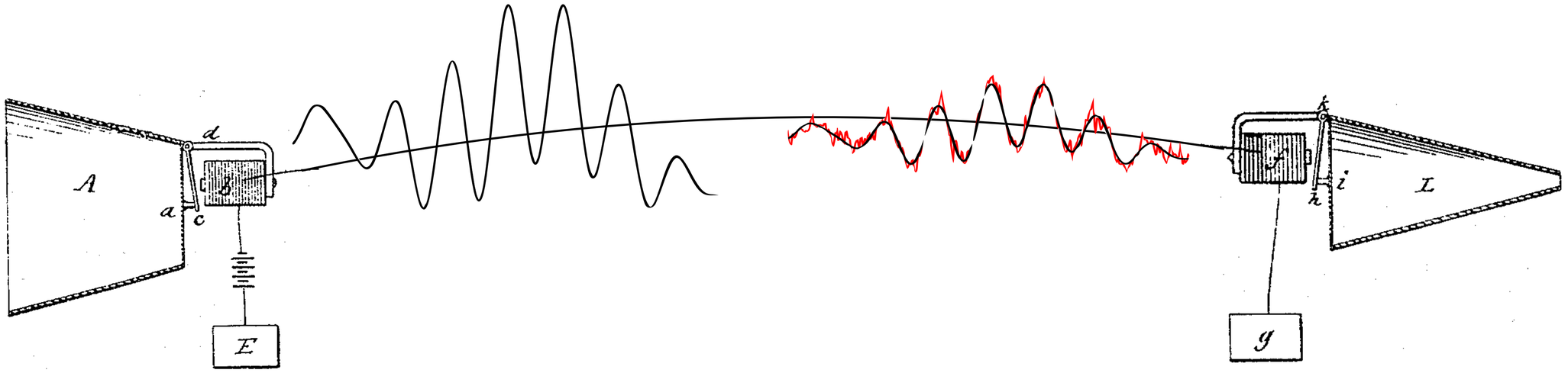
patents.google.com/patent/US174465A

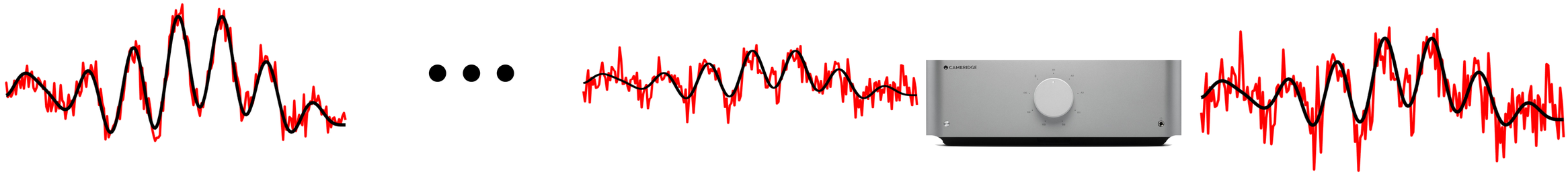
Transferring analog signals



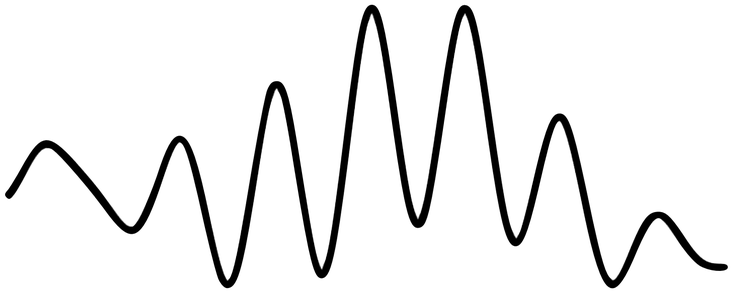


Transferring analog signals

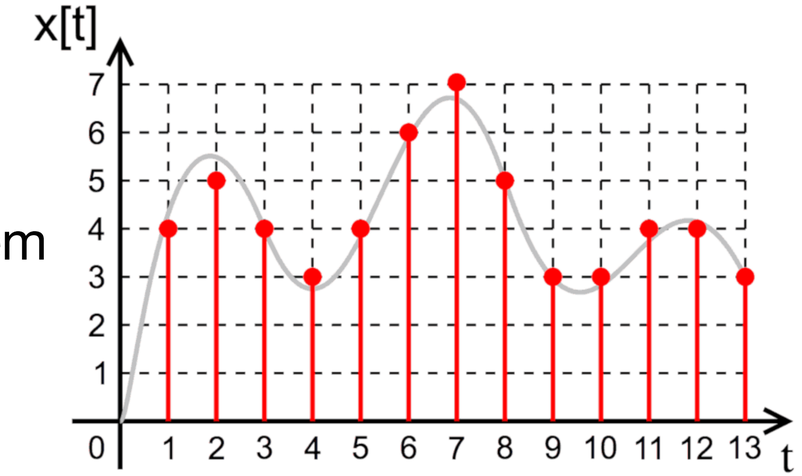




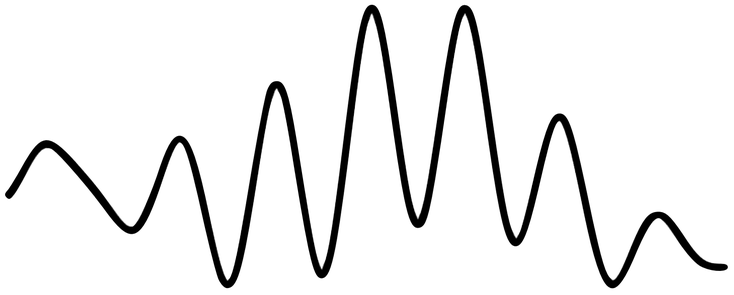
Analog to digital: Two theorems

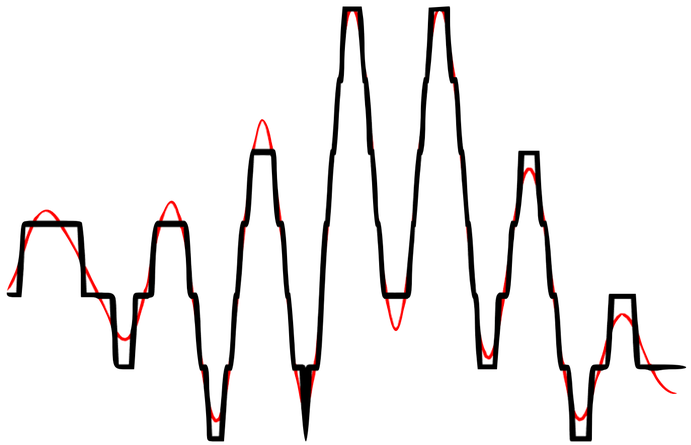


Nyquist-Shannon sampling theorem

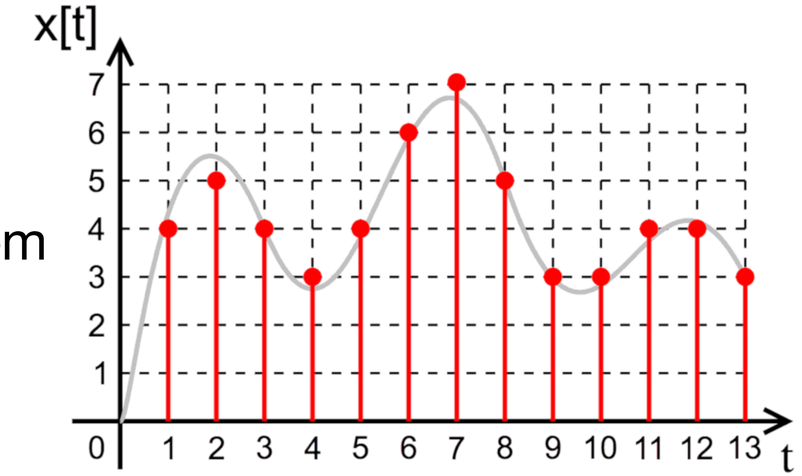


Analog to digital: Two theorems





Nyquist-Shannon sampling theorem



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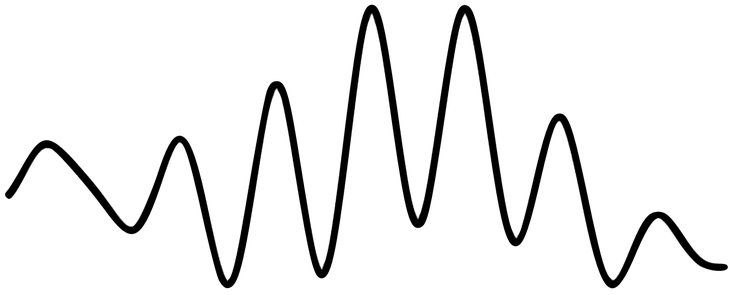
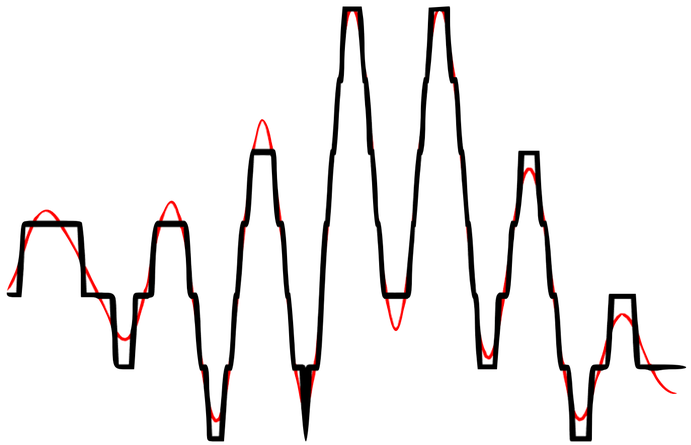
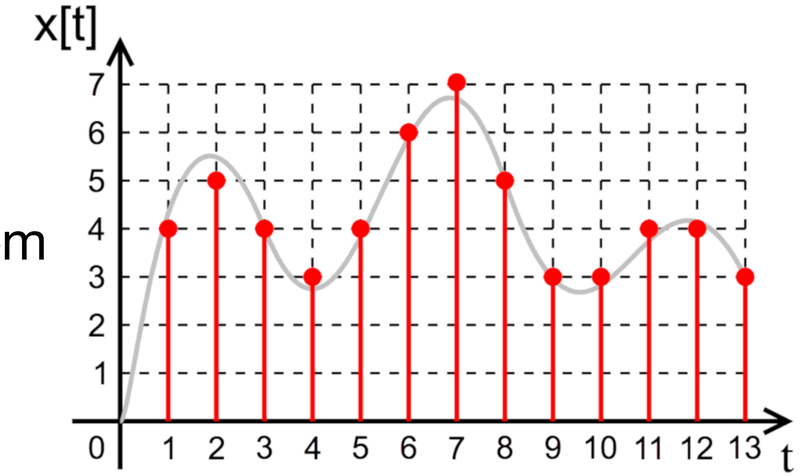
1 1 0 1 1 0 1 0 1 1 0 0 1 0 1 1 1 1 0 1 1

Analog to digital: Two theorems





Nyquist-Shannon sampling theorem



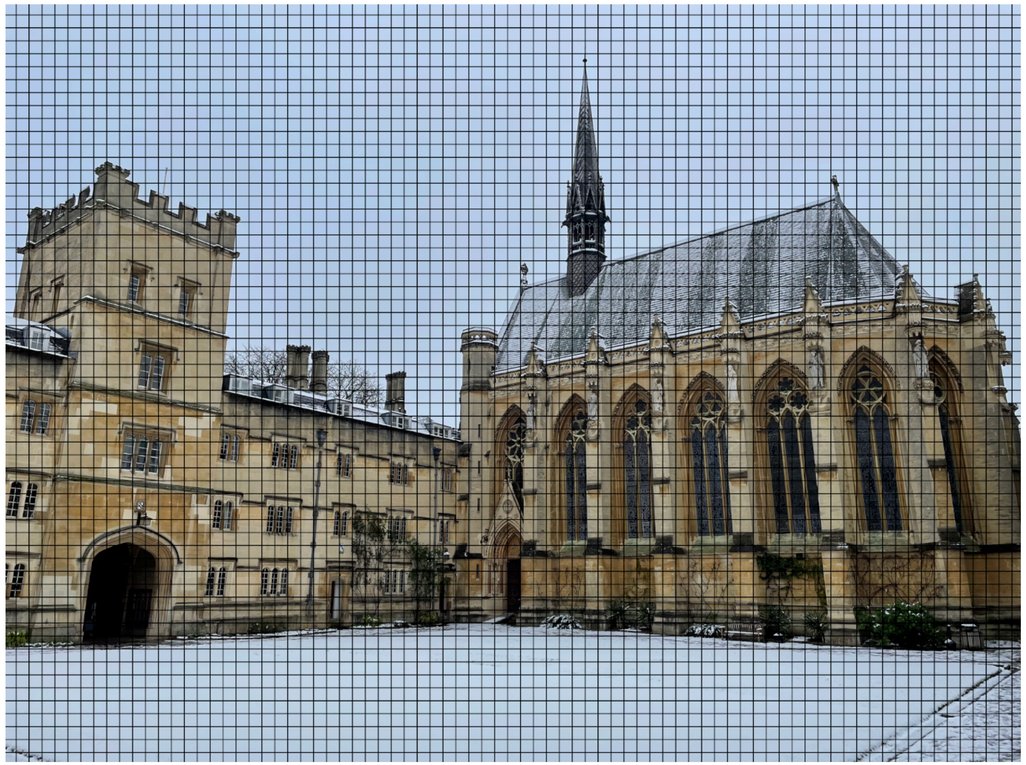
Shannon source coding theorem

1 1 0 1 0 0 1 0 1 1 1 0 1 0 1 1 0 1 0 1 1

1 1 0 1 0 0 1 0 1 1 1 0 1 0 1 1 0 1 0 1 1 • • •

1 1 0 1 0 0 1 0 0 1 1 0 1 1 1 1 0 1 1 1 1
1 1 0 1 1 0 1 0 1 1 0 0 1 0 1 1 1 1 0 1 1
1 1 0 0 0 0 1 1 1 1 0 1 0 1 1 0 0 0 1 1

High-resolution signals: bandwidth limitation

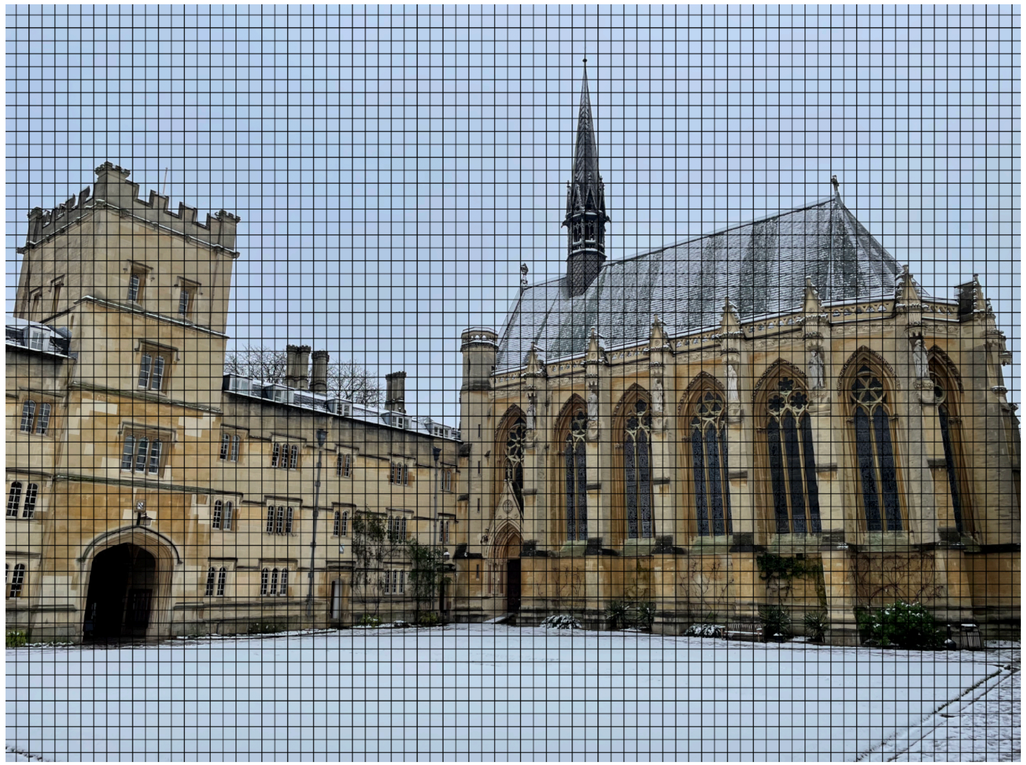


1 1 0 1 0 0 1 0
1 1 1 0 1 0 1 1
0 1 0 1 1 …

Full HD movie:

$$1920 \times 1080 \times 24\ \text{fps} \times (120 \times 60)\ \text{sec} \times 3 \times 8 = 8.6\ \text{Tb}$$

High-resolution signals: bandwidth limitation



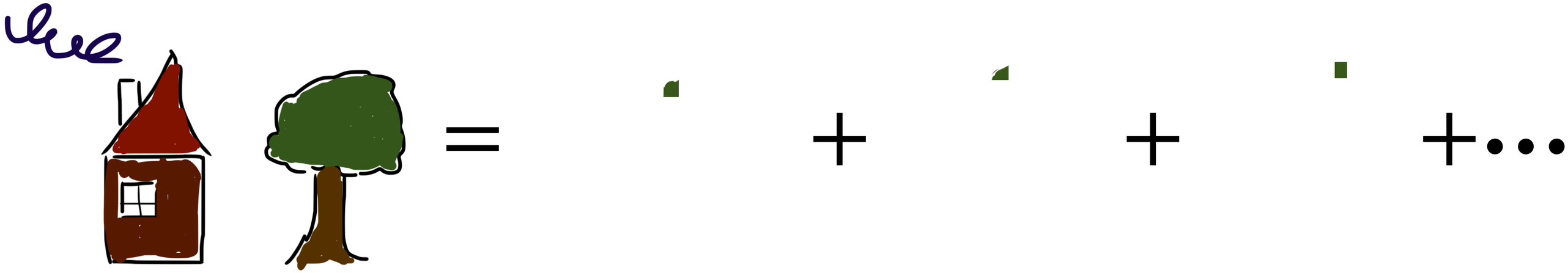
11010010 11010010
11101011 11101011
01011 … 01011 …

11010010 11010010
11101011 11101011
01011 … 01011 …

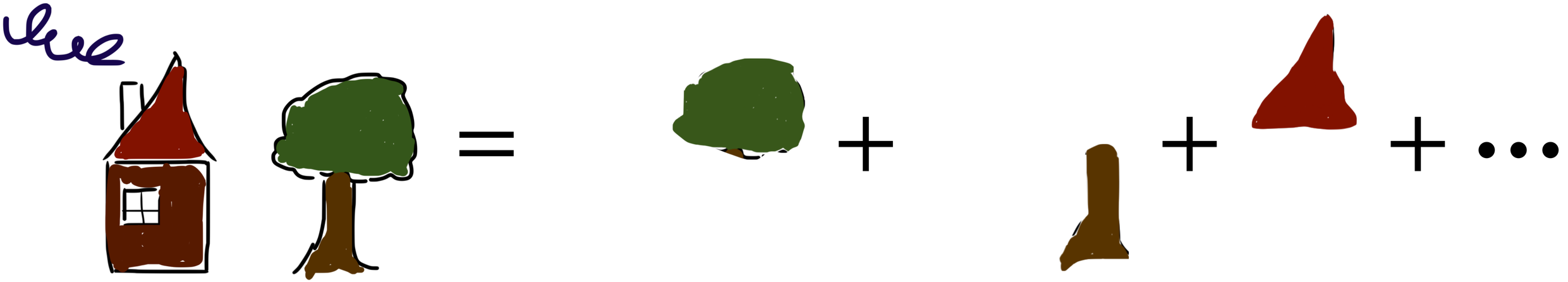
4K movie:

$$3840 \times 2160 \times 24\,\text{fps} \times (120 \times 60)\,\text{sec} \times 3 \times 8 = 34.4\,\text{Tb}$$

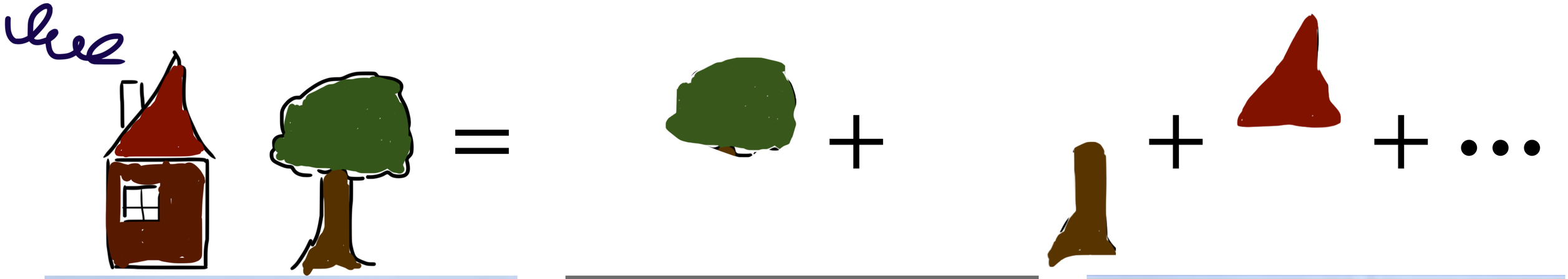
High-resolution signals: compression



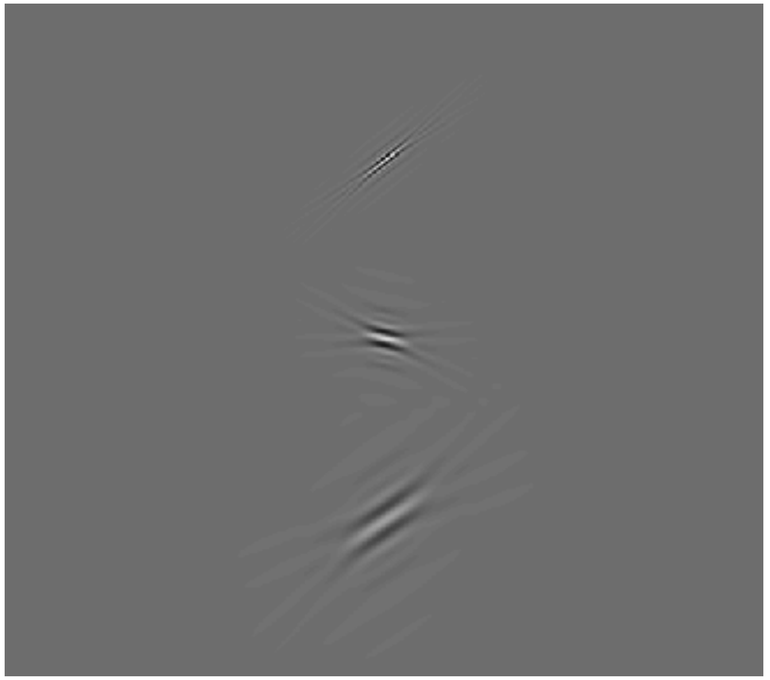
High-resolution signals: compression

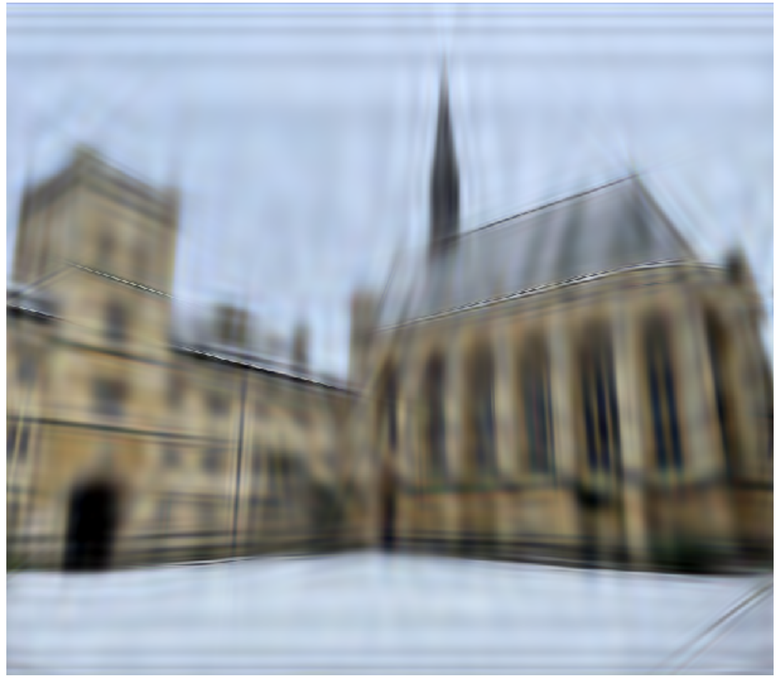


High-resolution signals: compression



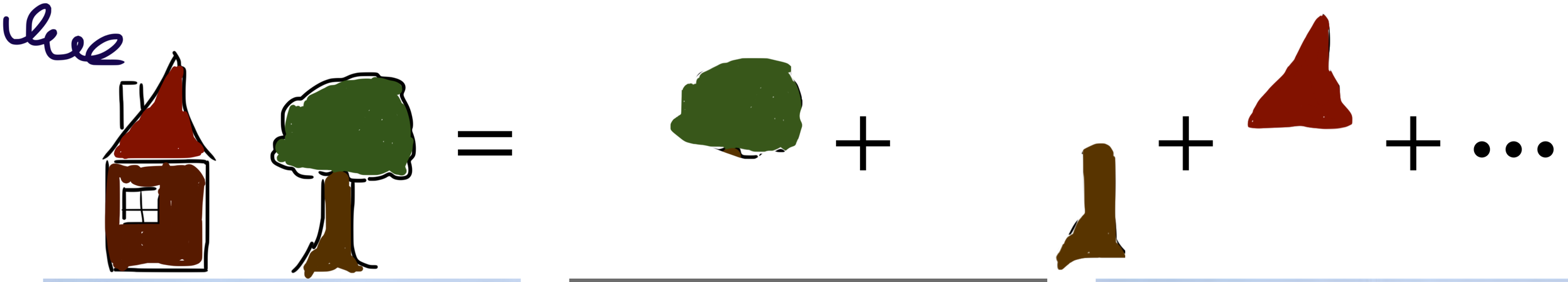
Groundtruth



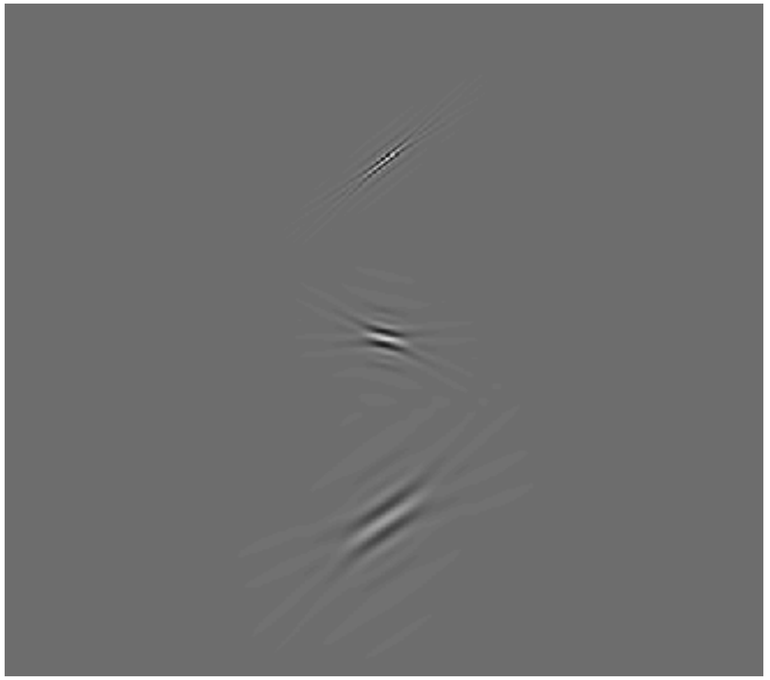


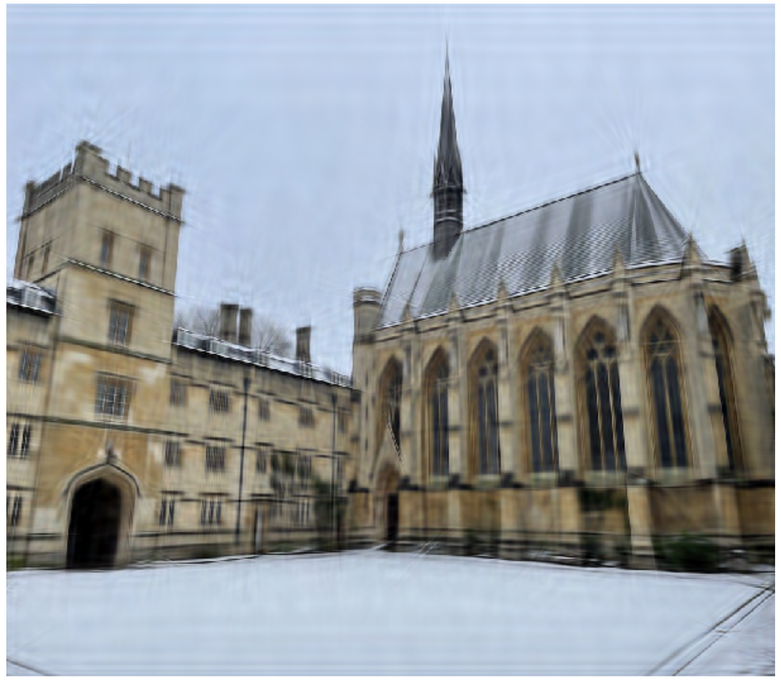
1/200 compression

High-resolution signals: compression



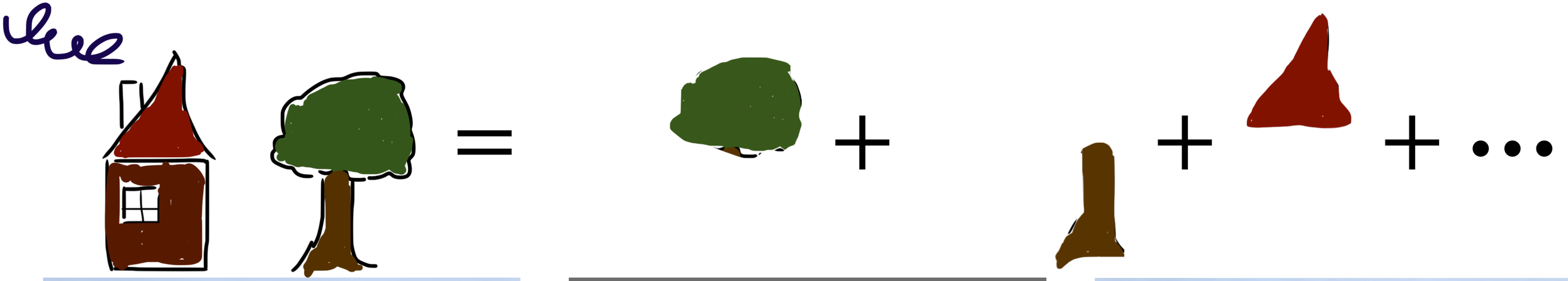
Groundtruth



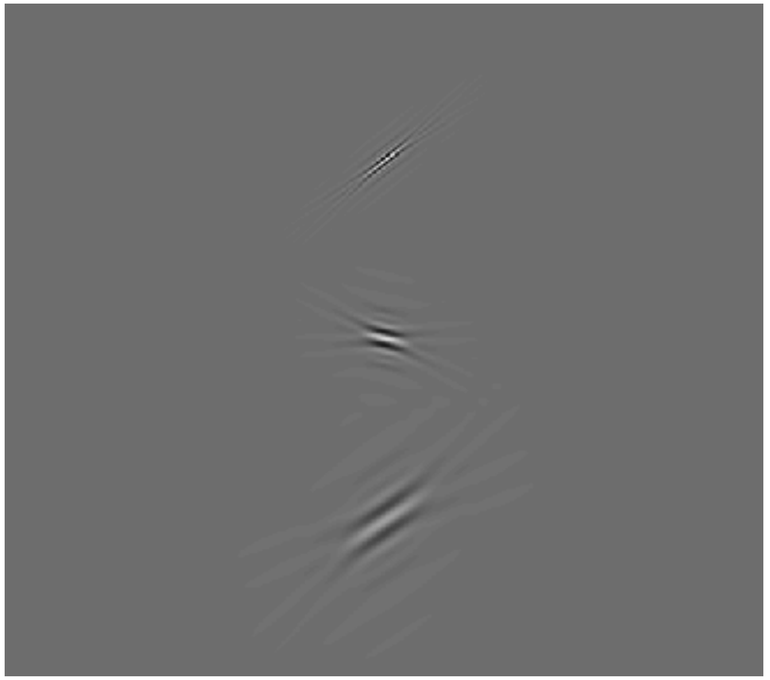


1/20 compression

High-resolution signals: compression

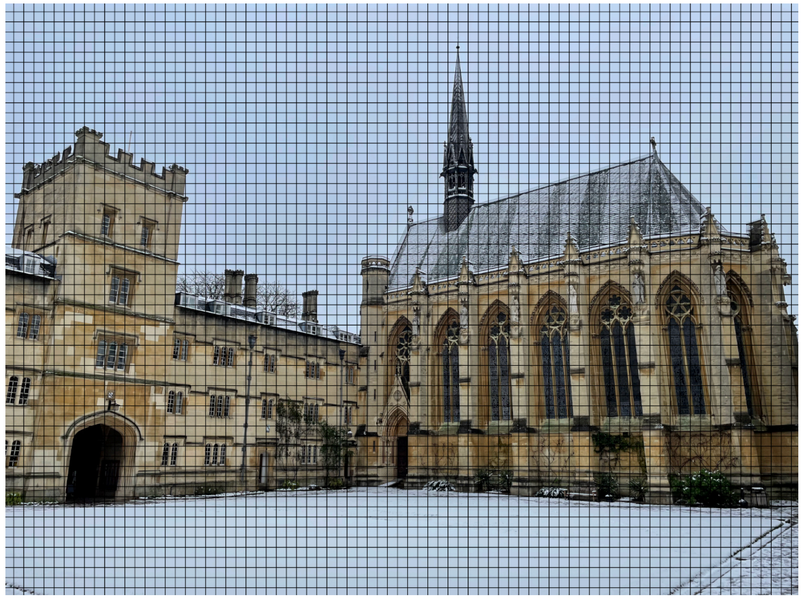


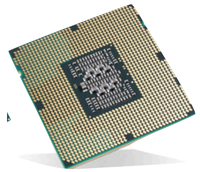
Groundtruth

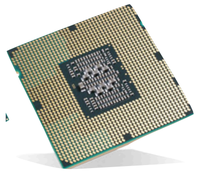


1/10 compression

High-resolution signals: compression







11010010
11101011
01011110
10010111
01011010
11 …

11010010
11101011
010 …

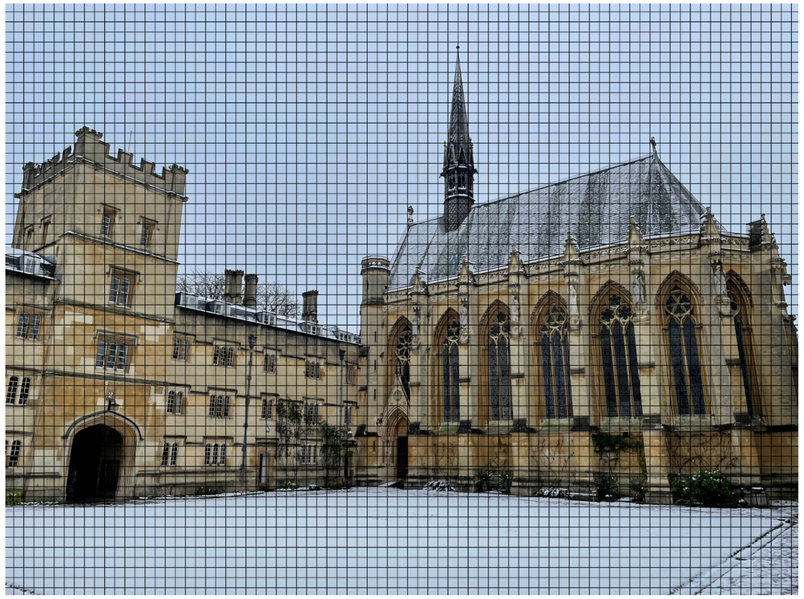
SAMPLING

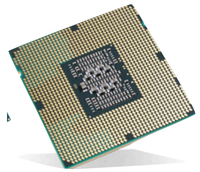
COMPRESSION

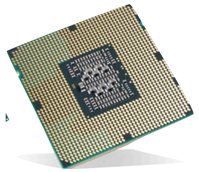
TRANSFER

DECOMPRESS.

High-resolution signals: compression







11010010
11101011
01011110
10010111
01011010
11 …

11010010
11101011
010 …

SAMPLING

COMPRESSION

TRANSFER

DECOMPRESS.

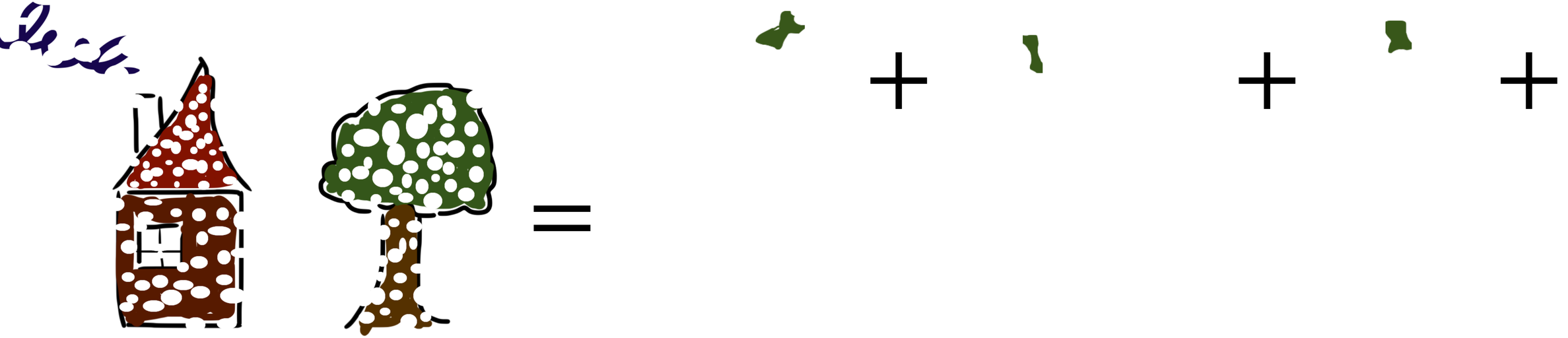
More computation ≈ Less transfer

Compressed sensing

Why sample in such a detail when we compress away most of the information?

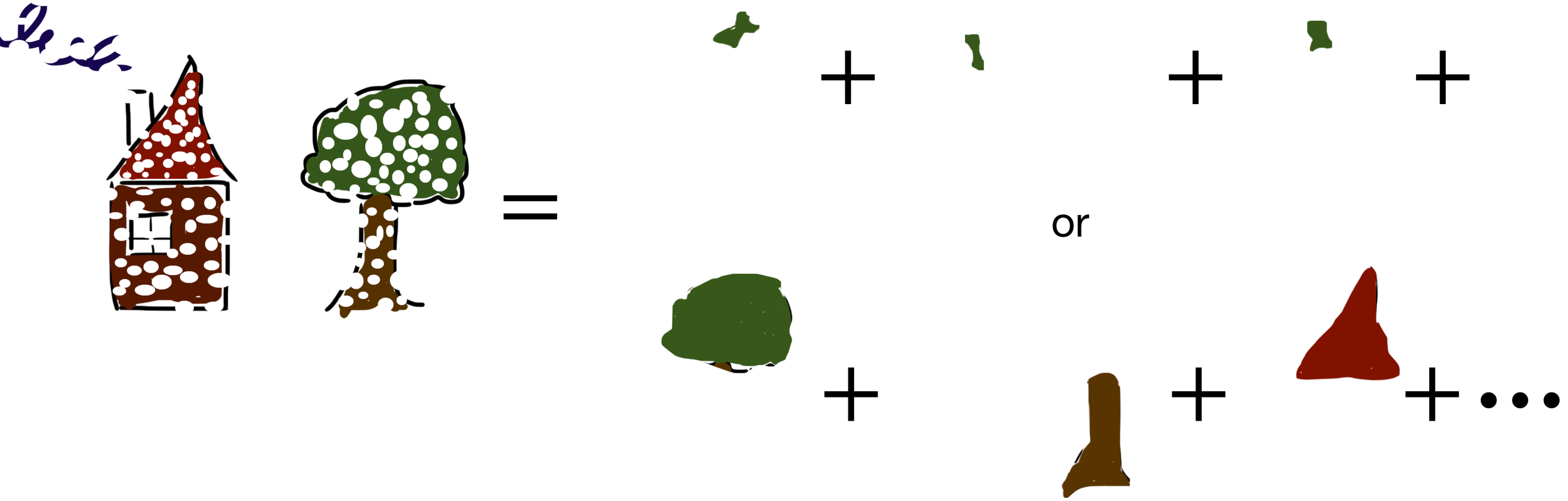
Compressed sensing

Why sample in such a detail when we compress away most of the information?



Compressed sensing

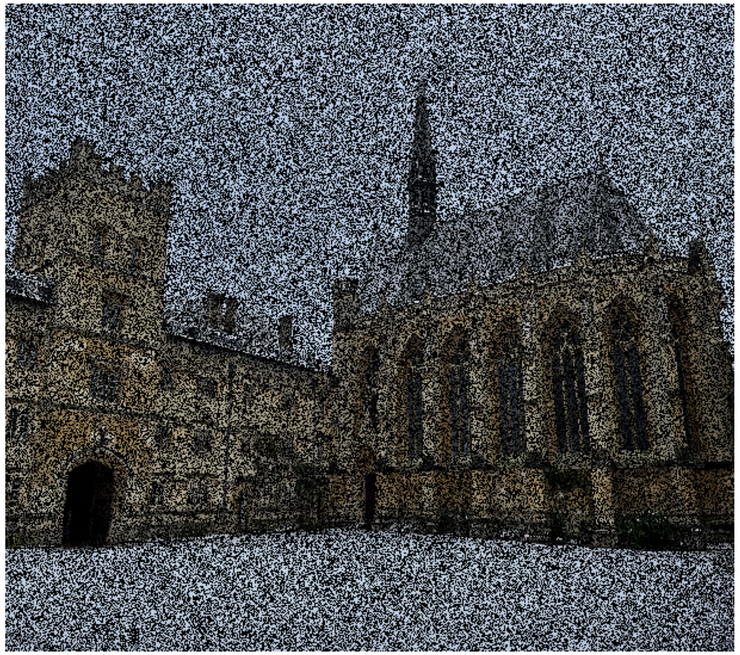
Why sample in such a detail when we compress away most of the information?



Compressed sensing

Why sample in such a detail when we compress away most of the information?

Groundtruth



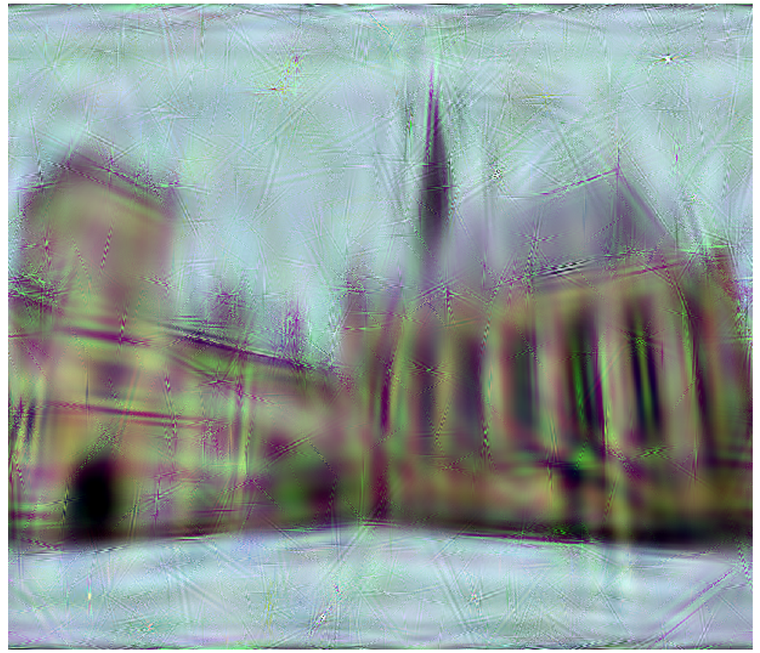
1/2 of pixels

1/20 compression

Compressed sensing

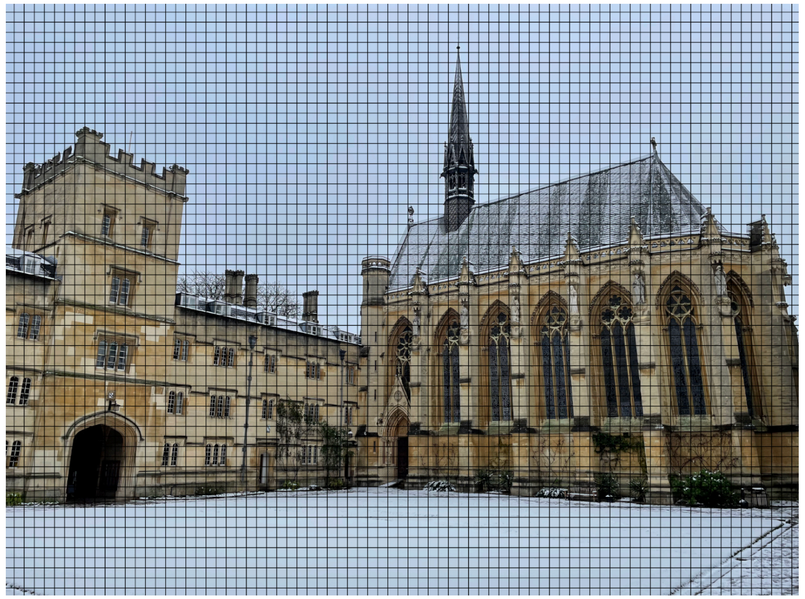
Groundtruth

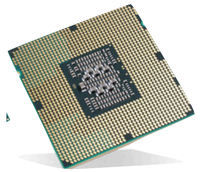
1/25 of pixels



1/200 compression

Compressed sensing





11010010
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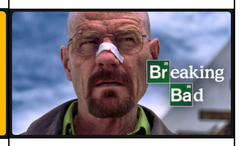
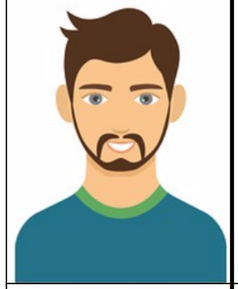
COMPRESSED SENSING

RECONSTRUCTION

More computation ≈ More precise measurement

Incomplete information in recommendation systems

				
	1	?	5	?
	4	2	?	3
	1	5	4	?

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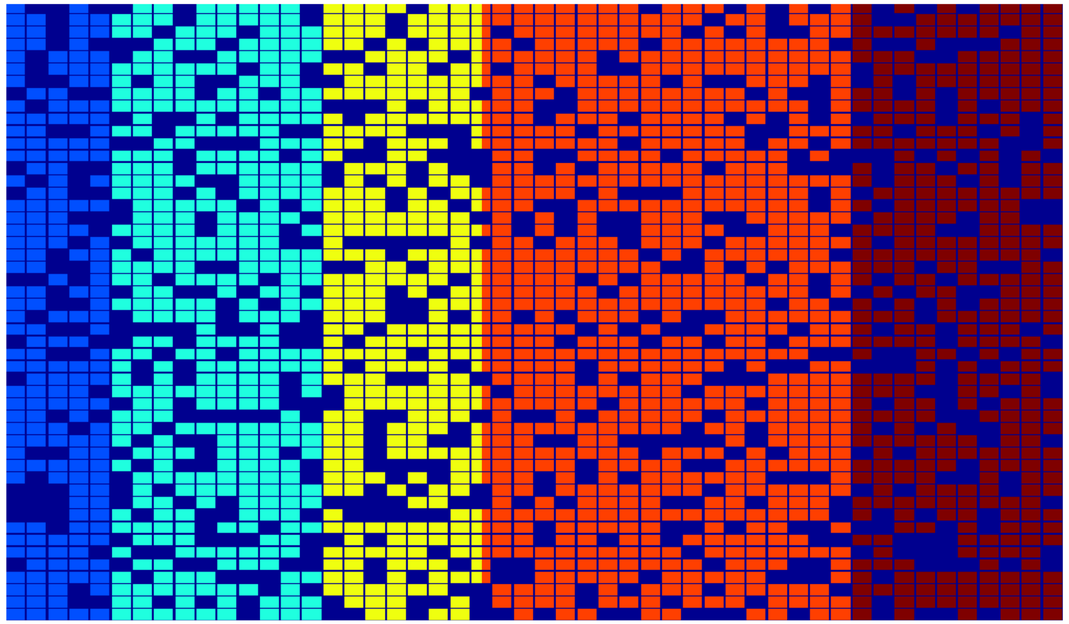
https://blog.echen.me/2011/10/24/winning-the-netflix-prize-a-summary/

Incomplete information in recommendation systems



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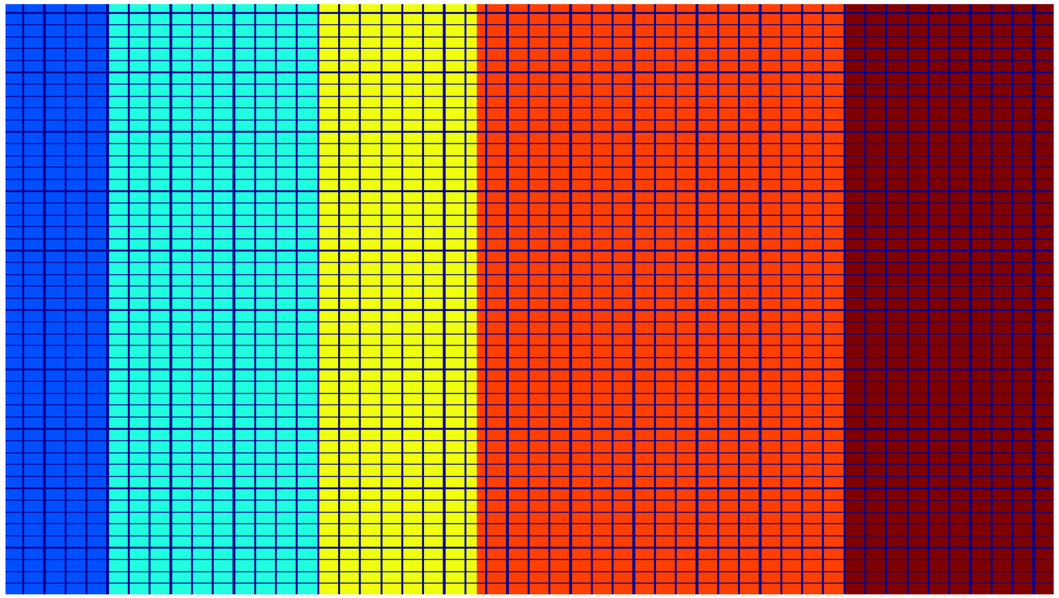
https://blog.echen.me/2011/10/24/winning-the-netflix-prize-a-summary/

Incomplete information in recommendation systems



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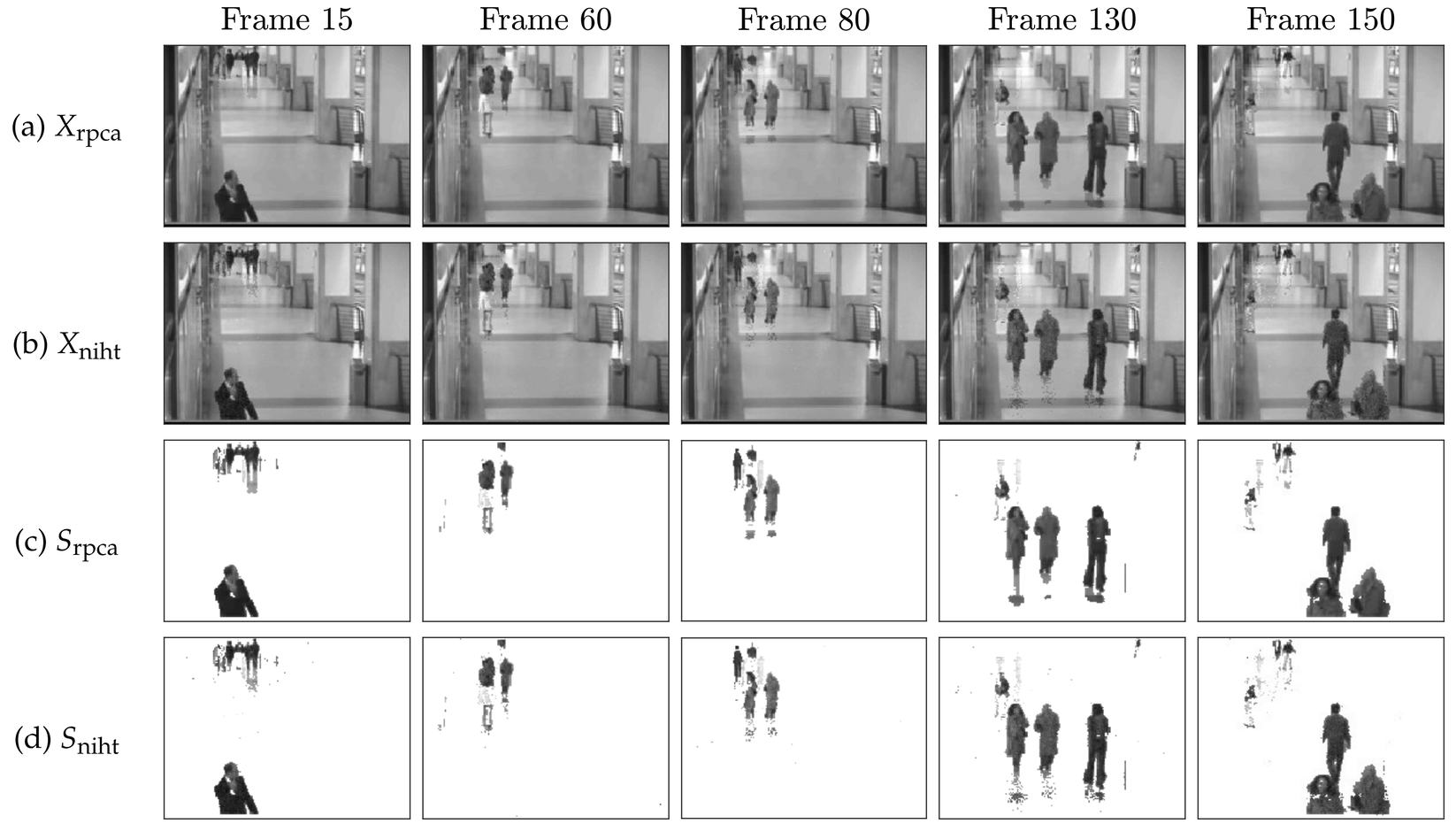
https://blog.echen.me/2011/10/24/winning-the-netflix-prize-a-summary/

Topic of my DPhil: Combining the two structures



Dynamic-foreground/static-background seperation from $1/3$ information.

Thank you for your attention.

people.maths.ox.ac.uk/vary/talk-exeter.pdf