

4C8: Digital Image and Video Processing

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2021/2022

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Introduction

4c8 is an introduction to the digital signal processing algorithms that are at the core of image and video compression.

2D SIGNAL PROCESSING concepts such as 2D Convolution, 2D Z-Transforms and 2D Discrete Fourier Transforms.

COMPRESSION STANDARDS for Images and Videos such as JPEG and MPEG2.

A Note

This course is built upon course material from Prof. **Anil Kokaram**, and some Assistant Prof. **David Corrigan** who have been teaching 4c8 in previous years.

Course Structure

- Monday 9-10 [M17]
 - Monday 13-14 [Crossland Theatre]
 - Tuesday 9-10 [Synge]
 - Tuesday 10-11 (Labs, Group A) [CADLAB]
 - Tuesday 11-12 (Labs, Group B) [CADLAB]
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lectures: on Mondays 9-10, 13-14, Tuesdays 9-10

labs: on Tuesdays 10-12, 25% of the final mark

exam: 2 hours

Prerequisites

SIGNAL PROCESSING prerequisites include:

- mainly 3c1 but 4c5 helps too
- Z-Transform
- Convolution
- Fourier Transform

INFORMATION THEORY prerequisites include:

- Entropy, Entropy Rate, Shannon's Coding Theorem etc.
- Huffman Coding

but these will be covered again.

A Digital Picture

Anatomy of a picture:



sRGB colour space



8bit per colour channel
(0-255)

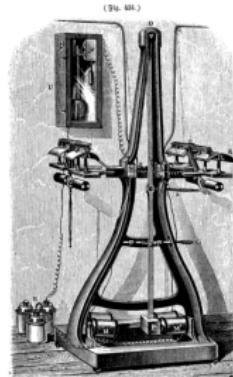
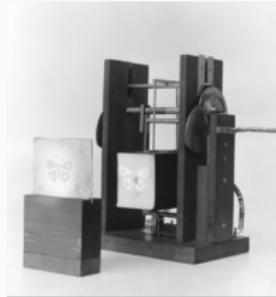
it could be floating point
(0-1)

resolution: 600 x 400 pixels

The Rise of Digital Media

- 1880-1920s First Fax Machines (Wire/Wireless)
- 1950s First Digital Images
- 1960s Digital Image Processing Research takes off
- 1970s Medical Imaging emerges (eg. CAT)
 - 1973 DIP used for first time in the cinema (Westworld)
- 1980s Introduction of Digital Video in Television Production
 - 1985 Broadcast quality video tape (Betacam)
 - 1989 Introduction of Digital Video cameras and tape (DigiBeta and DV standard)
- Late 90s Digital Television and DVD emerges
- 2000s Video on mobile phones / video over internet/
HDTV / 3DTV
 - 2002 First iPhone
 - 2004 YouTube founded
 - 2006 Netflix founded
- Now Online streaming of high quality Video (incl. 4k)
(Netflix, Youtube etc.)

The Rise of Digital Media



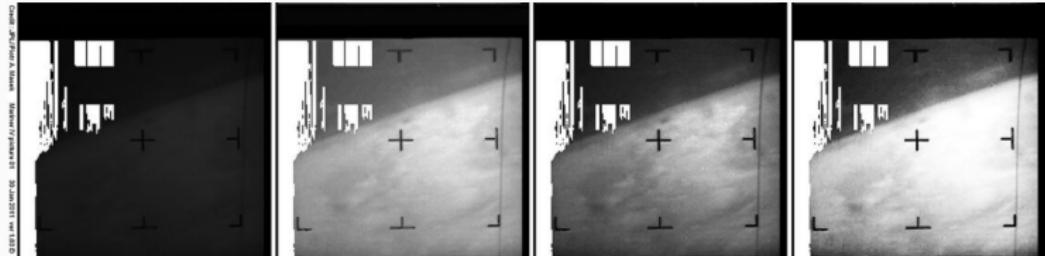
Late 1800s early 1900s: First Fax Machines (wired and wireless)

The Rise of Digital Media



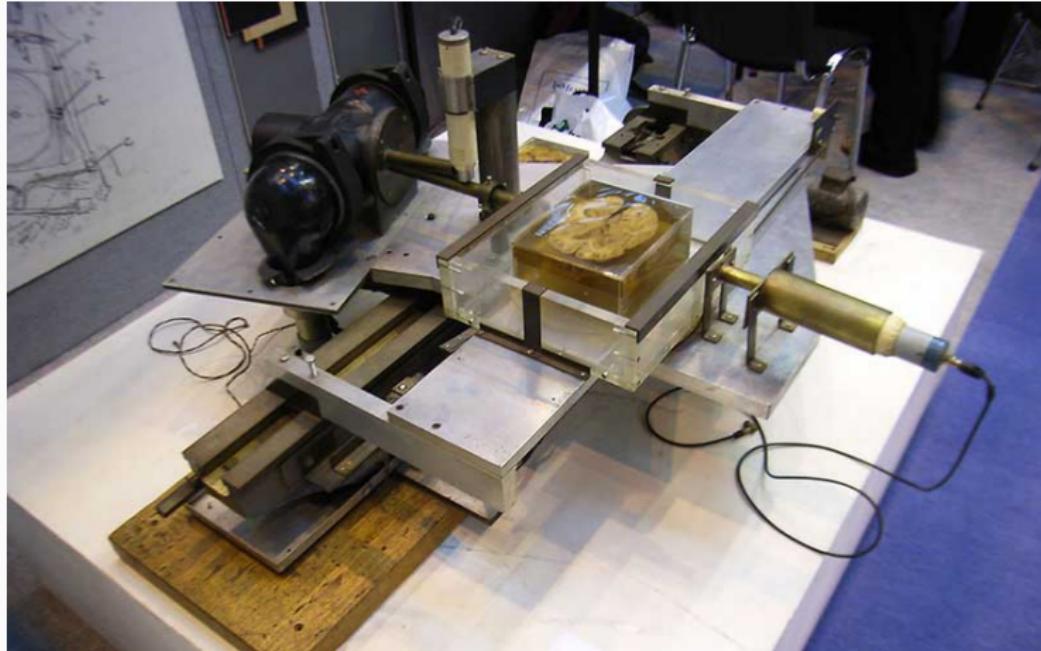
1957: First image to be digitally scanned and stored as digital pixels on the Standards Eastern Automatic Computer (SEAC).

The Rise of Digital Media



1964: The first digital image from Mars by Mariner 4 using a television camera, mounted on a scan platform.

The Rise of Digital Media



1972: First commercially available CT scanner.

The Rise of Digital Media



1973: Digital Image Processing used for first time in the cinema (Westworld).

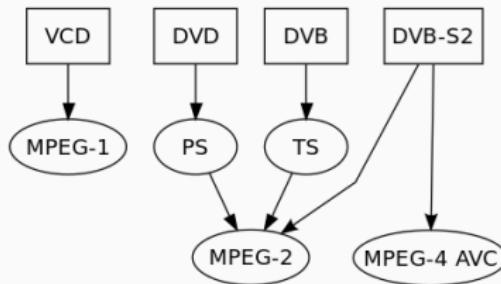
The Rise of Digital Media



1980s: Introduction of Digital Video in Television Production

1990s: introduction of Digital Video Cameras and Tape
(DigiBeta and DV standard)

The Rise of Digital Media



Late 1990s: Digital Television and DVD emerges. Compression standards like JPEG and MPEG2 are established.

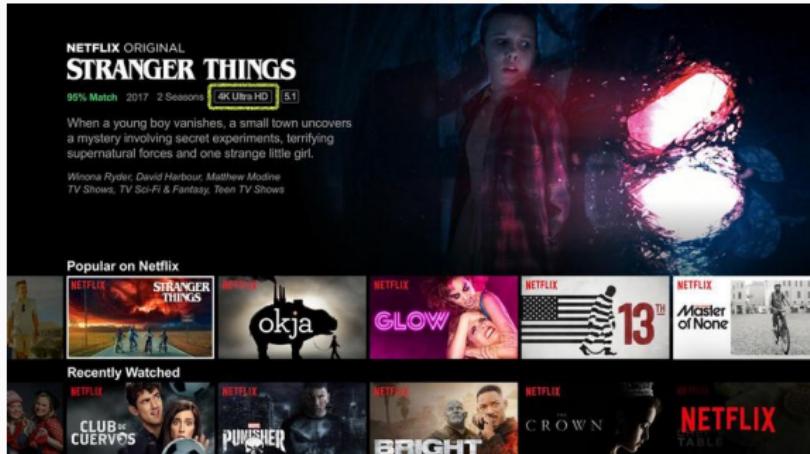
The Rise of Digital Media



MP3, MPEG4, QuickTime Video Format, FLV, etc.

2000s: Video on mobile phones / video over internet/ HDTV / 3DTV

The Rise of Digital Media



Now: Online streaming of high quality Video (incl. 4k) (Netflix, Youtube etc.)

Consolidation around 2 main compression standards: MPEG (h264, h265, etc.) and Alliance for Open Media (vp9, av1, etc.)

Why Compression?

Why Compression?

In the days of **standard definition** TV, the resolution was 720×576 pixels, with 3 colours per pixel ($3 \times 8 = 24$ bits per pixel) at 25 fps.

Let's look at the bandwidth of some uncompressed streams:

$$\text{SD} = 720 \times 576 \times 24\text{bpp} \times 25 \text{fps} \approx 250\text{mbps}$$

$$\text{HDTV} = 1920 \times 1080 \times 24\text{bpp} \times 60 \text{fps} \approx 3\text{gbps}$$

$$\text{UHDTV} = 3840 \times 2160 \times 24\text{bpp} \times 60 \text{fps} \approx 12\text{gbps}$$

$$\text{3D Cinema} = 4096 \times 2160 \times 36\text{bpp} \times 48 \text{fps} \times 2 \approx 30\text{gbps}$$

Why Compression?

By 2022, video viewing will account for 82% of all internet traffic. (CISCO)

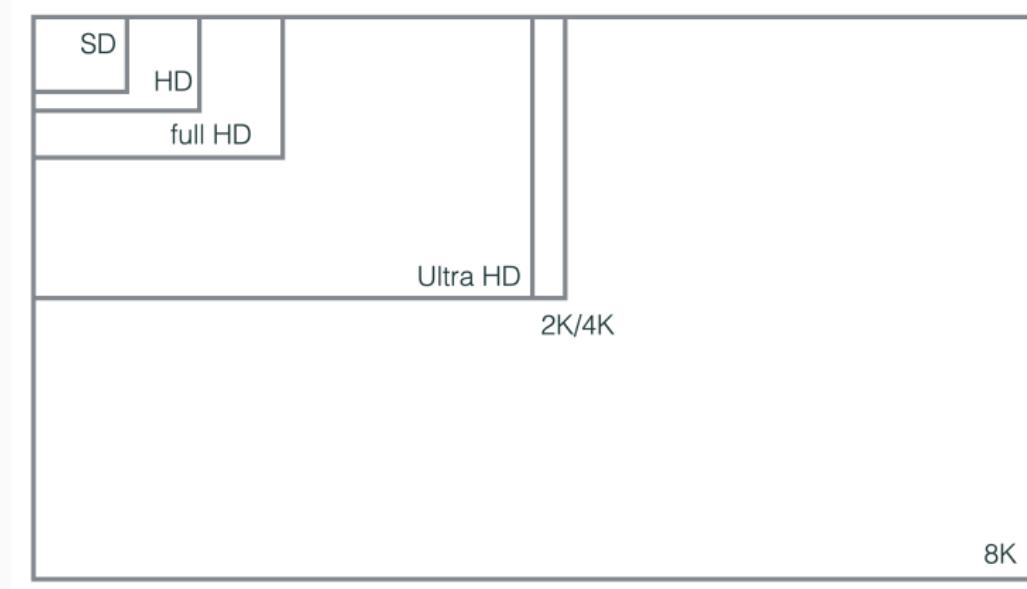
Internet traffic accounts for more than 1% of global emissions.

1% improvement on compression means Billions of \$ in bandwidth savings.

Why Compression?

Will Bandwidth ever catch up?
probably not,

Why Compression?



Youtube has been streaming in 8K for some years now...

Why Compression?



HDRTV (12+ bit per channel) has also been here for some time.

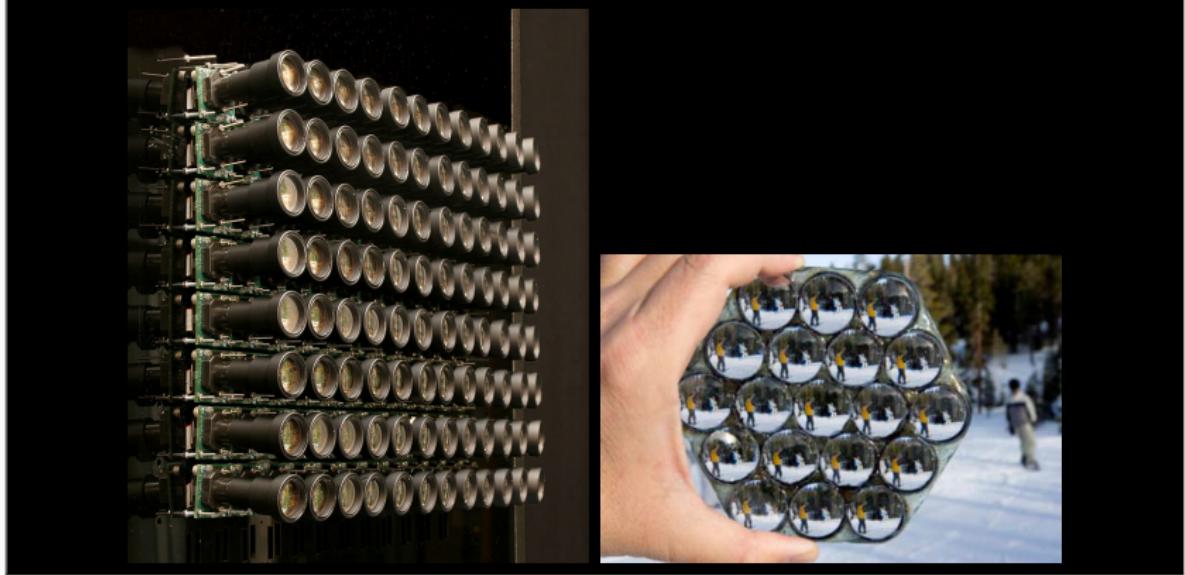
Why Compression?



Virtual Reality requires probably something like 16K at 120fps in Stereo 3D.

raw bandwidth \approx 1tbps

Why Compression?



Lightfield cameras (capturing light from all angles) will probably be the next revolution.

raw bandwidth \approx 14tbps

Why Compression?

Compression is ubiquitous:

Digital Cameras have built in compression on the chip itself.
Even for top of the range cameras like Arri and Red.

Cinema PostProduction Companies store images using lossless
image compression (EXR file format).

When working with images, the main consideration are
memory cache and data bandwidth between GPU and CPU.

Videos are just big.

Books and Links

DIGITAL IMAGE PROCESSING. GONZALEZ AND WOODS. PRENTICE HALL
(a good general purpose image processing text book)

JPEG: STILL IMAGE PROCESSING STANDARD. PENNEBAKER AND MITCHELL. VAN NOSTRAND REINHOLD. (a reference for JPEG)

DIGITAL VIDEO: AN INTRODUCTION TO MPEG2. HASSELL, PURI AND NETRAVALI. CHAPMAN AND HALL (a reference for MPEG2)

Engineering Blogs from YouTube and Netflix:

<https://youtube-eng.googleblog.com/>

<http://techblog.netflix.com/>