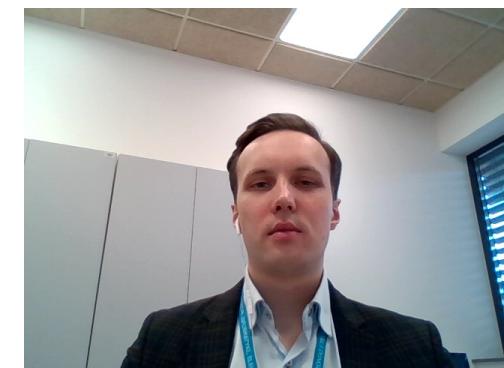




AKADEMIA GÓRNICZO-HUTNICZA
IM. STANISŁAWA STASZICA W KRAKOWIE
AGH UNIVERSITY OF SCIENCE
AND TECHNOLOGY

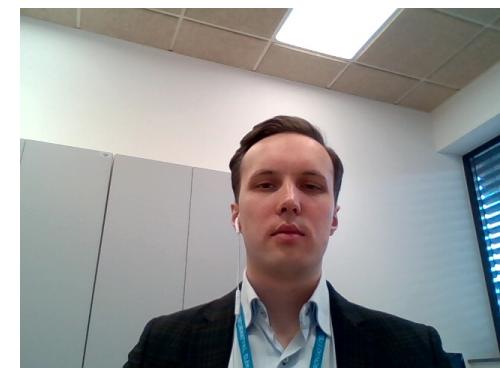
Digitization

Mikołaj Leszczuk, Jakub Nawała
MIPaC



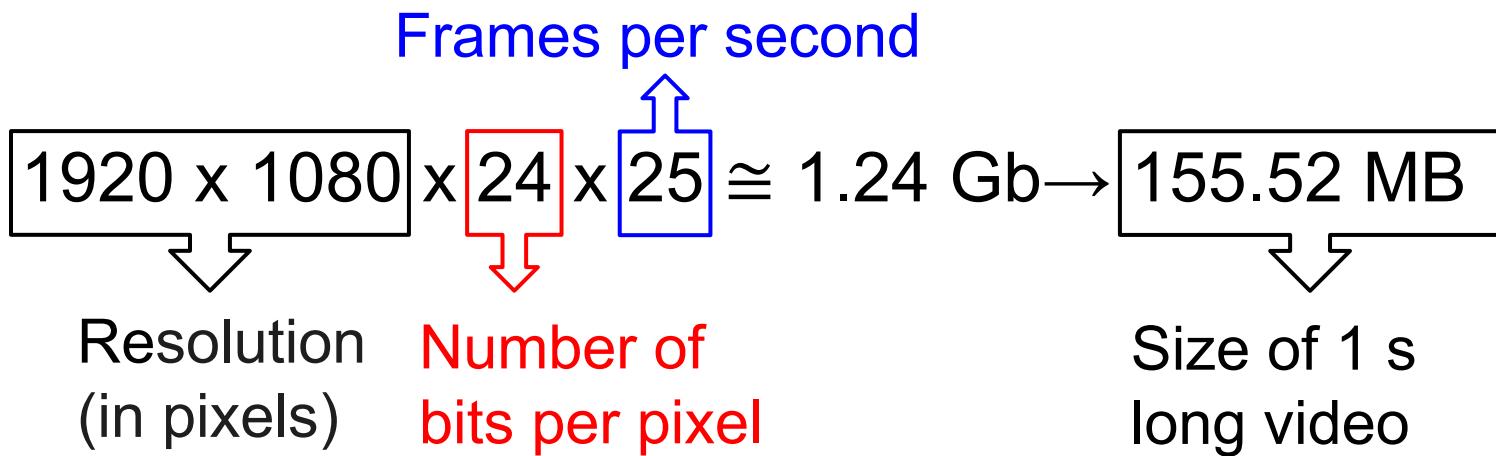
Why Digital Systems?

- » To process real-world (i.e., analogue) data using computers.
- » Digital signals are easier to interleave.
- » Switching analogue signals is expensive.
- » Switching digital signals is cheap.
- » Filtering of digital signals performs better than its analogue counterpart.



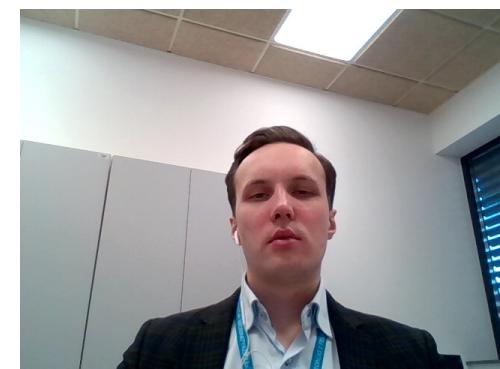
Digitization in Image Processing

- » Digital images are a special type of signals
 - they measure a parameter over space (and not time).
- » Their quality is highly subjective.
- » They contain a lot of information.



What Must Be Done?

- » We must have proper sensors to store digital data.
- » We must have proper interfaces to transmit digital data.
- » We must send only the most important information.



What Is Actually Done?

- » We use proper sensors.
- » We compress multimedia signals to make their storage and transmission easier.

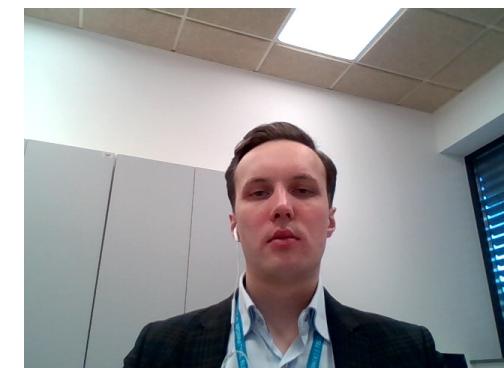
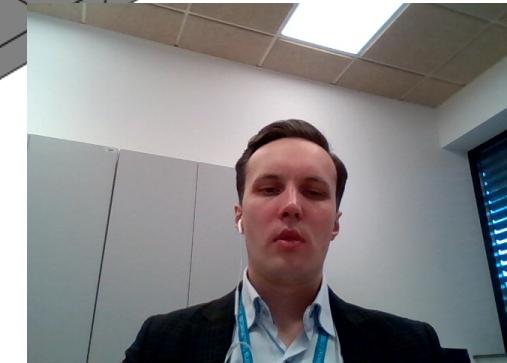
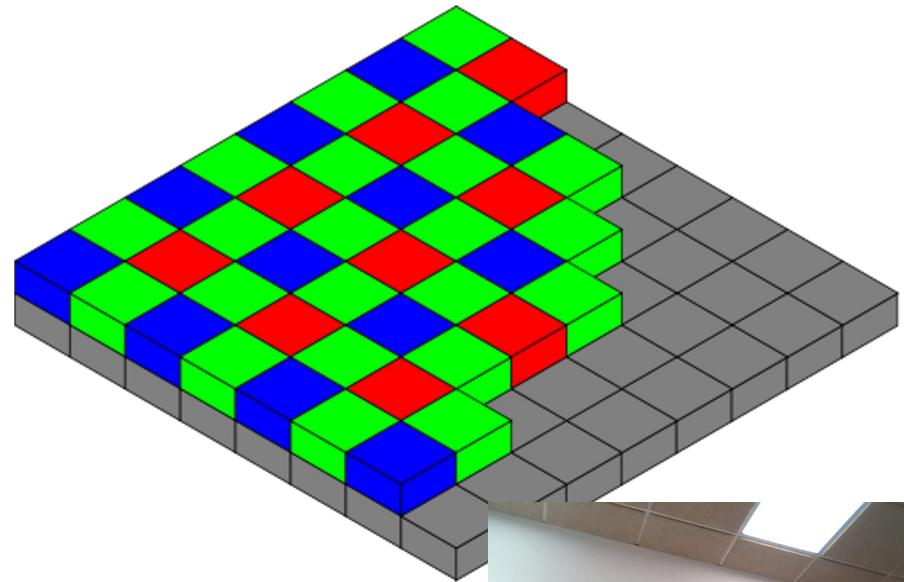
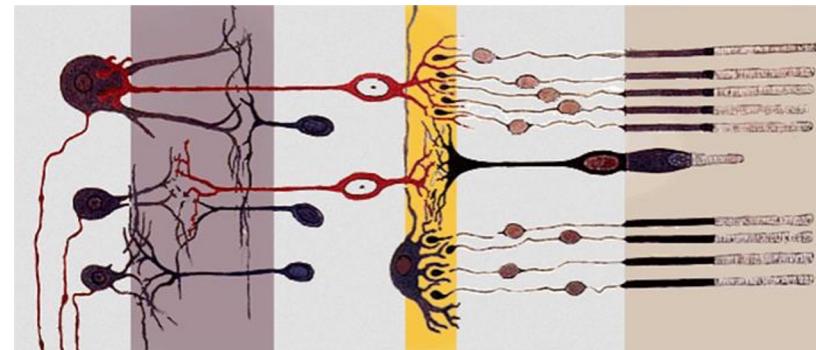
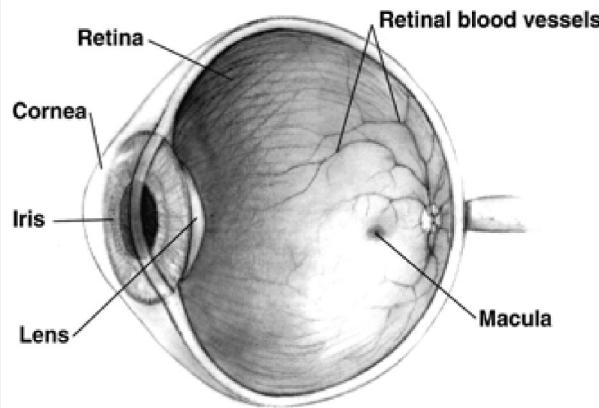


Image Sensor

- » Semiconductors based.
- » Consists of pixels.
 - One photodetector for each pixel (true for Active Pixel Sensor, APS - also called CMOS Sensor).
- » Bayer filter to distinguish between colours.



Human Vision Sensors



- » Rods – luminance (light level); ~ 90 mln.
- » Cones – chrominance (3 types, each sensitive to a different colour): **Red**, **Green**, **Blue**; 4.5 mln.



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Human Vision Sensors

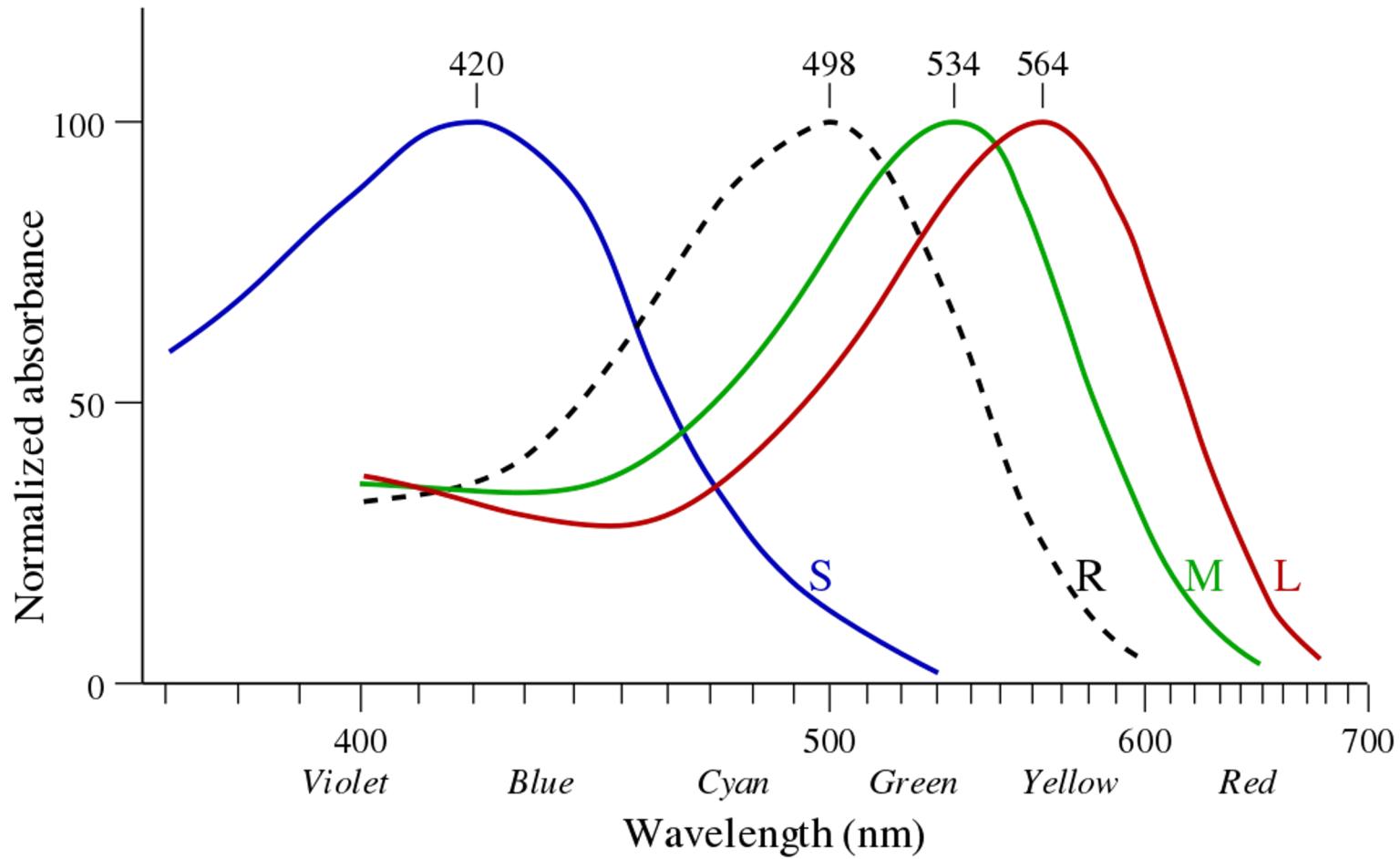


Image taken from Wikimedia Commons. For an author and licensing for the upper image see [here](#).

Human Visual System (HVS) Model

- » Models biological and psychological processes in human body related with visual stimuli perception.
- » The most important observations:
 - Lows-pass filter (due to a limited number of rods),
 - Low color resolution (fewer cones than rods),
 - Motion sensitivity (stronger than texture sensitivity),
 - Texture stronger than disparity.



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**WHAT IF I TOLD
YOU**

**IMAGE IS MATRIX OF
PIXELS**



How Matrix Represents Pixel Colours

52	55	61	66	70	61	64	73
63	59	55	90	109	85	69	72
62	59	68	113	144	104	66	73
63	58	71	122	154	106	70	69
67	61	68	104	126	88	68	70
79	65	60	70	77	68	58	75
85	71	64	59	55	61	65	83
87	79	69	68	65	76	78	94

„JPEG example subimage” by en:User:Cburnett – Own work in Inkscape based on the following data:. Licensed under CC BY-SA 3.0 via Commons –
https://commons.wikimedia.org/wiki/File:JPEG_example_subimage.svg
[#/media/File:JPEG_example_subimage.svg](#)

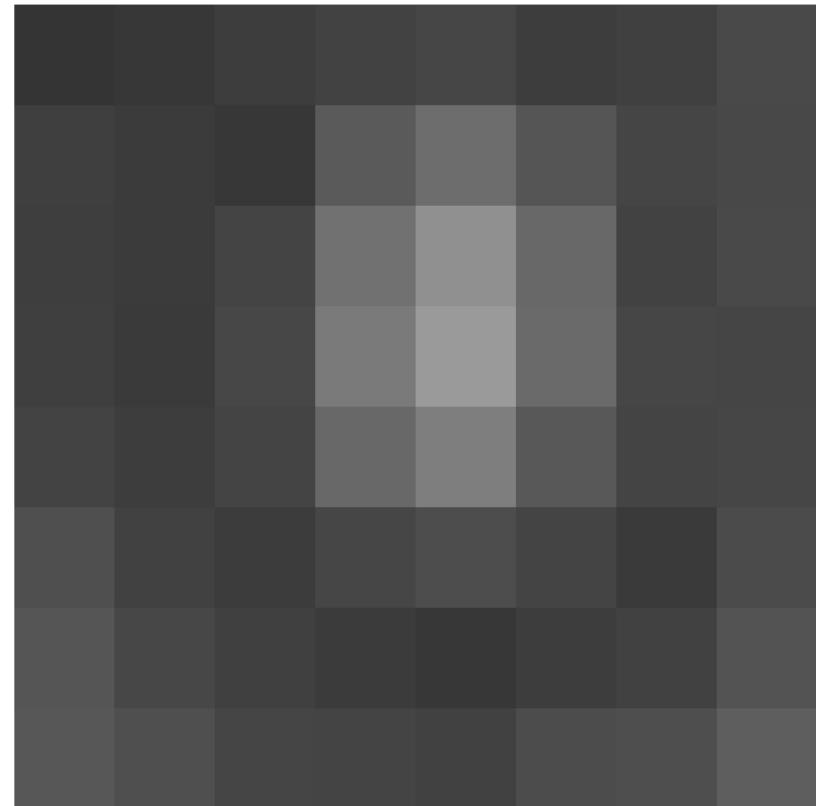


Image Types

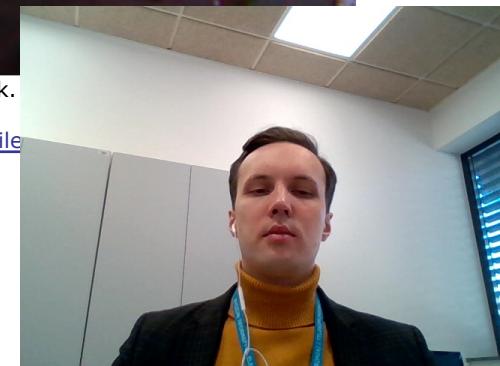
- » **True-colour (RGB)** – generated by digital camera & widely used in computer graphics
- » **(Scale) indexed** – often used to display scientific/engineering data with colour scale
- » **Grayscale** – often used in image processing/analysis algorithms
- » **Binary** – often used as mask to indicate segmentation results/region of interest

True-Colour (RGB) Images

- » Each image pixel has 3 components
- » Values associated with it:
 - **Red**
 - **Green**
 - **Blue**
- » Matrix representation:
3D array of $M \times N \times 3$

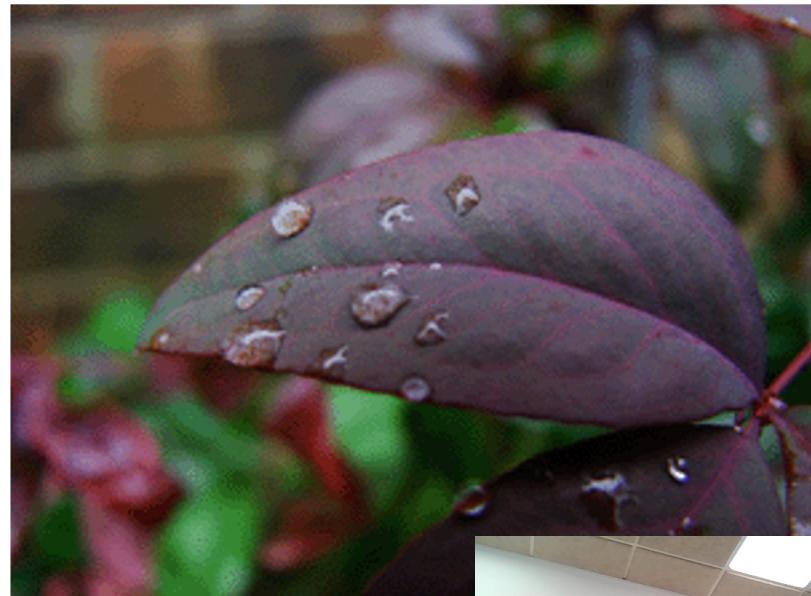


"True-colour" by Thegreenj – Own work.
via Commons –
<https://commons.wikimedia.org/wiki/File:Truecolor.png>

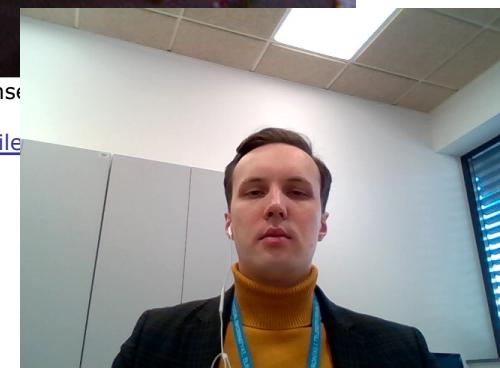


(Scale) Indexed Images

- » Not determining pixel colours
- » Using matrix values as indices
- » Looking up colours in colour-map

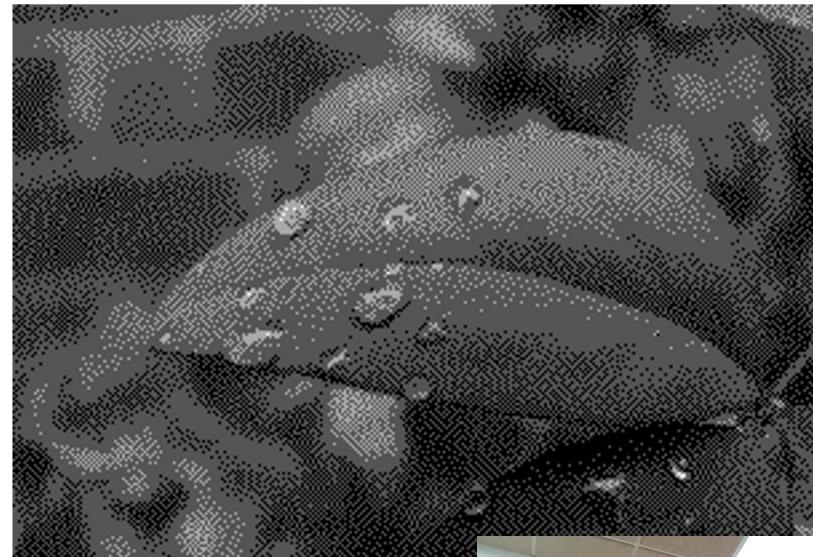


"8 bit" by Thegreenj – Own work. License: Commons – https://commons.wikimedia.org/wiki/File:8_bit.png

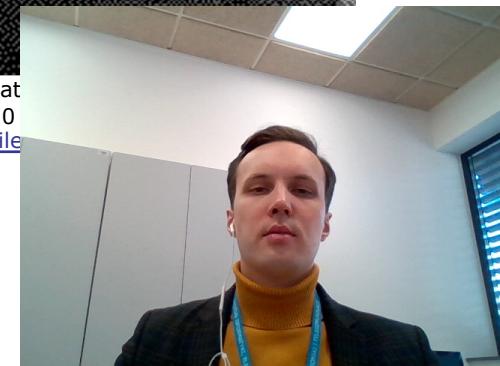


Grayscale Images

- » Only brightness information
- » Using grayscale colour-map

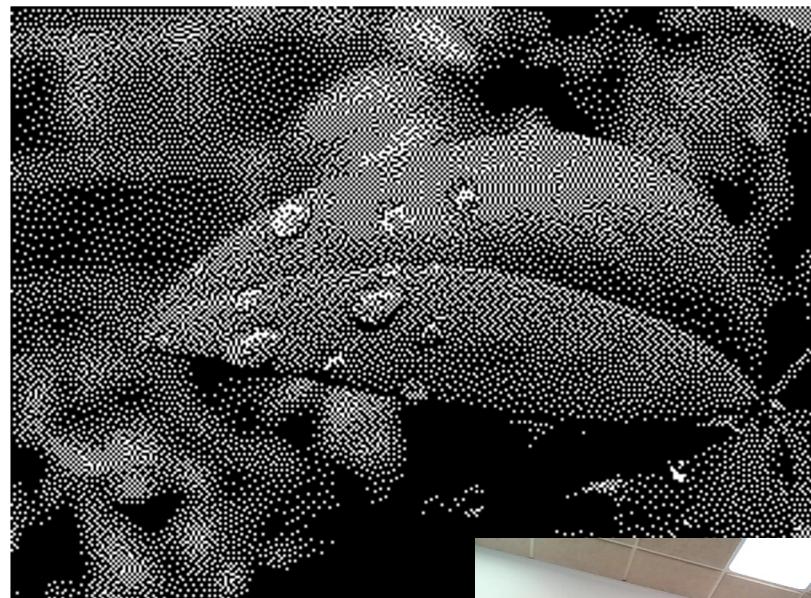


"2 bit" by 8_bit.png: JorgePeixotoderivat
8_bit.png. Licensed under CC BY-SA 3.0
https://commons.wikimedia.org/wiki/File:8_bit.PNG

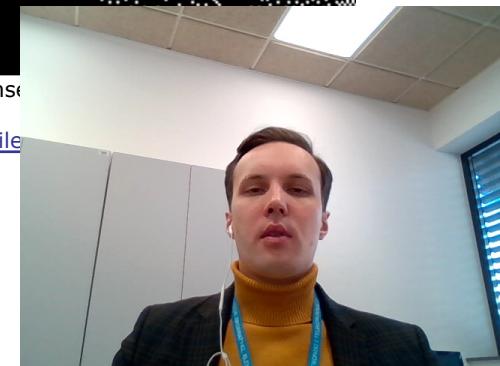


Binary Images

- » Containing only black/white pixels
- » Often output of image segmentation
- » Binary image, where:
 - White pixels: object of interest
 - Black pixels: background

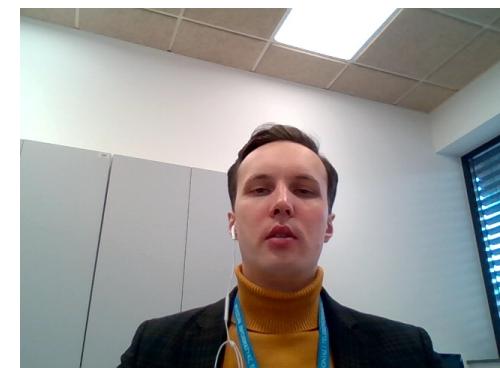
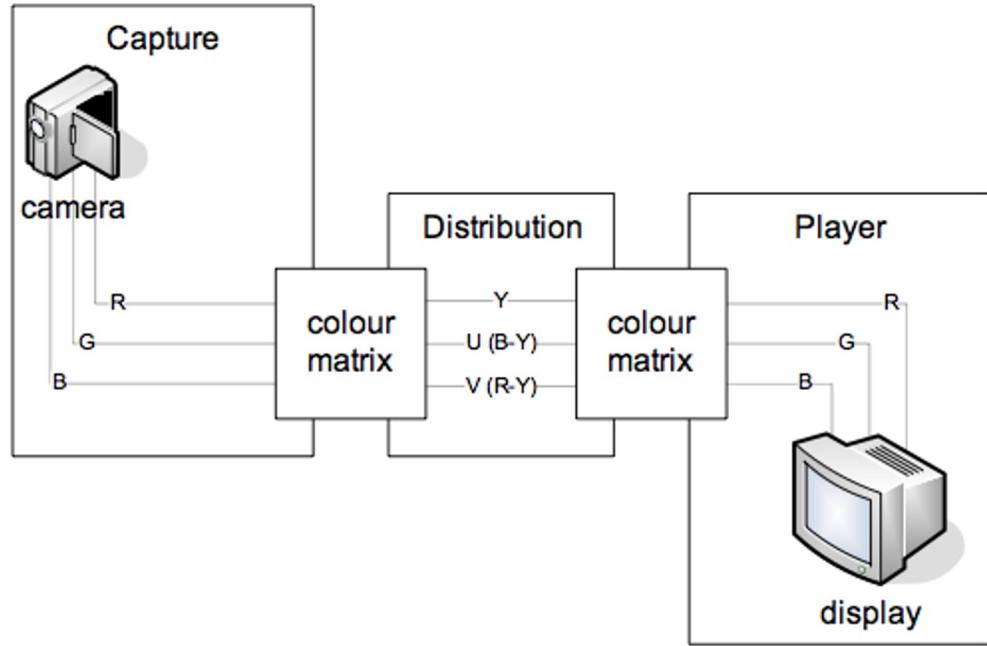


"1 bit" by Thegreenj – Own work. License Commons – <https://commons.wikimedia.org/wiki/File:.png>

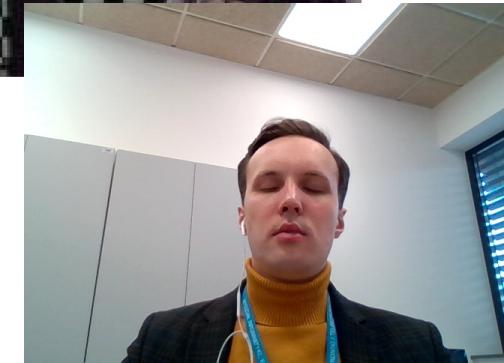


Colour Space Conversion – RGB and YUV

- » Y – Luminance
- » C – Chrominance:
 - U (B-Y)
 - V (R-Y)
- » Related to *pixel formats* and *FourCC codes*.

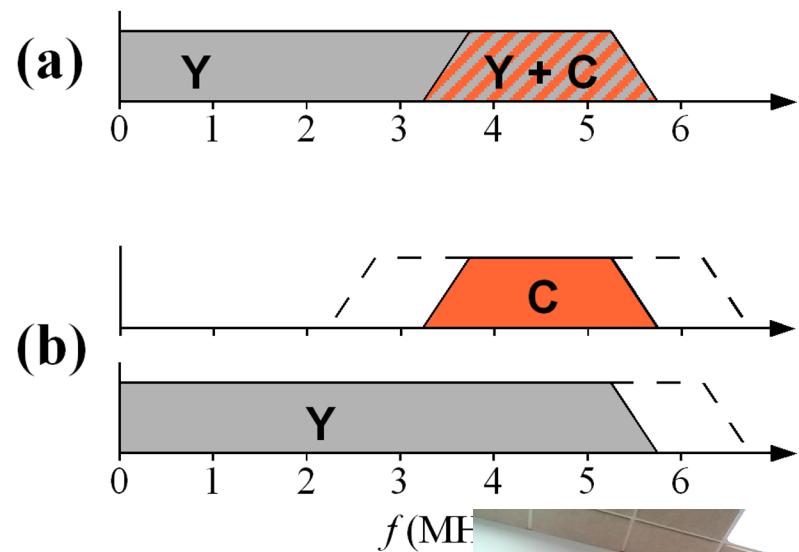


Chroma Keying Special Effects

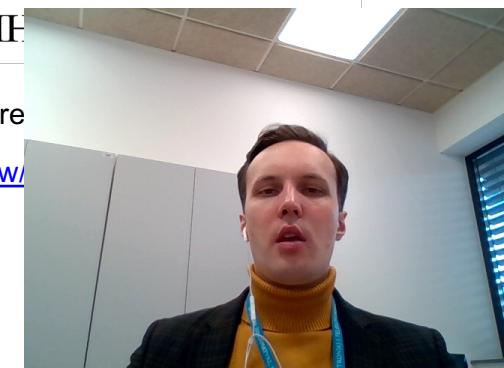


Chrominance Band Limiting

- » Human eye perception:
 - Lower **C** detail – lower resolution
 - Higher **Y** detail – higher resolution
- » More bandwidth for **Y** than for **C**
- » In analogue system transmitted:
 - a) Composed together
 - b) Separated



By Michael Schmid – Drawing created by Michael Schmid
2.5, <https://commons.wikimedia.org/w/index.php?curid=1000000>

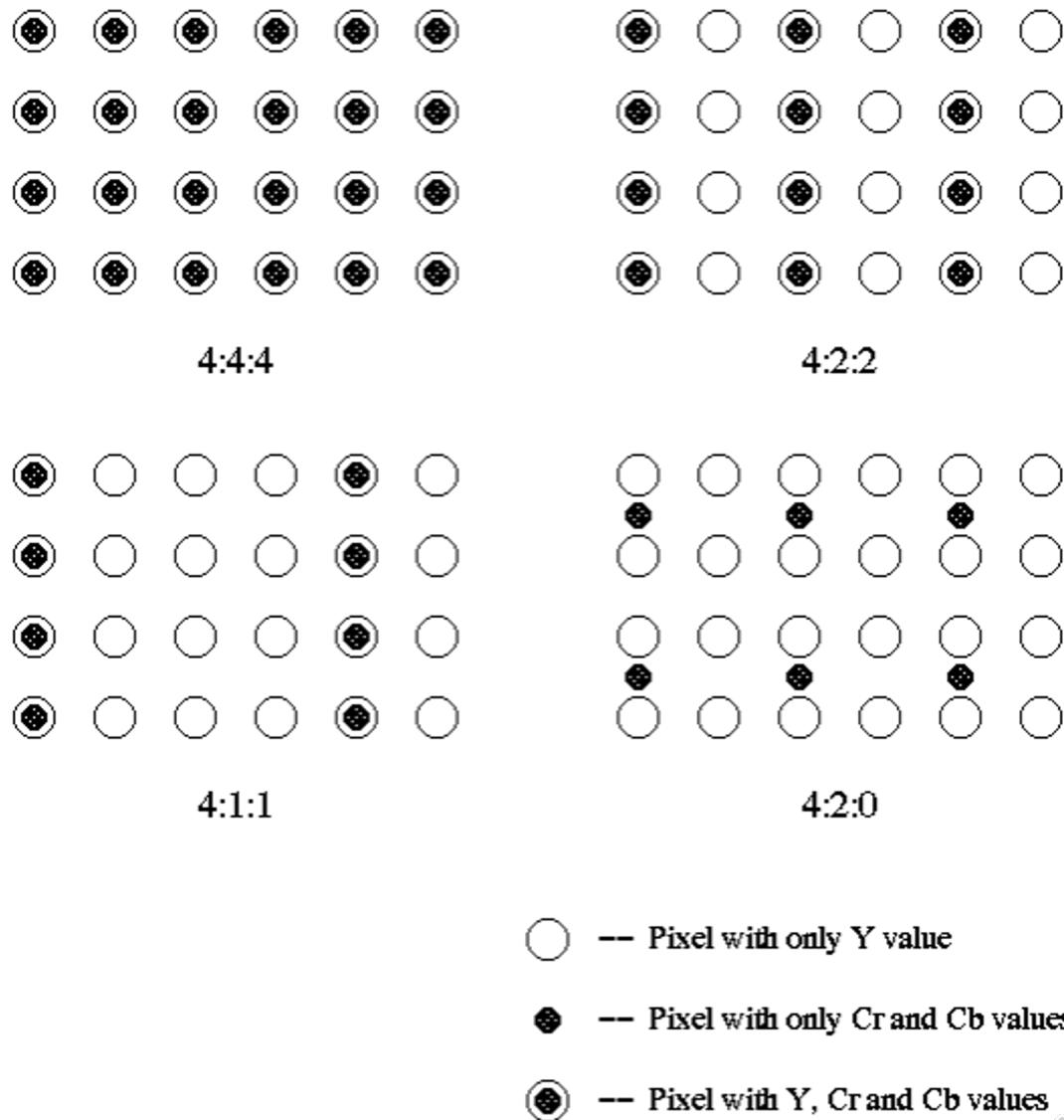


Sampling Structures

Source:

„Basics of Video”

<http://lea.hamradio.si/~s51kq/V-BAS.HTM>





“Colorcomp” by Janke – I (Janke). Licensed under CC BY-SA 3.0 via
AGH Wikipedia –

<https://en.wikipedia.org/wiki/File:Colorcomp.jpg#/media/File:Colorcomp.jpg>



4:1:1



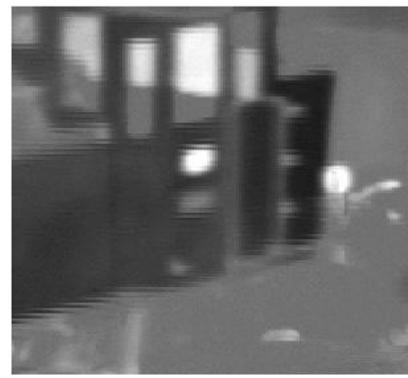
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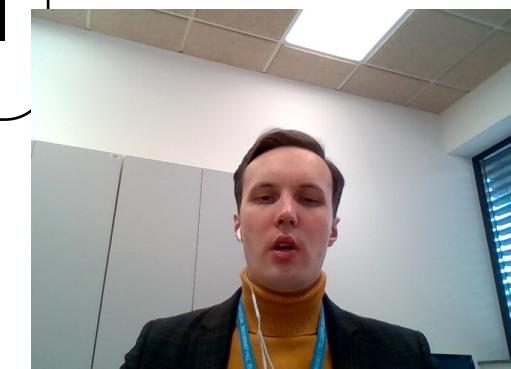
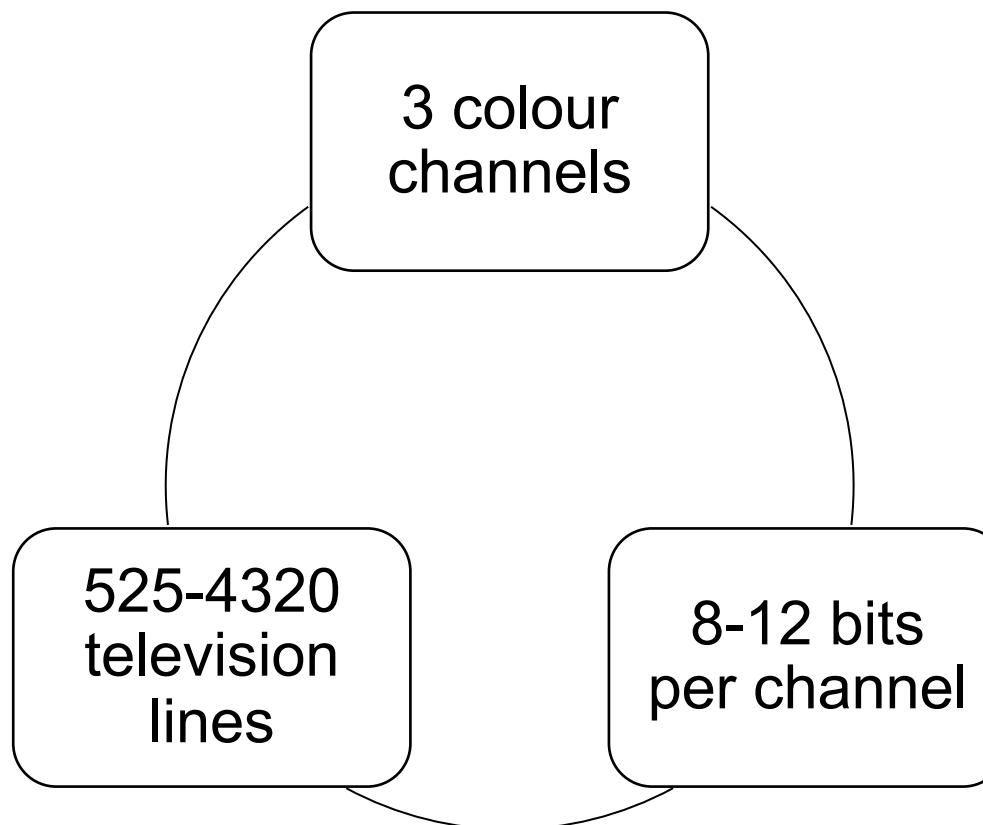
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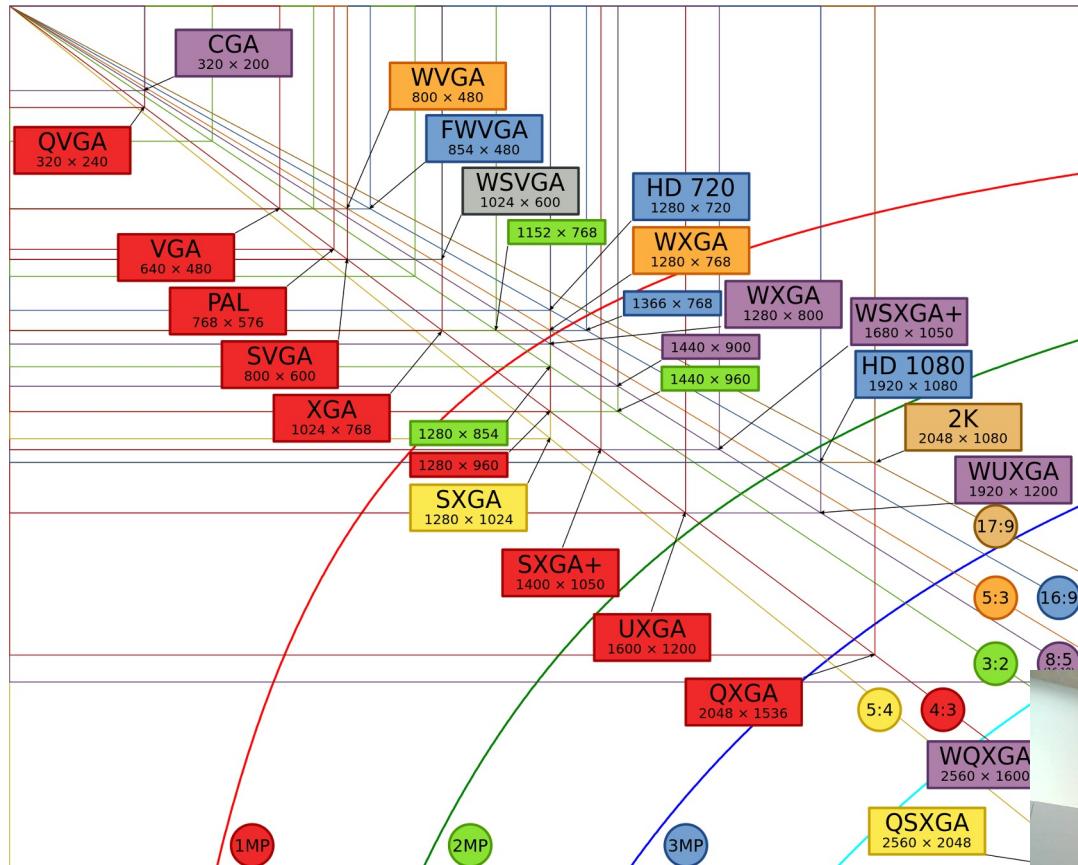
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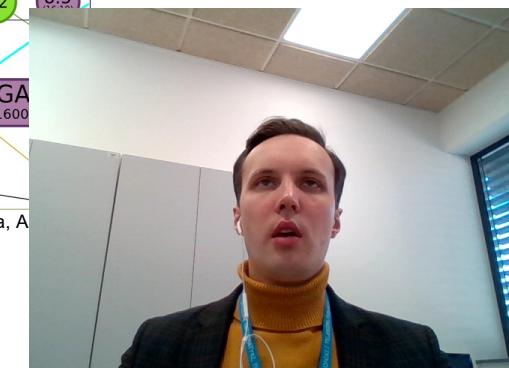
Ground Rules of Video Digitization



Common Display Resolutions



"Vector Video Standards2" by Original uploader was XXV at en.wikipedia. Later version(s) were uploaded by Jjalocha, A at en.wikipedia. – sTransferred from en.wikipedia. Licensed under CC BY-SA 3.0 via Wikimedia Commons – https://commons.wikimedia.org/wiki/File:Vector_Video_Standards2.svg#/media/File:Vector_Video_Standards2.svg



Video Compression Sneak Peak

- » Upper from raw video stream,
- » Lower compressed,
- » Raw video stream size:
~389 MB,
- » Compressed size:
~300 KB,
- » Smaller more than 1300 times!

