

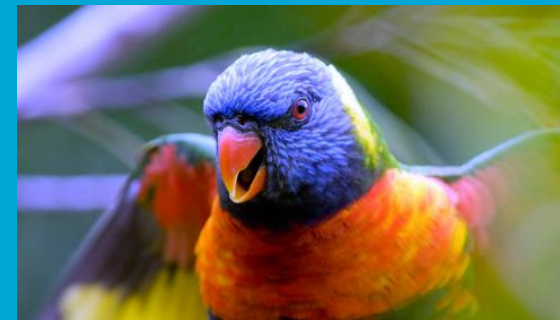
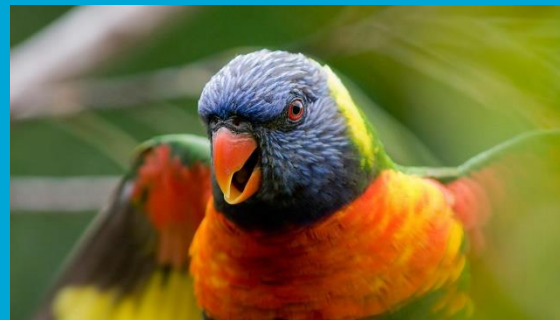
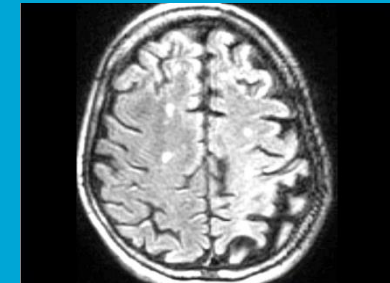
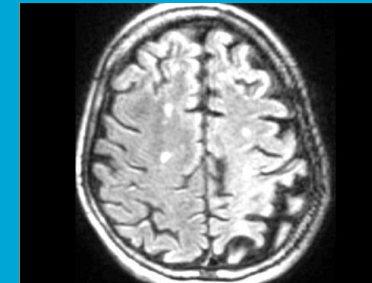
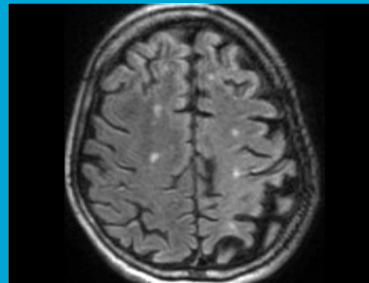
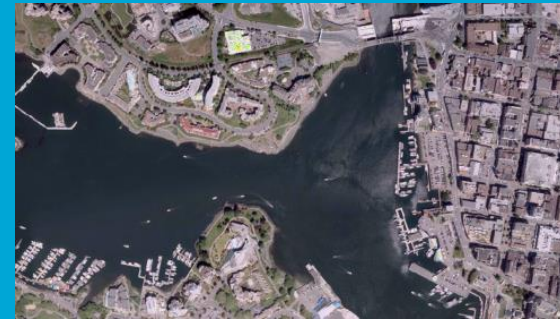
Video Contrast and Sharpness Enhancement

T. Petersen, T. C. Mol, E. Cozza

16/02/2024

Fields of Application

- Satellite Imaging
- Medical Imaging
- AI and Computer Vision applications
- Multimedia applications



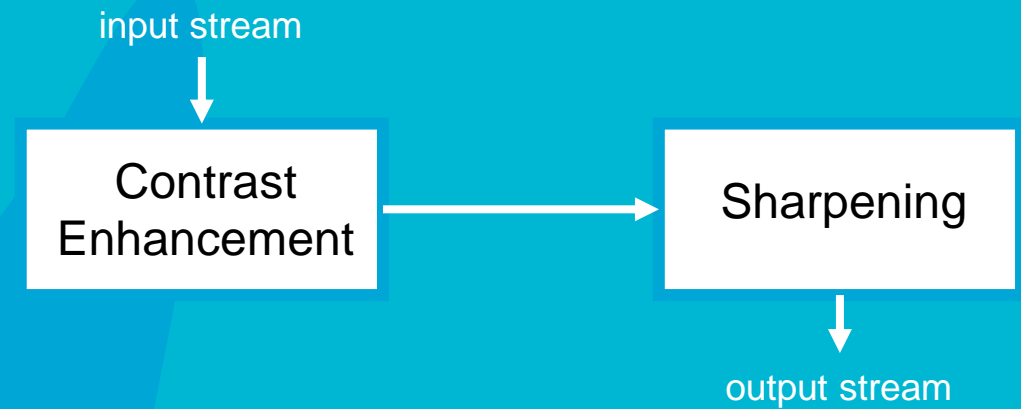
Design Modules

1. *Contrast-Enhancement* module
2. Convolution with *sharpening* filter

Software Implementation

```
def image_sharp(image):  
    ...  
    return sharpened  
  
def contrast_enh(img, p):  
    ...  
    return final_image  
  
input_image = cv.imread(...)  
  
ce_image = contrast_enh(input_image, p)  
output_image = image_sharp(ce_image)
```

Hardware Implementation





01

Software Implementation

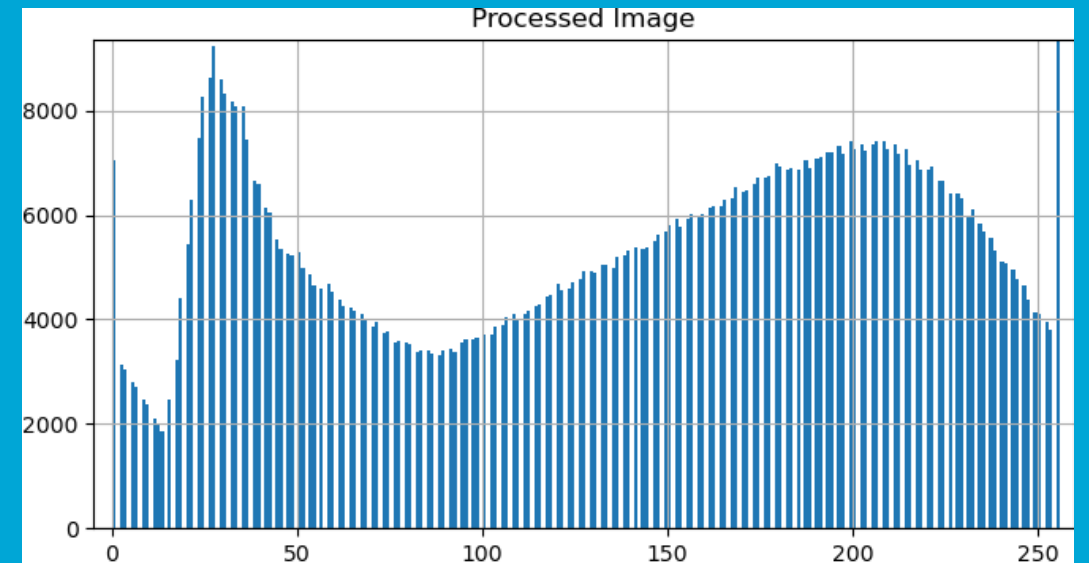
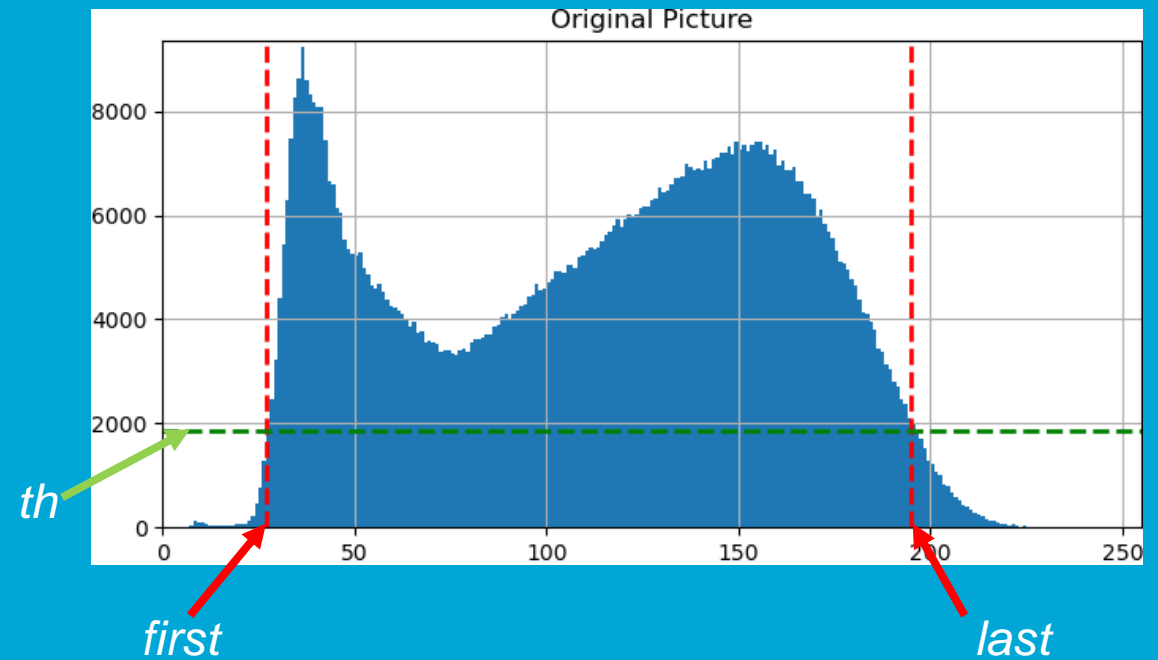
Contrast Enhancement

1. Image decomposition into 3 channels
2. Histogram Computation
3. $th = \max(histogram) \cdot p$
4. $k = \frac{255}{last - first}$
5. Adjust the brightness level of all the pixels:

$$g(x, y) = \begin{cases} 0 & \text{if } f(x, y) < \text{first} \\ k \cdot f(x, y) - \text{first} & \text{if } f(x, y) \in [\text{first}; \text{last}] \\ 255 & \text{if } f(x, y) > \text{last} \end{cases}$$

6. Repeat steps 2-5 for each channel

(p is a user-defined input parameter)



Results



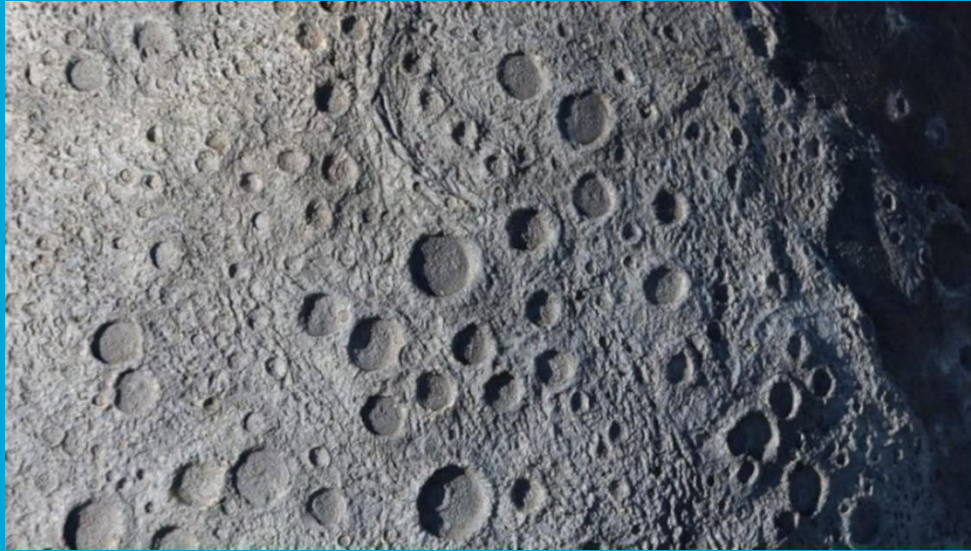
Original Picture

Contrast Enhancement



Contrast Enhancement + Sharpening

Results



Original Picture

Contrast Enhancement



Contrast Enhancement + Sharpening

Results

- Time measurements were recorded for each call to both the contrast and edge enhancement functions during the transmission of 60 frames.
- The performances of the final design have been evaluated in terms of (average) processing time per frame and (average) frame rate.

Module	Processing time [s/frame]	Frame Rate [frame/s]
Contrast Enhancement	0.977	1.024
Edge Enhancement	0.218	4.588
Total Pipeline	1.233	0.811



02

Hardware Implementation

Constraint:

- Acquisition, processing, and output of 1 pixel per clock cycle

Limitations:

- Working on entire frames would require:
 - Too much memory
 - Too much latency

Solution:

- Stream-Processing approach
- Exploit similarities among contiguous frames

Contrast Enhancement

- Synchronization of computation steps by mean of a pixel counter
- Two phases exist:

Pixel Pipeline:

Each received pixel increments the histogram count

Apply contrast enhancement according to the parameters evaluated for the previous frame

Parameters Update:

Reset: reset all the parameter concerning the previous frame

Max: find the maximum value of the histogram for each channel

Th: calculate the threshold

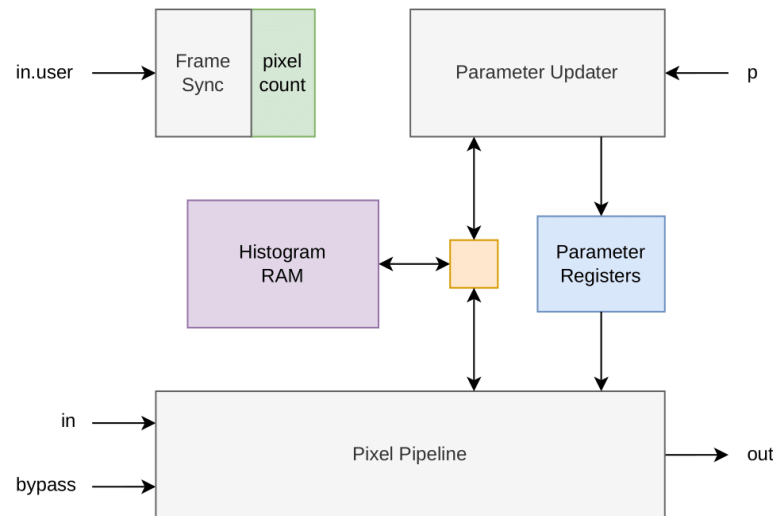
F&L: find first and last

PU: update all the parameters to be used for the next frame.

Pixel Pipeline



Frame structure depicting the different processing phases



Top-level diagram of the contrast enhancement module

Results



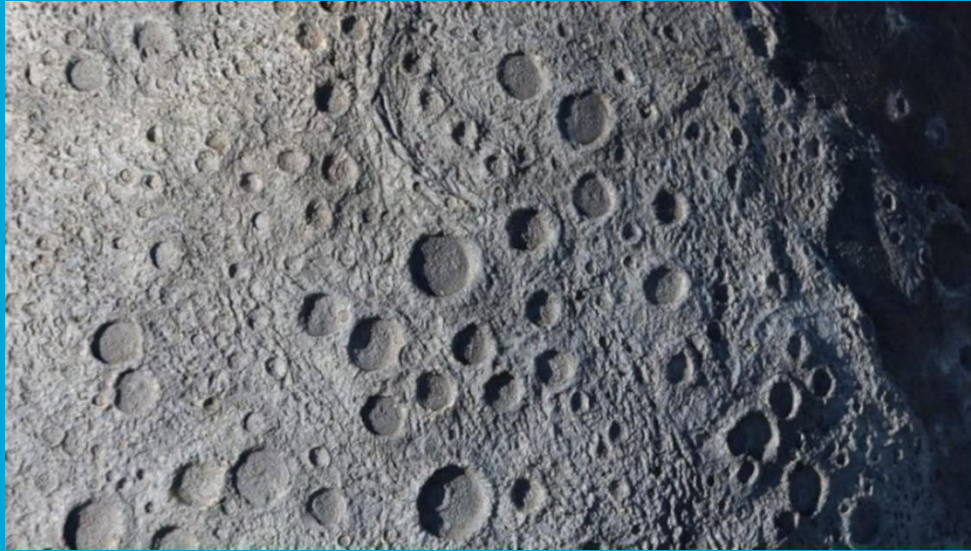
Original Picture

Contrast Enhancement



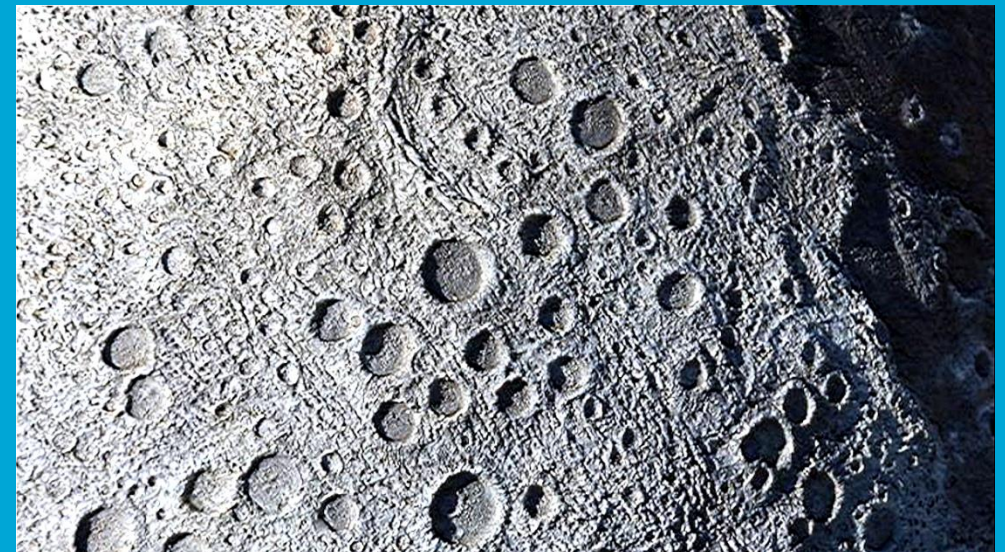
Contrast Enhancement + Sharpening

Results



Original Picture

Contrast Enhancement



Contrast Enhancement + Sharpening

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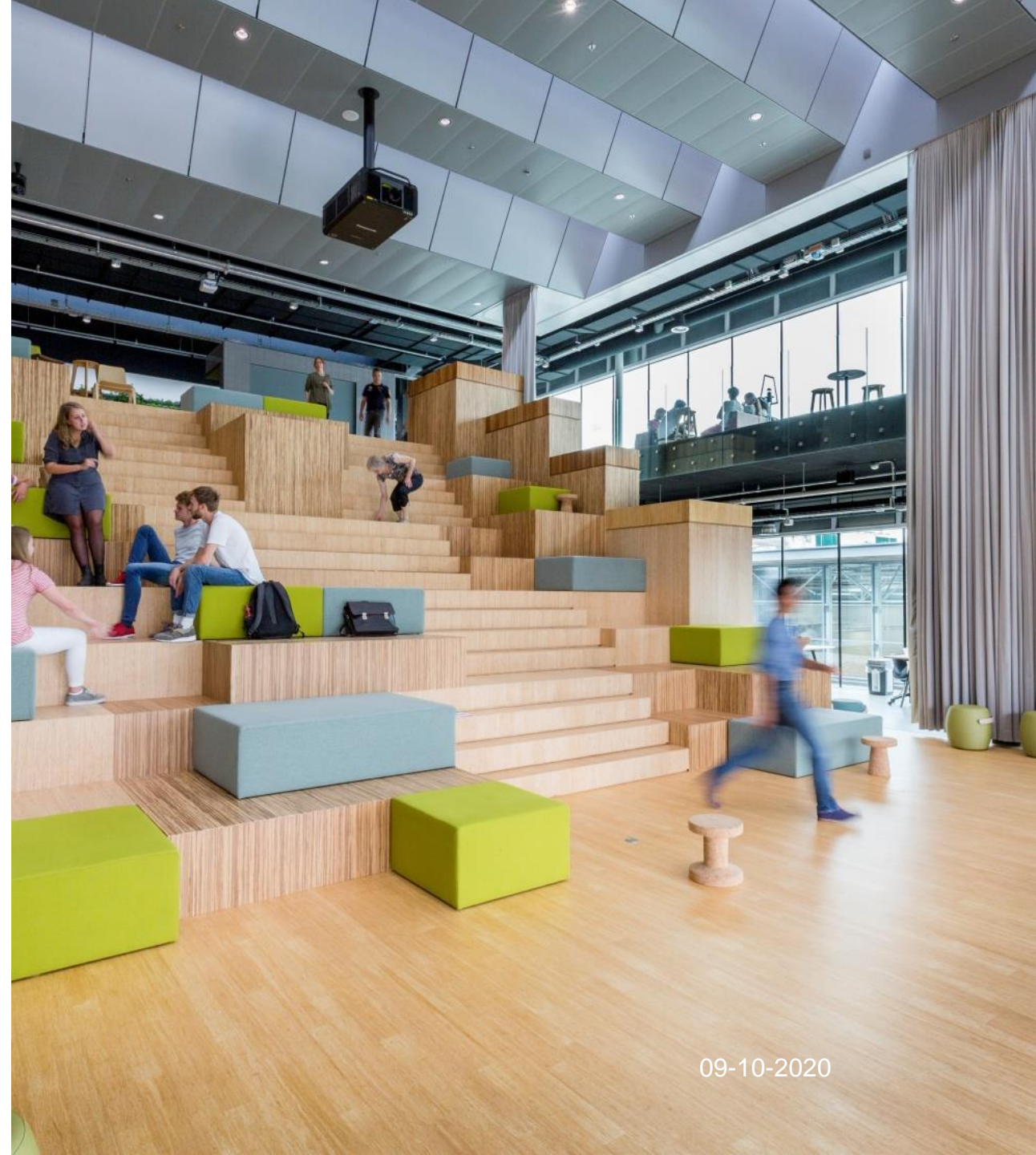


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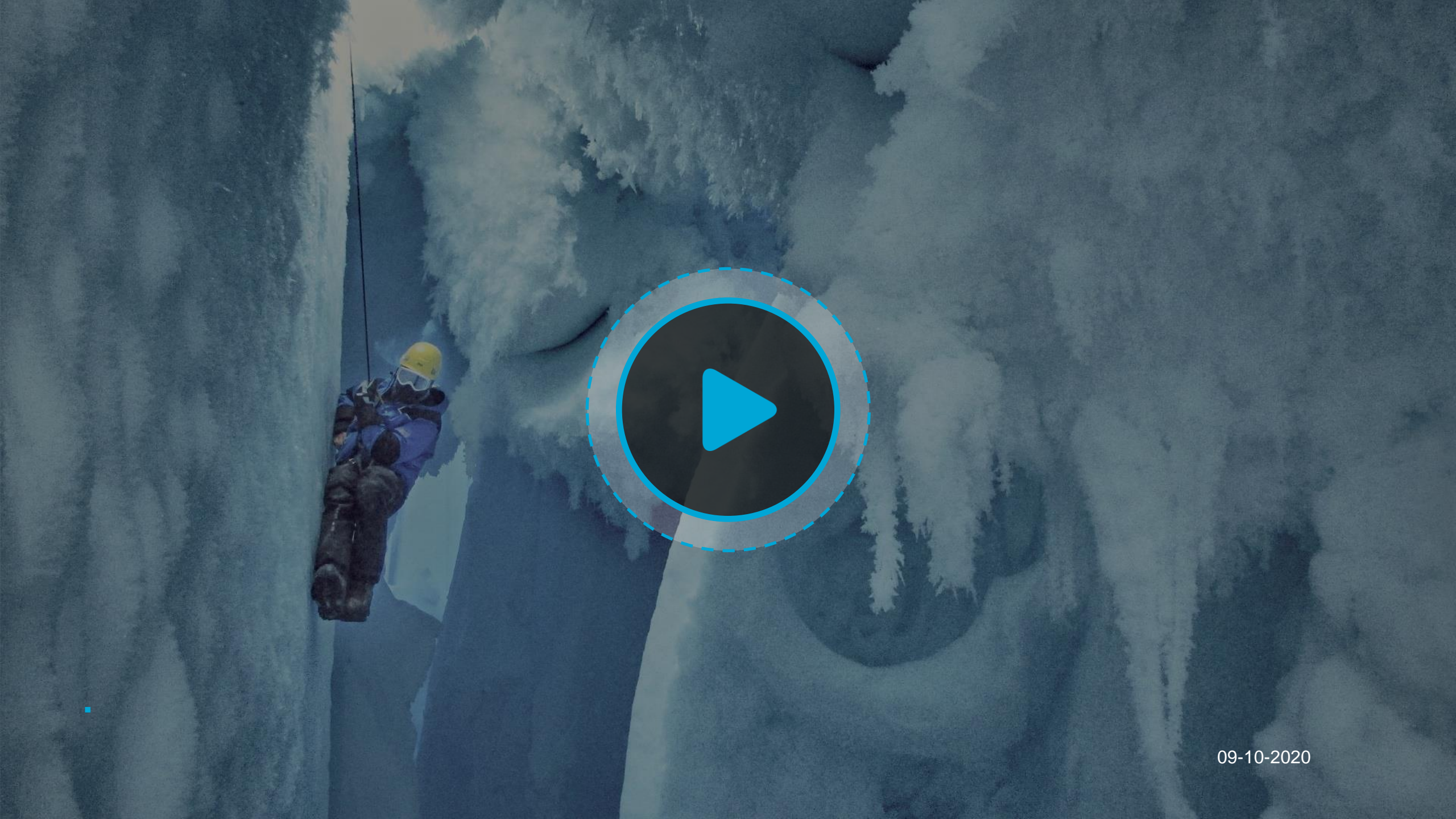






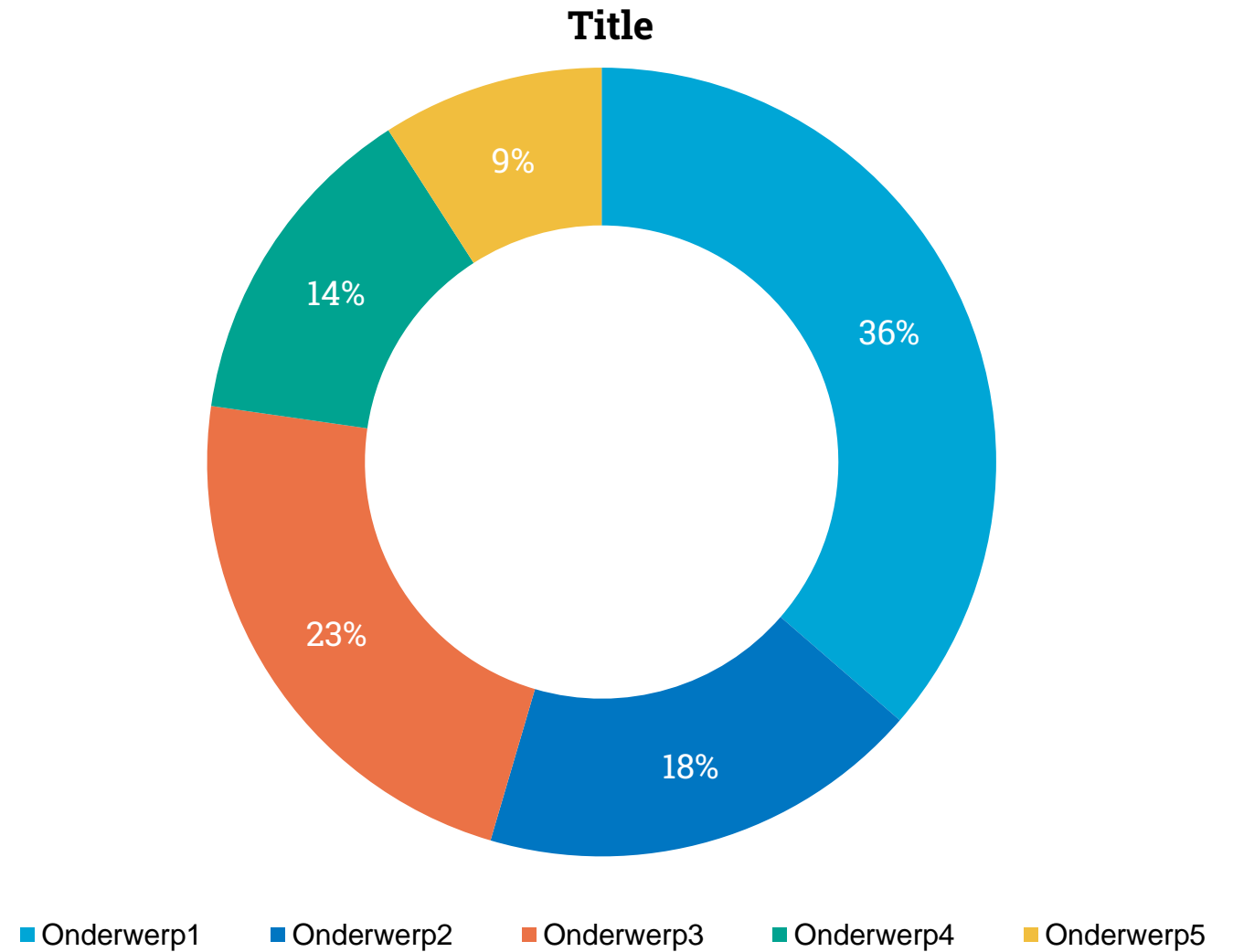
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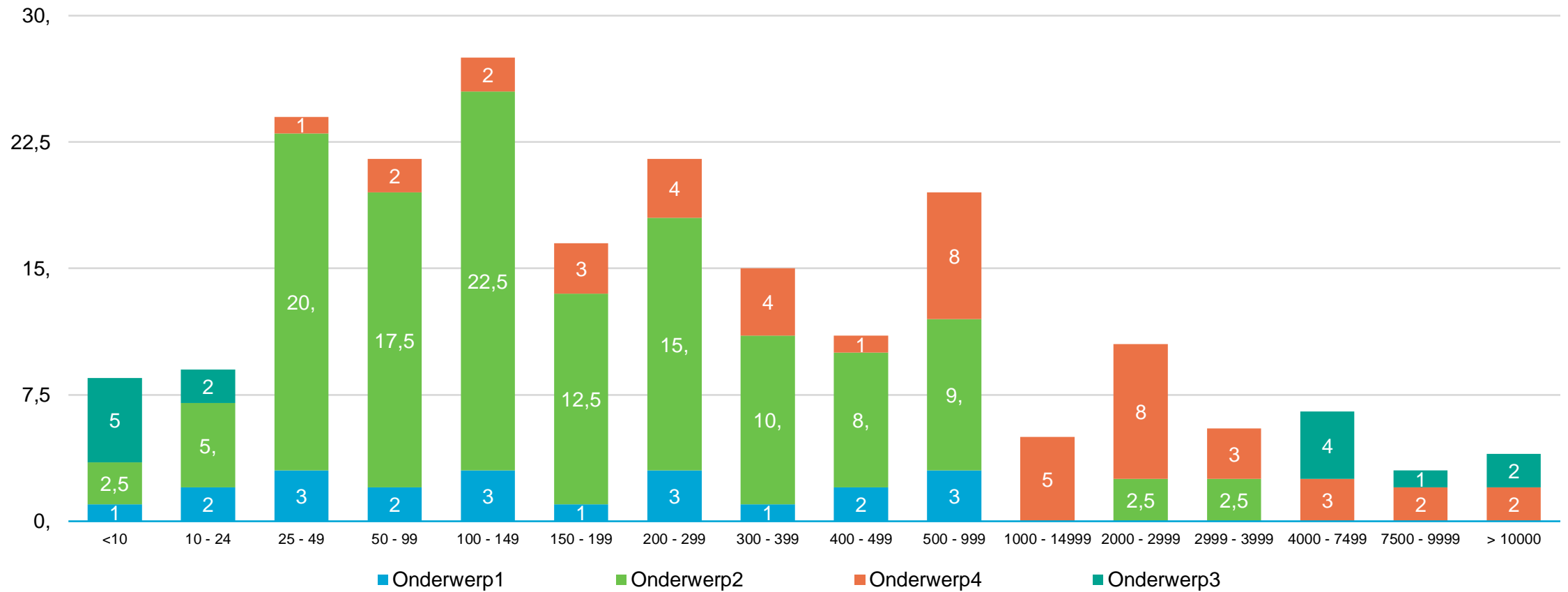


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Page title

Year	Subject 1	Subject 2	Subject 3	Subject 4
2014	40%	55%	40%	55%
2015	7%	80%	7%	80%
2016	20%	26%	20%	26%
2017	69%	31%	69%	31%
2018	82%	85%	82%	85%
2019	89%	92%	89%	92%

Thank you for your attention

Name