Portrait colorization, a model comparison - Deep Machine Learning

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Background

Colorization of monochrome images:

- Increases visual appeal.
- Time consuming- and often requires manual effort [4].

Figure 1: Monochrome colorization of portrait

Understanding the LAB colorspace:

- Resembles the human visual system [2].
- One channel for image brightness (L), two channels for image color (a- and b).
- Commonly used in networks aiming to colorize black- and white images [3].

Aim: We want to build two models to automate the task of colorizing human portraits and compare their respective advantages- and disadvantages.

Method

The dataset *Human Faces* was used. Contains **7219** images of human faces varying in size [1].

Data preprocessing steps:

- Remove black- and white images.
- Normalize data: [0,255] $\rightarrow$ [0,1].
- Convert from RBG to LAB using `skimage-color`.
- Homogenize image size $\rightarrow$ 128x128 pixels.

Post preprocessing dataset size: **6501** images.

Model 1: **U-net**

- Built with convolutional blocks forming an encoder, bottleneck and decoder.
- Convolutional block: Two convolutional layers with depth n, ReLU activtion functions, kernel size: 3x3, stride: 1 and padding: 1.
- Resolution decreased in encoder and increased in decoder.
- Decoder uses spatial information concatenated from the encoder.

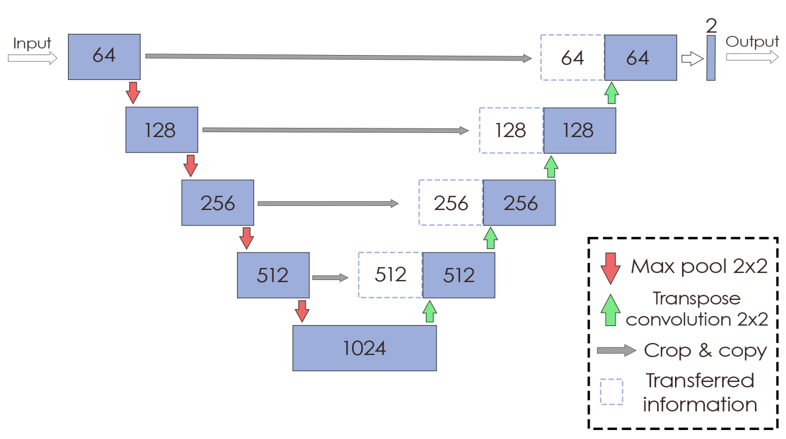

Figure 2: U-net architecture. Convolutional block represented as blue rectangle.

Model 2: **uVGG-net**

- Use transfer learning from VGG-19 in parallel with U-net.
- Frozen parameters.
- Concatenate spatial information in bottleneck.

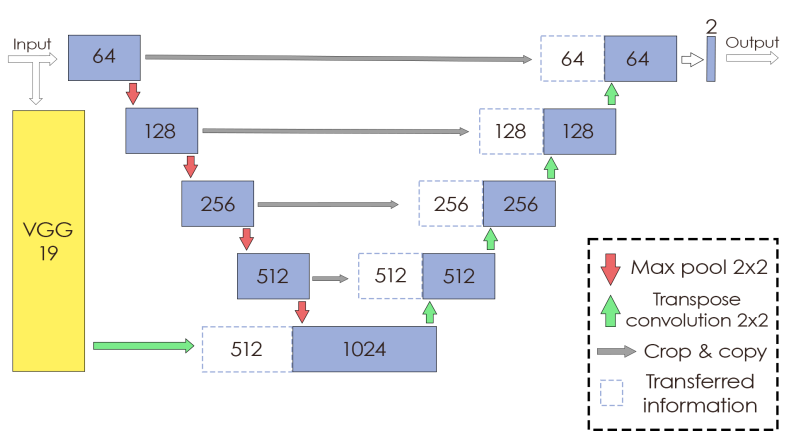

Figure 3: uVGG-net architecture. Convolutional block represented as blue rectangle. VGG19 represented by yellow rectangle.

Results & Discussion

Models were trained with:

- Batch size of 32 (U-net) and 24 (uVGG-net) images.
- 20 epochs.
- L_1-loss.
- Adam optimization algorithm
- Learning rate of α = 0.001.

Observations:

- $\approx$ 70 mins training per model.
- U-net stagnates.

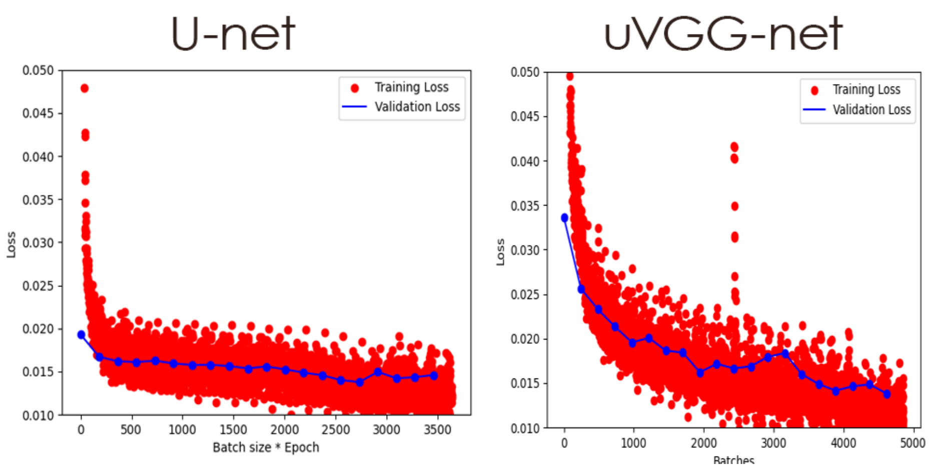

Figure 4: Training- and validation loss for the two models.

Model colorizations:

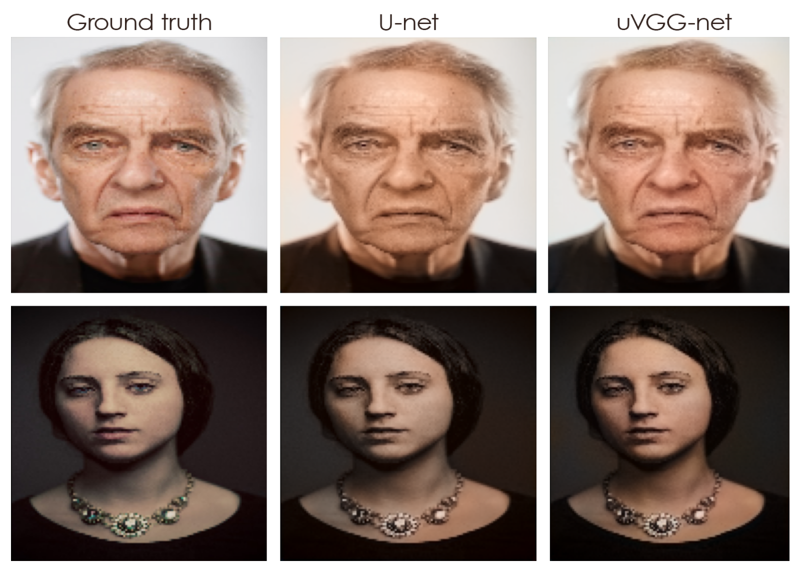

Figure 5: From left to right: Ground truth of predicted image, colorization made by U-net, colorization made by uVGG-net.

Color distribution:

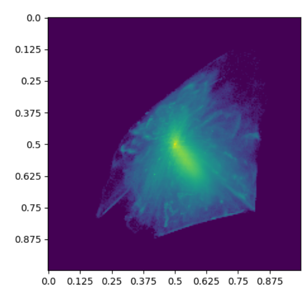

Figure 6: Distribution of pixel values in a- and b channels ($\log_e$).

- Each pixel is put into a bucket. 40 k buckets in total. 95 mil total pixels.
- Largest bucket: 7 mil pixels, 7.4%.
- Empty buckets: 28 k, 70%.
- Distribution is highly skewed.
- Bias towards less colour?

Visual appeal:

- 52 participants answered the question *"Which of the following images looks more realistic?"*
- One image from U-net and one uVGG-net (non-labeled).
- 73.1% of participants favoured output from uVGG-net.

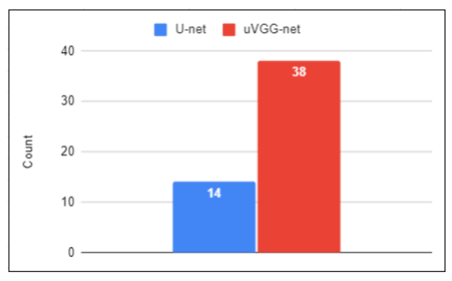

Figure 7: Visual appeal. Blue column is U-net and red column is uVGG-net.

Conclusion & Future development

- Both models colorizes the facial area of the image with a skin tone color.
- The use of VGG19 improves the U-net model in visual appeal from asked participants without a substantial increase in training time.
- Both models reaching the same magnitude of validation loss after training. Thus the numerical loss does not correspond to the visual appeal.
- *Areas of improvement*:
  - Experiment with different loss functions for the networks.
  - Use weighted loss proportional to color occurrence to express more rare colors.

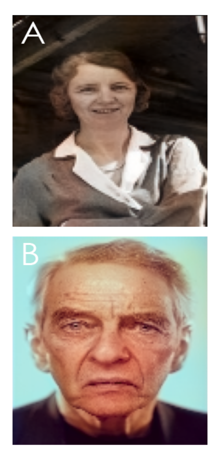

Figure 8: A: Colorized image of Vera Sandberg. B: uVGG-net trained with 1 epoch of weight bias

References

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