# Colouring and interactive visualizaion of historical Earth observation data

by **Yiwei Wang**

**The CORONA project is one of the satellite projects aimed at building a reconnaissance system launched by the US during the 1960s to the 1970s (Peebles, 1997). During its 12 years of operation, numerous satellite images were taken. These so called CORONA images are available at a high spatial resolution but provide only panchromatic (greyscale) information. This study implements a deep-learning based method to colourize these greyscale images, and evaluate the colourized images both quantitatively and qualitatively. Furthermore, a web mapping application is developed to visualize the colourized images. The users can download dataset in a self-defined region of interest.**

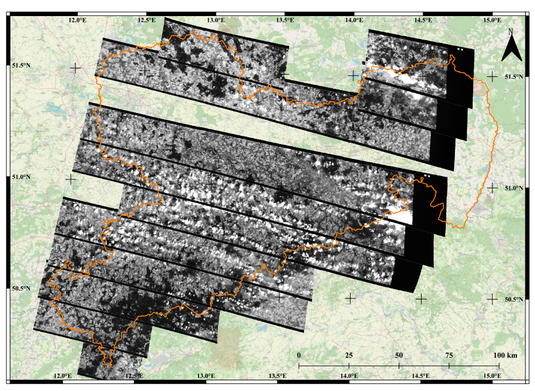

*Figure 1: Data overview*

## Method and setup

This study can be divided into three parts: colourization, evaluation and visualization. The existing DeOldify model (Antic et al., 2019), which implements a Generative Adversarial Network (GAN), is used and adapted for colourization. A set of training data derived from the CORONA images as shown in Figure 1 and the corresponding colour reference images are used for retraining the DeOldify model. Root Mean Square Error and Peak Signal-to-Noise Ratio are chosen for quantitative evaluation. Additionally, a user study is used to ask the participants to decide if the displayed colour image looks natural to evaluate the plausibility of the colours. The workflow for colourization and evaluation is shown in Figure 2. To visualize the results, a web mapping application consisting of two parts is developed: a backend data server that can provide image data storage and optimize data access through tiling and caching service, and a frontend web map client that can display image data and provide GIS functionalities. The workflow for the web mapping application is shown in Figure 3.

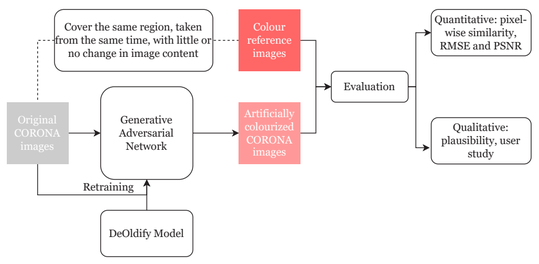


*Figure 2: workflow for colourization and evaluation*

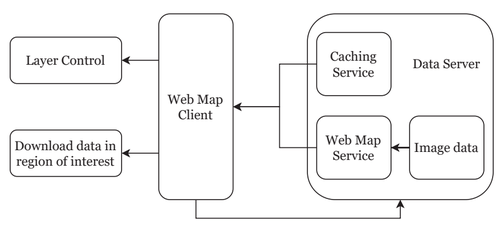


*Figure 3: workflow for visualization*

## Experiment and results

In total, 2000 training images of size 224x224 are selected from the CORONA satellite image dataset, along with 2000 colour reference images. The training implements the NoGAN training style used in the DeOldify model. The steps are as follows:

1. Pretrain the generator
2. Save the images colourized by the generator
3. Pretrain the critic
4. Train the generator and critic in a GAN training approach
5. Save the generator model and repeaet steps 2 to 5

Initially the entire network was retrained on the CORONA images. But after experiments, the output colour images were not satisfying. To get a better result, the pretrained generator from the original DeOldify model is used. The retraining starts with pretraining the critic , followed by direct GAN training. This training cycle is repeated for 3 times in total. For each round of training cycle, the generator model is saved after each iteration to select the one with the best performace. After the training, the selected generator is used to colourize test images. These colourized images are evaluated and results are shown in Figure 4. Figure 5 shows the evaluation results for test images colourized by the original DeOlidfy model. P indicates the percentage of participants thinking the colour image natural. Figure 6 shows the comparison between the two models. Images colourized by the retrained model has significantly higher plausibility but worse RMSE and PSNR performance. Figure 7 shows the interface of the web mapping application. A download panel is on the upper left corner, where the user can create a rectangle by drawing or inputting coordinates and download data of the selected layer in the region. A layer control is on the upper right corner where user can switch between layers.


*Figure 4: evaluation results of test images by retrained generator*

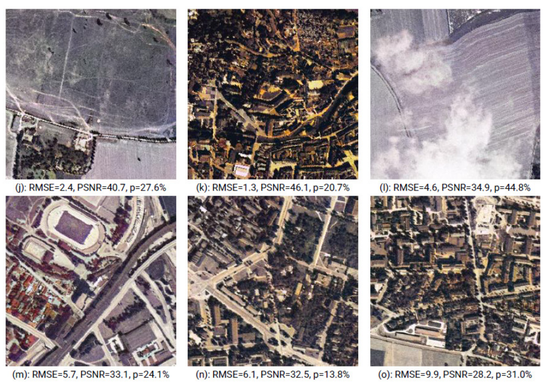


*Figure 5: evaluation results of test images by DeOldify model*

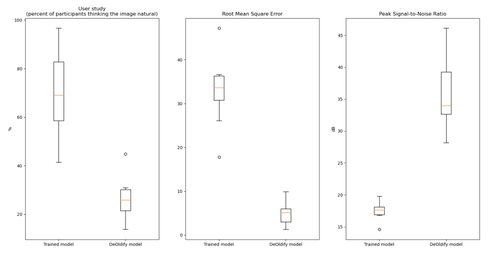


*Figure 6: comparison of evalution results between the two models*

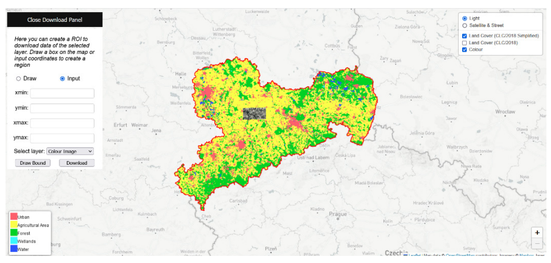


*Figure 7: interface of the web mapping application*

## Conclusion

On average, 70.1% participants think the images colourized by the retrained model are natural. This is significantly better than the original DeOldify model. Limitation exists due to slight inconsistence of image content in the training images and colour reference images. More urban land should be included. The web mapping application implements tiling and caching service and Web Processing Service to optimize image display and download respectively.

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## Keywords

Generative adversarial network, user study, web mapping application

## References

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