Coloring the Past: Neural Historical Monuments Reconstruction from Archival Photography

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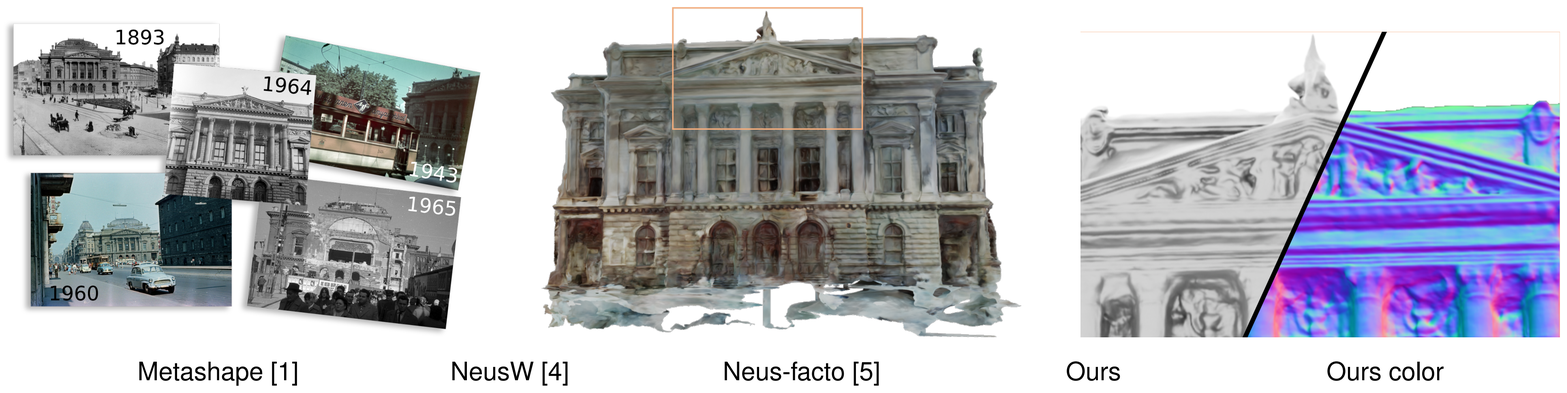
Motivation

The **Hungarian National Theater** was demolished in 1965, yet hundreds of analog photographs remain.
It is valuable to reconstruct and visualize it for tourism, historical research, etc.
Historic images are taken between 1900 and 1990 using analog cameras. This makes them significantly more challenging than modern tourist photography on the internet due to unique characteristics:

- Unknown camera intrinsics
- Sparse viewpoints
- Sub-optimal radiometric quality
- Changing geometry over time



Metashape [1] NeusW [4] Neus-facto [5] Ours Ours color

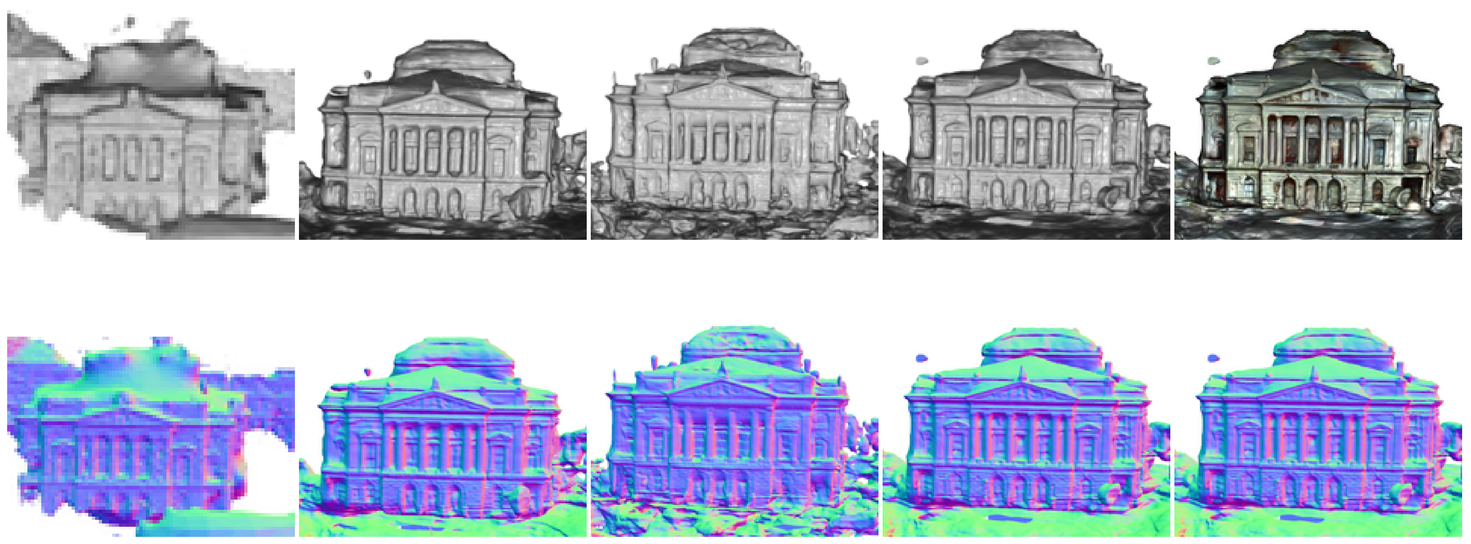


Figure 2:Reconstructed mesh results compared to other methods. Metashape [1] can get clean geometry reconstruction but fails to get the details. Our method is able to provide comparable mesh reconstructions while additionally recovering the color of the mesh.

Method

Historic datasets are usually sparse and large portions are gray-scale images (more than 90%).
We propose two loss functions to NeuS in the Wild [4]:

- Color Embedding Loss

  We project the rendered color of the network to gray-scale using perceptual weights when the corresponding input image is gray-scale.

$$g(C'(\mathbf{r})) = w_r c_r + w_g c_g + w_b c_b\,, \tag{1}$$

$$l_c(\mathbf{r}) = \begin{cases} \frac{1}{2}|C(\mathbf{r}) - g(C'(\mathbf{r}))|^2, & \text{if } \mathbf{r} \text{ is gray-scale}\,, \\ \frac{1}{2}|C(\mathbf{r}) - C'(\mathbf{r})|^2, & \text{otherwise}\,. \end{cases} \tag{2}$$

GT Baseline Unconditional Colorization [3] Color Appearance loss (Ours)

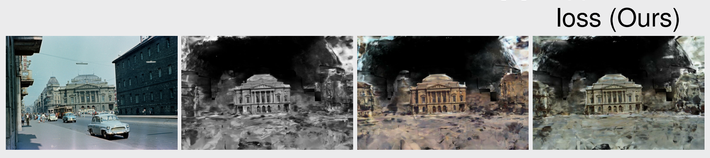
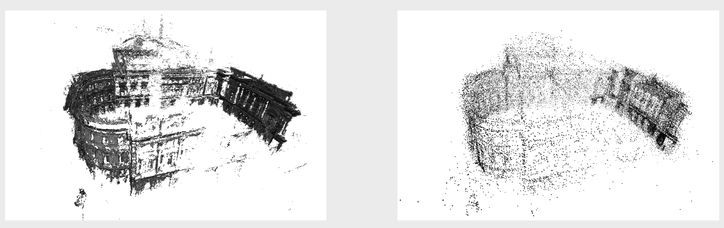


Figure 1:The baseline is gray-scale and therefore unnatural, the unconditional colorization results in plausible but historically inaccurate colors. The Color Appearance loss results in the closest color scheme to the ground truth.

- Geometry Loss

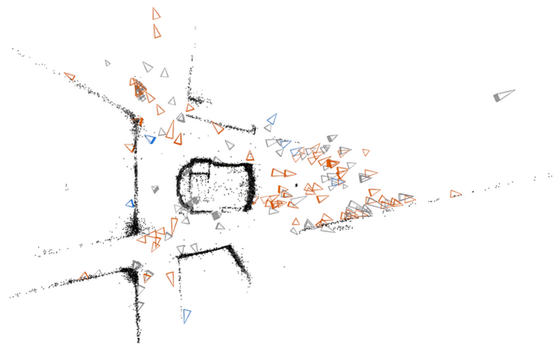
  We use the dense point cloud from patch match stereo [2] as geometric prior to guide the $\mathbf{MLP}_{\text{SDF}}$ surface.

$$l_g(\mathbf{x}) = \lambda \frac{1}{|\mathcal{P}_i|} \sum_{\mathbf{x} \in \mathcal{P}_i} |\mathbf{MLP}_{\text{SDF}}(\mathbf{x})|\,, \tag{3}$$



Dataset

The photos are collected from several sources: Fortepan, Metropolitan Ervin Szabó Library, MTI (color coded). The dataset contains the reconstructed point cloud and camera poses, year of image creation.



Ideal for evaluating feature matching, doppelganger disambiguation and 3D reconstruction methods for generalization and robustness.

Figure 3:Aligned historical images with recovered 3D mesh for the National Theater dataset. The input images are mainly in gray-scale, only a small portion is color image, and the color quality is not comparable with modern RGB images. Views rendered on the Benaco platform (`https://benaco.com/`).

Future Work

City-scale reconstruction of Budapest from large historic photo collection, aligned to lidar ground truth.
Currently, 1300 images are correctly registered along the Danube River including the Castle Hill.

Code & Contact

Project page with interactive visualization:

SCAN ME

Code is available:
`https://github.com/dawars/coloring_the_past`

Contact:
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Acknowledgment

The research upon which this paper is based has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101135556 (INDUX-R).

References

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