Analysis of Natural Lighting Condition for the Digitization of Artwork in an Art Gallery Interior

Irena Drofova[0000-0002-8543-0098]
Tomas Bata University in Zlin
Faculty of Applied Informatics
Nad Stranemi, 4511
760 01, Zlin, Czech Republic
drofova@utb.cz

Milan Adamek[0000-0002-0306-6852]
Tomas Bata University in Zlin
Faculty of Applied Informatics
Nad Stranemi, 4511
760 01, Zlin, Czech Republic
adamek@utb.cz

ABSTRACT

The paper discusses the analysis of natural lighting conditions for digitizing art. The emphasis is on a realistic 3D digital reproduction of a work of art in natural lighting conditions in the interior of an art gallery. The art object is scanned and digitized in two natural lighting conditions. The photogrammetry method was used for a realistic 3D reconstruction of the artwork. This experiment aims to analyze the influence of lighting conditions on the quality of 3D reproduction of an art object concerning image processing and color reproduction. In this study, no accessories were used to increase the quality of the captured image, such as reflective and diffusive plates or lights to illuminate the art object. The art object was scanned and digitized in two natural lighting conditions. This study aims to analyze the influence of actual lighting conditions on the quality of a realistic digital 3D reproduction of a work of art.

Keywords

3D model, artwork digitization, photogrammetry, image processing, point cloud, color, art gallery

1. INTRODUCTION

Currently, digitization processes are reflected in all areas of human activity. Digital technologies are used in commercial, scientific, and artistic fields. [Näs20a] In art in particular, emphasis is often placed on the highly realistic quality of digital reproduction. Digital technology and image processing processes are projected into artistic creation. [Gul18a] Nevertheless, the digital reproduction of works of art is still a great support for the application of new procedures and methodologies such as machine learning. [Cst20b] Especially in connection with new trends such as 3D and virtual presentations in the online environment. [Bia17a]

3D realistic digital reproduction of a work of art also brings many challenges and unsolved problems in image processing. The high-quality reproduction of the object in conjunction with its texture and color are often variable due to light and weather conditions. The method and procedure of digitization depends primarily on the final output of the digitized object. It can be 2D and 3D printing, 3D online presentation or using the object in a virtual and augmented reality (VR/AV) environment in interaction with the user.

Realistic 3D digital image reproduction aims to get as close to the original. The same attribute for color evaluation of reproduction quality is directly related to light and human vision. Colorimetry, color and human vision deal with this issue. [Mol24b] This text responds to current trends in art digitization and the issue of realistic digital reproduction using the photogrammetry method. [Cer20c] Also considers the use of LiDAR (Light Detection and Ranging) sensors. [Gue24c]

The presented experiment aims to find to what extent the ambient light conditions can affect the 3D digitization of the artwork in connection with the chosen modeling method. The following sections describe the digitization of the artwork using the photogrammetry method and LiDAR scanning in daylight in the interior. The influence of lighting conditions on the color reproduction of the 3D model is analyzed in 3D point cloud models of one precisely defined color. The findings from this experiment are used for follow-up research in the field of realistic 3D digital reproduction of works of art.

2. ARTWORK DIGITIZATION

With the development of digital technologies and sensing devices, image digitization processes and graphic software for image processing have evolved and improved according to the type and purpose of the resulting output, as well as the development of digital and 3D printing and 2D / 3D online and virtual presentations. This section describes image digitization using ground image photogrammetry to create a realistic 3D digital model.

An artwork for creating a 3D model

The artistic object for 3D digital reproduction was painted with acrylic paints on canvas. The artwork is dominated by green and brown colors, as seen in Figure 1.

Figure 1. Artwork object - acryl on canvas

The object was captured in the interior of an art gallery, in which the daylight conditions were suitable. This experiment influences these lighting conditions on the resulting color reproduction of the resulting 3D model.

Digital Image Capture

An innovative mobile device with LiDAR technologies was used in this experiment. A smart tablet from Apple, which has a high-quality camera with high resolution, was chosen to capture and digitize the work of art. This smart device was used for a 3D reconstruction of a work of art using terrestrial image photogrammetry. The experiment used the free Scaniverse application to compare the quality of a 3D model, which is intended directly for the 3D digitization of objects and spaces using a LiDAR sensor. Both methods are described in the following section.

The Photogrammetry Method

The SfM (Structure from Motion) photogrammetry method calculates the position of an object in 3D space based on the description of information obtained from individual images taken from multiple angles. In the case of a specific object, the 3D reconstruction described below includes 17 photographs. From the basic information contained in the sparse point cloud, the points they create in the model, or they build a dense point cloud, and this large number of points already concretely displays the object and its position in space. This creates a complete point 3D model. This cloud of points is also a source of information about color values. The individual steps of creating a 3D model are visualized by the Figure 4 in the next section.

3D Reconstruction by LiDAR Sensor

To compare the quality of the digital reproduction of the artwork, a 3D scanning method using a LiDAR sensor on the same sensing device, the iPad 11 Pro tablet, was chosen. The Scaniverse application was used for scanning purposes. The resulting image before export to the 3D modeling software Agisoft is shown in Figure 5 in the next section.

3. COLOR SEGMENTATION

In this experiment, in which a real object is transformed into a digital form, the RGB (red, green, blue) color model and the sRGB color space (gamut) are used. In the Agisoft 3D modeling, the SW environment can work with information about the color of individual points or group points in a Dense cloud, as shown in Figure 2.

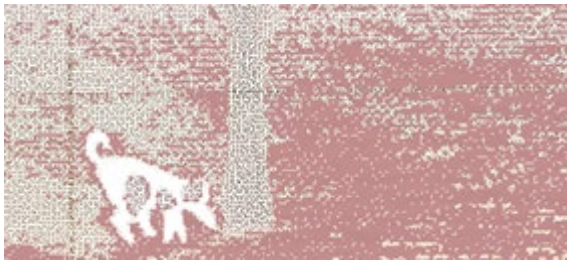

Figure 2. Definition points of the color #758605

As Figure 2 shows in SW, Agisoft can define the exact number of points based on the definition of colors (Hex) and work with RGB and HSV (Hue, Saturation, Value) color models. Figure 10 shows the points in the dense cloud 3D model that carry color information. That means we can define the points with a color value of #758605 in the green color channel, as shown in Figure 3.

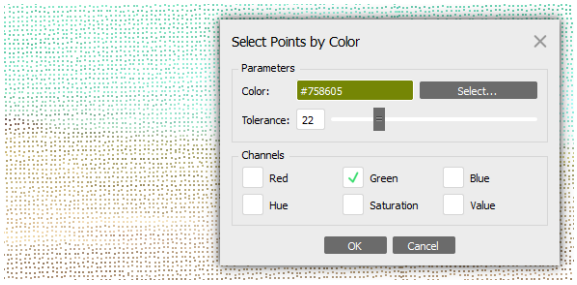

Figure 3. Points #758605 in the 3D model Dense cloud

4. VISUALIZATION

This section visualizes the creation process of a digital 3D model of a work of art using the photogrammetry method and the LiDAR sensor. The Figures 4 and 5 shows the segmented color measure with color value #758605 in the 3D model.

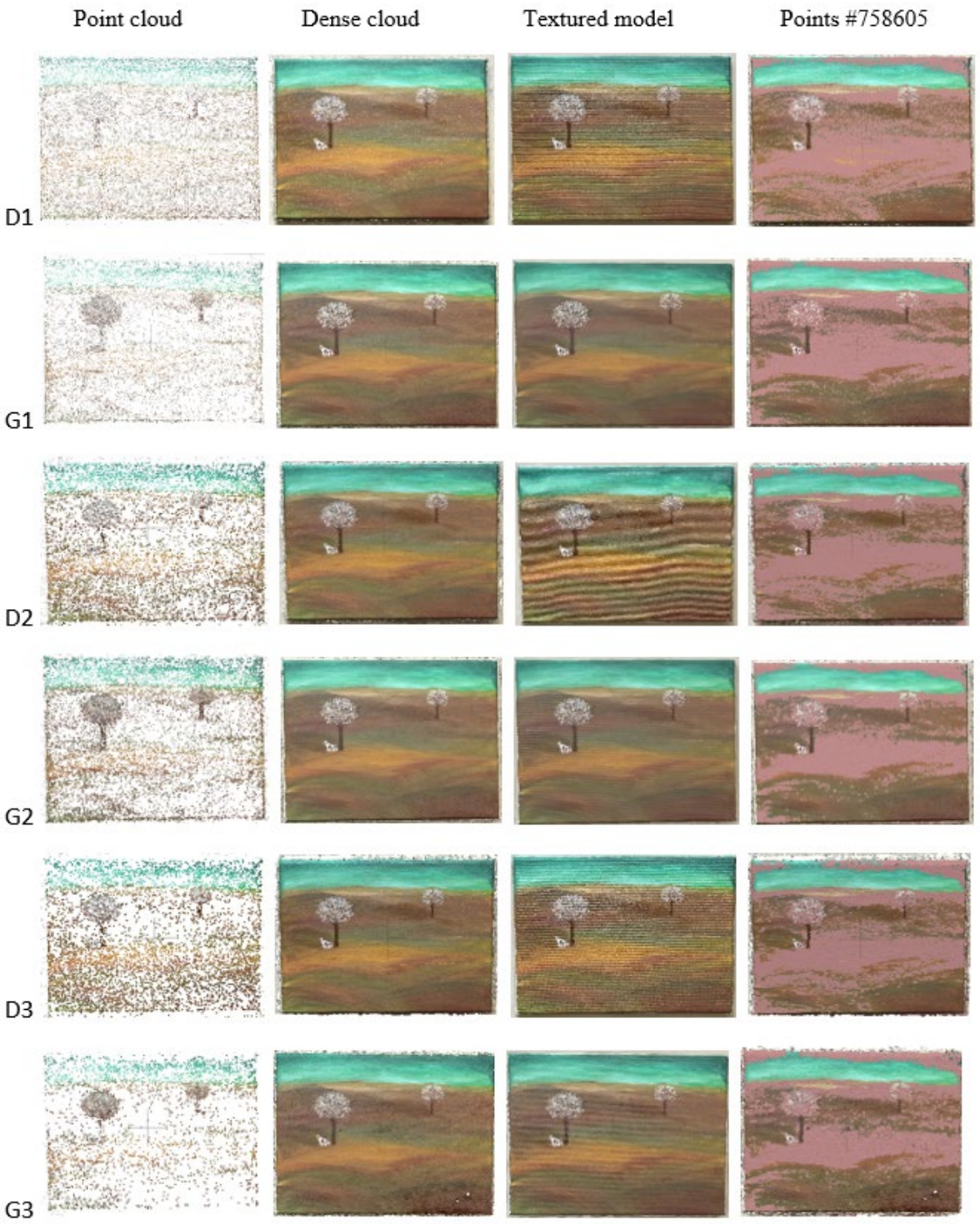

Figure 4. Points in Dense cloud by Color

Figure 5. 3D models by LiDAR sensor

Figure 4 visualize the 3D models of the object in individual digitization steps by SfM method. 3D models marked D1 visualize the 3D reconstruction of the object in natural daylight. The G1 images visualize the same 3D models of objects in natural indoor darkness. Three series of 3D models in denim light D1-D3 and three series of object models in dark G1-G3 were produced. Even during the first visual analysis of the image, significant differences in the created 3D models are visible.

SfM	Images	Point Cloud	Dense Cloud	Points #758605
D1	24	13 828	383 170	236 418
G1	17	10 710	413 688	248 703
D2	13	9 327	405 385	221 648
G2	29	16 219	310 913	178 275
D3	8	7 100	325 107	194 873
G3	9	4 617	363 348	208 232
LiDAR	**Images**	**Point Cloud**	**Dense Cloud**	**Points #758605**
D1	⁄	⁄	21	⁄
G1	⁄	⁄	21	⁄
D2	⁄	⁄	23	⁄
G2	⁄	⁄	18	⁄

Table 1. Values of the Points in 3D models

Figure 5 shows the 3D models created by LiDAR technologies and using the Scaniverse mobile application on a mobile device. 3D models D1 and D2 were captured in natural daylight, and object models G1 and G2. However, this 3D modeling method cannot generate a dense point cloud with enough points to identify the points with color value #758605, as shown in Table 1. The different differences in 3D reconstruction require different image processing.

6. DISCUSSION AND CONCLUSIONS

The contribution contains a partial issue of 3D realistic digital reproduction of a work of art. The experiment was carried out in the interior of an art gallery. The ambient light conditions of daylight and dusk were used to take the picture. The iPad 11 mobile device camera and LiDAR sensor captured the object. This work aimed to compare the effect of light on color reproduction. The photogrammetry (SfM) method was used to create the 3D model. A LiDAR sensor also scanned the object. A visual analysis of the 3D texture models was performed, and it is clear that direct daylight is not suitable for this type of 3D reconstruction. The same visual result can also be observed on 3D models of LiDAR sensor scans. Table 1 contains the attributes for object reproduction analysis, including the number of generated points of points with a well-defined color value of #758605. The minimum number of points was generated in the case of 3D captured by a LiDAR sensor. This sub-experiment using the mentioned 3D modeling methods shows the research direction in the realistic digitization of art.

5. ACKNOWLEDGMENTS

This research was based on the support of the International Grand Agency of Tomas Bata University in Zlin, IGA/CebiaTech/2024/004.

6. REFERENCES

[Näs20a] Näslund A., Wasielewski, A., Cultures of Digitization: A Historiographic Perspective on Digital Art History. Visual Resources 36, pp339–359,https://doi.org/10.1080/01973762.2021.1928864, 2020.

[Gul18a] Gultebpe, E., Thomas, E., Conturo, M. M., Predicting and grouping digitized paintings by style using unsupervised feature learning. In: Journal of Cultural Heritage, pp. 13-23, ISSN 1296-2074. doi: 10.1016/j.culher.2017.11.008, 2018.

[Cst20b] Cstellano, G., Vessio, G., Deep Convolutional Embedding for Painting Clustering: Case Study on Picasso's Artworks. In: Advanced Data Mining and Applications. Advanced Data Mining and Applications. pp. 68–78. Available on Internet: doi:10.1007/978-3-030-61527-7_5, 2020.

[Bia17a] Bialkova, S., Van Gisbergen, M.S.,When sound modulates vision: VR applications for art and entertainment. Available on Internet: doi: 10.1109/wevr.2017.7957714, 2017.

[Mol24b] Molada-Tebar, A. at all., Practical RGB-to-XYZ Color Transformation Matrix Estimation under Different Lighting Conditions for Graffiti Documentation. Sensors 24, https://doi.org/10.3390/s24061743, 2024.

[Cer20c] Cerasoni, J. at all, Do-It-Yourself digital archaeology: Introduction and practical applications of photography and photogrammetry for the 2D and 3D representation of small objects and artefacts. PLOS ONE. 17. e0267168. 10.1371/journal.pone.0267168. 2020.

[Gue24c] Guenther, M., at all, Tree Diameter at Breast Height (DBH) Estimation Using an iPad Pro LiDAR Scanner: A Case Study in Boreal Forests, Ontario, Canada. Forests 15, doi:org/10.3390/f15010214, 2024.