

FINDING HIDDEN INFORMATION IN THE INFRARED SPECTRUM IN PAINTINGS IN THE CARMELITE MONASTERY IN REMETE AND A PRIVATE COLLECTION IN ZAGREB

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Sažetak

U ovom su radu izdvojene dvije slike u vizualnom i bliskom infracrvenom području od 1426 fotografiranih u sedam muzeja, tri zbirke, deset povremenih izložbi i pet privatnih zbirki u Zagrebu. Na slikama koje se prikazuju otkrivena je u cijelosti preslikana slika i preslikani sloj, što je tema ovog rada. Umjetničke slike imaju dva odvojena stanja slike u različitim spektralnim područjima. U članku će biti prikazane razlike između tih dviju slika prilikom snimanja u dva spektralna područja RGB kamerama.

Pri istraživanju je korištena ZRGB kamera koja snima u vizualnom i u bliskom infracrvenom (NIR) spektru na Z vrijednosti [1]. Cilj istraživanja bio je utvrditi stanje slike u bliskom IR području kako bi se uočili preslikani podaci u sloju ispod vidljive slike koji su nevidljivi golim okom.

Prijedlog je da konzervatorsko-restauratorski postupci respektiraju dva stanja slike i da se slike fotografiraju u bliskom IR-u i nakon radova. Rezultati provedenih istraživanja dio su doktorske disertacije na temu *Slike u infracrvenom području – odlaganje vidljivog*.

Ključne riječi: vizualni i infracrveni spektar (NIR), slike u infracrvenom području, preslikani sloj, ZRGB kamera

Abstract

In this work, two paintings photographed in visual and near infrared (NIR) area are selected among 1426 photographs taken in seven museums, three collections, ten temporary exhibitions and five private collections in Zagreb, Croatia. The topic of this work is the paintings discovered underneath these two paintings. Therefore, the paintings have two separate

conditions in different spectral areas. The article shows the differences between these two images in these spectral areas using RGB cameras. Here, a ZRGB camera was used, which records visual and NIR spectra on Z value [1]. The aim of this research is to determine the conditions of the paintings in NIR spectrum to find the overlapping data in the layer underneath the visible painting, which are not visible to the naked eye. It has been proposed that the conservation and restoration procedures take into consideration these two conditions of the image, and that the paintings be photographed in NIR after the restoration. The results of the research are part of the doctorate thesis on the topic: *Paintings in the infrared area – postponing the visible*.

Key words: visual and infrared (NIR) spectra, images in the infrared area, painted layer, ZRGB camera

1. Introduction

Infrared light has a wavelength range of 700 to 30,000 nanometers (nm) and is divided into several sub-ranges for specific uses. In the Croatian language, the defined abbreviations IR (infrared) and IC (infracrveno) are used. The term used in the conservation-restoration profession for recording works of art is IR reflectography. In this paper, it is referred to by the abbreviation NIR (near infrared spectrum or near infrared) and covers the range from 700 to 1400 nm. We use general purpose digital cameras because the CCD sensors can capture a wide range including the NIR range. Within this near-infrared spectrum, the region at 1000 nm has been studied. We call the point at this particular wavelength Z [2]. Under the surface

of Pablo Picasso's 1901 painting *The Blue Room*, a hidden painting *Portrait of an Unknown Man* was found in Washington this June using IR reflectography. Art historians and experts are trying to unravel the mystery of who the mysterious person beneath the surface of the painting is, why the artist painted over him, and how he was connected to Picasso [3]. This recent example proves the importance of research in the field of NIR.

In this work, the paintings are documented in near IR and thus included in the database of recorded paintings, in case one day the originality of a single artwork is questioned. The purpose and initial reason for photographing in this way is to establish a base of painting conditions in two spectral regions. This allows for a more accurate decoding of the hidden data and facilitates the protection of the art from forgery. Another reason is discovery; to find out if there has been any study of these paintings and if certain paintings hide interesting discoveries in the lower layer. The third reason is to record changes that occur over time and possible future damage using photographs. The collection of images taken in two states justifies the number of images taken. Infrared photographs reveal inherent information not seen on the original color painting. With the help of these photographs, we have obtained new information about the paintings. There are not enough reports in the public domain describing the information obtained by photographs taken in the near IR to distinguish them by visual spectrum.

Beneath the two paintings described in this text are images hidden in the lower layer, invisible to the naked eye. One painting is partially painted over and hides the representation of the figure's head on the painting, which also breaks through in some details in the visual spectrum. The second painting shows a completely different image in the infrared spectrum. It is known from scientific research in the conservation and restoration profession that many painters throughout history have painted over their own works. However, the paintings shown were most likely painted over by other painters, which can be concluded from the information visible in the NIR.

2. Capturing images using a non-destructive method in the NIR region

IR reflectography is a non-destructive optical technique used to analyze works of art to discover details hidden from the human eye beneath the visible surface of the painted layer. Near Infrared (NIR) imaging is not mandatory for all paintings in most museums in Croatia and in the Croatian Restoration Institute, the central state service for the conservation and restoration of art and other cultural assets, but mainly for selected paintings of greater historical or artistic value. Photographing paintings on various media in the visual and near-infrared spectrum at 1000 nm was carried out in the permanent exhibitions of seven museums: the Modern Gallery, the Museum of the City of Zagreb, the Museum of Contemporary Art Zagreb, the Mimara Museum, the Museum of Arts and Crafts, the Croatian Museum of Naive Art, and the Strossmayer Gallery of Old Masters of the Croatian Academy of Sciences in Zagreb, as well as in three collections: the Anka Gvozdanić Collection, the Memorial Collection of Dr. Ivan Ribar and Cate Dujšin-Ribar, and the memorial collection and apartment of architect Viktor Kovačić.

The paintings were also photographed at ten temporary exhibitions in museums and galleries: Modern Gallery, Zagreb City Museum, Museum of Contemporary Art, Strossmayer's Old Masters Gallery of the Croatian Academy of Sciences, Klovičevi Dvori Gallery, Croatian Association of Fine Artists and Art Pavilion. Paintings from five private collections were also examined and included. A total of 1,830 artworks were examined in Zagreb and 1,426 artworks were photographed in the near-IR. Since all paintings were photographed simultaneously in the visible light (VIS) and near infrared (NIR) range, two photographs were taken and processed for each painting; therefore, a total of 3,660 photographs of paintings were examined and 2,852 were taken.

The technique for revealing thinner, lower layers is based on the fact that infrared radiation passes through the painted layer and is reflected on the carrier or on the preparation, or this radiation is absorbed by the drawing. IR Radiation is absorbed mainly by carbonaceous materials, such as black pigments and dyes [4]. Classical

infrared reflectography had very good penetration through thinner layers in the near infrared region of the spectrum. This method is also important for detecting fake paintings and solving some attribution problems. In cases where the paint layer is too thick for IR reflectography, X-ray photography (radiography) is the standard method for examining layers of paintings.

3. Recording works of art with a ZAGREB camera

In this near-infrared research, two custom digital cameras were used: Casio EXILIM Zoom EX-Z150, 8.1 MP and Canon EOS 350D/Digital Rebel XT, 8.0 MP. Both cameras are capable of near-infrared imaging at 1000 nm. In the case of the Casio EXILIM Zoom EX-Z150 camera, the measurement values are given as Z value. This camera can be used for daytime imaging because it filters out the Z value from the solar spectrum. The reflected region is the light coming from the IR source, it is partially absorbed and the rest is reflected from matter [5]. All images are different in the visual and infrared regions. They were taken simultaneously in both spectra (NIR and VIS) under the same conditions.

A ZRGB camera was used in the study, recording in the visual and near infrared spectra at Z value. Calibration was performed by matching with a Projectina forensic scanner at 1000 nm, which was also used to calibrate the ZRGB camera. A numerical variable called Z describes the absorption strength of NIR light at 1000 nm. Projectina is the world's leading company in the manufacture and development of forensic instruments and was founded in Switzerland in 1946. A wide range of their products enables forensic experts around the world to secure evidence and examine documents with a high level of efficiency and reliability [6]. One such device is owned by the Croatian National Bank as the central bank and the Ivan Vučetić Forensic Science Center of the Police Directorate of the Ministry of Interior of the Republic of Croatia. The center is a unique forensic facility in the Republic of Croatia, which performs forensic and technical work and witness examination [7].

For the NIR spectrum, the Canon EOS 350D camera was modified by removing the IR

blocking filter (removal of the hot mirror), which is placed in front of the CCD or CMOS sensor. A IR-pass filter was installed so that a specially threaded Heliopan RG -filter of 1000 nm was cut to the dimensions of 22 x 28 mm and attached in place of the IR -blocking filter. The IR -blocking filter in the camera makes it possible to take a photo that the eye can see. Without such a filter, the sensor captures IR reflectography (NIR spectrum), i.e. what the eye cannot see.

In the visual spectrum, the paintings in the museum's permanent collection were photographed with two digital cameras: Canon EOS 400D, 10.1 MP and Olympus FE -360, 8.0 MP.

4. Research results on images in the NIR spectrum

The overpainted images were observed in seven paintings in the museums visited: Aeneas and Dido by Guido Reni, early 17th century; Blue Fairy Tale by Nives Kavurić Kurtović, 1993, Museum of Arts and Crafts; Panorama of Vukovar by Oskar Herman, mid-20th century, Strossmayer's Gallery; Portrait of Marija Radočaj-Pintar by Vjekoslav Karas, mid-19th century; Sai Baba* Cate Dujšin-Ribar, 1982, Memorial Collection of Dr. Ivan Ribar and Cate Dujšin-Ribar; The Mother of God of Remete by an unknown author from 1717, the exhibition Restless Times, Archaeology and 725 Years of the Sanctuary in Remete in the Museum of the City of Zagreb and In Boka Kotorska - Tivat by Nasta Rojc, around 1927, the exhibition Critical Retrospective in the Art Pavilion.

In this paper, two paintings painted with the technique oil on canvas were selected, where changes in the layer under the visible are visible, because in these paintings hidden data were found in the lower layer.

In the studio of the painter Marijan Richter, out of the 20 paintings examined, 12 paintings with visible overpaintings of completely different motifs were found in near IR, from his series Painting by Denial and Renunciation. In a private collection in Zagreb, an overpainted painting by the artist Fabio Fabbi (*) was found under a visible painting by Dunav Rendić (*), Painters'

Circle Split, 4th decade of the 20th * It is assumed that it is the aforementioned painters.

The results of the research have shown that from the mentioned examined paintings from the period from the 6th (*) to the 20th century in museums and temporary exhibitions, five paintings have a visible shift or pentimento in the near-IR. These are the paintings *Vera* by Vladimir Becić, 1926; *Odalisque* by Milivoj Uzelac, 1934, Modern Gallery; *Aeneas and Dido* by Guido Reni, early 17th century, Museum of Arts and Crafts; *Antun Bedeković Komorski* by an unknown author, c. 1750, Zagreb City Museum and the painting *Symbolic Self-Portrait* by Nasta Rojc, 1914, from the exhibition *Critical Retrospective* at the Art Pavilion in 2014.

4.1. The painted layer in the painting from the Carmelite Monastery in Remete

In 2013, the Museum of the City of Zagreb presented the results of the exhibition *Restless Times, Archaeology and 725 years of the sanctuary in Remete*, after many years of intensive research. The archeological findings on

the site next to the Church of the Blessed Virgin Mary in Remete were researched from 2007 to 2009 on the initiative of the City Institute for the Conservation of Cultural and Natural Heritage in Zagreb. At the exhibition, the presentation begins with the year 1288 and ends with the celebration of the Assumption of the Blessed Virgin Mary, which is inextricably linked to the spiritual life of the inhabitants of today's Zagreb. The Pauline monks especially worshiped and spread the cult of the Mother of God.

Eight paintings were examined in the visual and NIR spectra at 1000 nm and two were recorded. In view of its sacred and historical significance, the painting of the Mother of God of Remete was recorded, which is permanently in the possession of the Carmelite Monastery in Remete. The painting dates back to the Pauline period. It was placed in the church in front of the retable where there was a miracle-working statue of the Mother of God from 1490, dating from the late Gothic period of the German master. In 1706 the statue was placed on a new altar. The painting of the Mother of God by Remete was raised and lowered for the major



Figure 1: V



Figure 1: Z

Figure 1: *Mother of God of Remete*, unknown author, 1717, oil on canvas, image in VIS and NIR spectrum at 1000 nm showing an overpainting on the mantle invisible to the naked eye



Figure 2: V



Figure 2: Z

Figure 2: Detail of image in VIS and NIR spectrum showing the ochre color of the various compositions



Figure 3: V

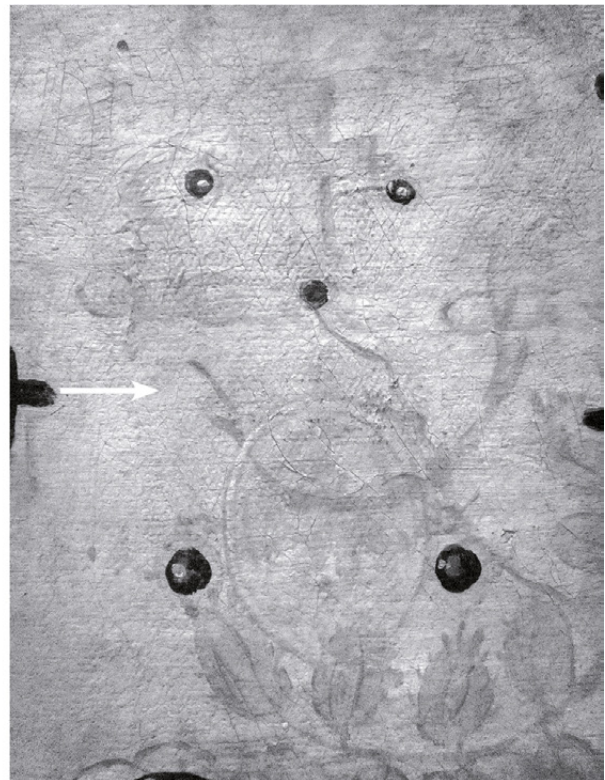


Figure 3: Z

Figure 3: Detail of the overpainted outline of the head and branch with leaves, which only became visible when the photograph was enlarged in the NIR range of the canvas.



Figure 4: V



Figure 4: Z

Figure 4: The difference in visibility of the ochre color in the inscription and the mantle decorations in the VIS and NIR range

Marian holidays, Christmas, Easter and other feasts, thus concealing and revealing the statue of the Mother of God. This method of covering the statue was used until 1786, when Emperor Josip II. abolished the Pauline Order [8]. After the painting was no longer used to cover the statue, it was placed on a base, and the restoration work was not completed. At first glance, in the near infrared, the image under the painting was not visible, nor was the previous conservation and restoration procedures. However, on closer inspection and by magnifying the NIR image, the outline of the head of a figure can be seen in the center in the lower part of the mantle, below the cross. It is probably an angel or a saint hidden in the image of the Virgin Mary. In the lower part of the mantle, partly also in the visual spectrum, there are intertwined motifs of branches with leaves and tendrils. The very placement of the overpainting suggests that the painting was probably cut from a larger painted canvas. Unexpectedly, the yellow paint on the mantle of the Mother of God is white, as ochre is often seen at a darker intensity in the near IR. The inscription painted in ochre on the underside of the mantle is visible in the NIR because the painter used a different color composition. It was expected that the red color would be white in the near

infrared, as on the saint's mantle on the left side of the background of the painting. Also, damage to the painting is visible, especially on the edges of the canvas.

It is assumed that the Virgin's hair was previously covered with black paint and then painted over with ochre. A transparent ochre color can be seen on the details of the mantle in the NIR, although the hair is painted in the same tone, which is dark in the near-IR, which is typical for black. The painter achieved the ochre tone in different ways. From this we conclude that the process of painting the painting lasted a long time.

On the edge of the cloak there is an inscription in Latin: Mater Amabilis et Admirabilis Remetensis Protege Nos, 1717 (Beloved and miraculous Mother of Remete, protect us). The letters are visible in the NIR, i.e. they were added afterwards with an ochre color that absorbs the light from IR.

4.2. Repainted painting from a private collection

The painting by Dunav Rendić (*) comes from a private collection belonging to Nataša Lenoir from Zagreb. The painting is very mysterious, as it has an inscription in block letters on the back: N.

DANZA NELL' HAREM (F. Fabbi). Fabio Fabbi (1861 - 1946) was born in Bologna, Italy. He is known as the most important Italian painter of oriental paintings. As a young man, he enrolled at the Accademia di Belle Arti in Florence, where he studied sculpture and painting. After his studies, he traveled to Paris, Munich and Egypt [9].

In translation, the title Dance in the Harem corresponds to the content of the oriental motifs painted by Fabbi. The motif of the ship is painted on the painting, which does not correspond to the printed inscription. The painting was photographed in the visual and infrared spectrum at 1000 nm. The painter who painted over the painting used a



Figure 5: V



Figure 5: Z

Figure 5: Trabakul (*), Dunav Rendić (*), 4th decade of the 20th century, oil on canvas, an image in the VIS and NIR spectrum at 1000 nm



Figure 6: V

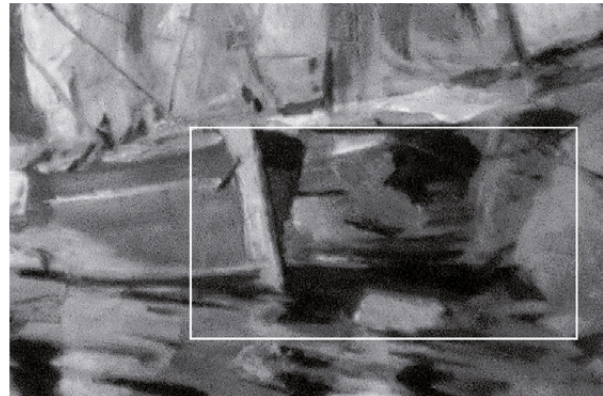


Figure 6: Z

Figure 6: A detail showing the refinement of the painting and the difference in the composition of the green color



Figure 7: V



Figure 7: Z

Figure 7: Detail showing the painted over painting visible in the VIS spectrum, but not visible in the NIR region as the colors are the same in absorption of IR light



Figure 8: V



Figure 8: Z

Figure 8: Detail of the painted over painting in the VIS and NIR spectrum where the detail of the frame is visible



Figure 9: V

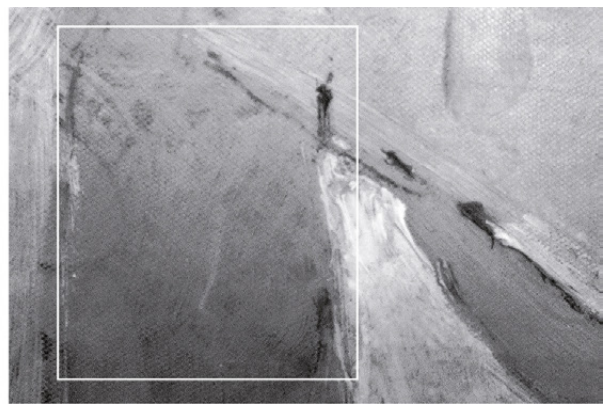


Figure 9: Z

Figure 9: Detail of painted over painting in VIS and NIR spectrum where semicircular shape is visible

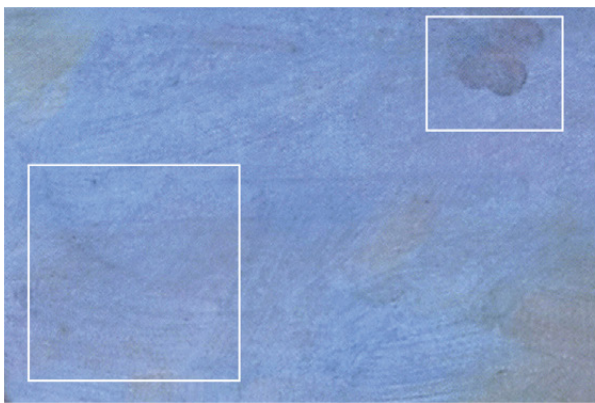


Figure 10: V

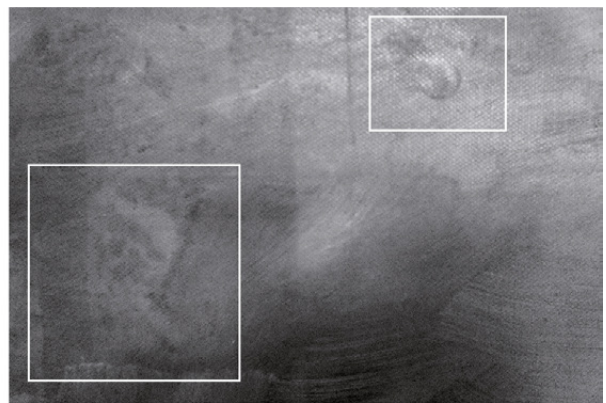


Figure 10: Z



Figure 10 a: V

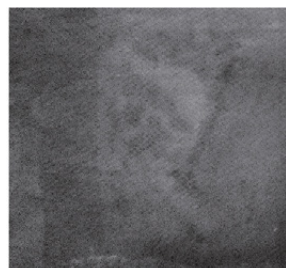


Figure 10 b: Z

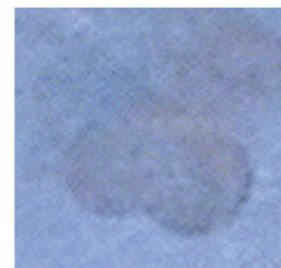


Figure 10 c: V

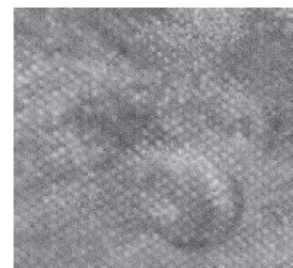


Figure 10 d: Z

Figure 10: V a, c; Figure 10: Z b, d - Magnified details of the blue sky in the VIS and NIR spectrum where the overpainted details in the lower layer of the subject of the teddy bear* and the flower are visible. The first detail is invisible in the NIR region, and the second is visible in the visual and near IR spectrum.



Figure 11: V



Figure 11: Z

Figure 11: Detail of the printed number, the name of the painting and the name of the author in the VIS and NIR spectrum, above which the original red color of the copied painting by F. Fabbi can be seen along the edge (*)

different composition of dyes in the painting, which is revealed in the IR image. Thus, two identical shades of green in the visual spectrum behave quite differently in the near IR spectrum because they have different compositions. In this painting, the green color that appears in many places is light gray, while the dark green is dark in contrast because it has a completely different composition. In painting no. 6, a black line can be seen under the green color (in near IR), which means that the painter changed the initial strokes and refined the painting. The light green color was added at the end, and there is a stroke and a line below it that can only be seen in the NIR.

In the detail of painting no. 7, Dunav Rendić, vertical dark red and black stripes of Fabio Fabbio's overpainted painting are covered in the visible area, which can be seen more clearly through the IR photograph. The flat strokes have been smudged several times, so in this painting also appears the background of the painting below, which was painted over. In the fresh parts there are no subsequent interventions with a brush on which colorants are mixed. From this way of looking, one could conclude that the painter has refined certain details of the painting. In the painting in the visual spectrum, there are freshly painted parts of the painting in one stroke, but also refined ones. In painting no. 8, in the painted over painting in the infrared spectrum, the painting is of a completely different content, as can be seen from the frame that penetrates the painting seen in IR. The visible painting was created on an overpainted painting of Fabbi (*), which is confirmed by the details of the photographs in the near IR.

5. Conclusion

From this overview, it is clear that for this research, among the visible layer of painting, the

most interesting are the paintings that duplicated or completely painted over paintings. In this work, we wanted to investigate which paintings have mirrored layers below the visible painting and how these changes are visible with a ZRGB camera at 1000 nm. Since 33 such paintings were selected from the entire study, the expectations for this study were met.

The goal was not to capture and process all paintings in the NIR range with the ideal technical capabilities, but to investigate, find, and confirm that there are paintings on permanent display in museums with overprints, pentimenti, underpaintings, visible working steps, underlining, and other changes in the invisible lower layer. Also, attempts have been made to confirm what is known from the literature [10], or to discover paintings that have some secrets of their own that can be discovered in the near IR spectrum.

The amount of the light source itself affects the sharpness of the painting photographs in the NIR. In all museums, there was a sufficient amount of light to directly see if there was an overpainted painting or other major changes of interest to this research using a ZRGB camera at 1000 nm, but without a constant source of radiation in IR. We conclude that, regardless of the sharpness of the photographs taken, the paintings were successfully verified under the circumstances for the purposes of this work.

These procedures and recording methods remain documented for future reference. Photographs taken in two spectral ranges, in the VIS and NIR spectra, ensure protection of the same painting from both forgery and changes that occur over time, as well as from possible future damage. Thanks to such recordings, conservators-restorers know in what condition the painting was, depending on the time when it was taken. And

today's artists who want to protect their most important or all works can do so by recording paintings in two states.

The author of this text records her own paintings to ensure that they can be seen in their original spectral range in any future conservation and restoration efforts. This will also ensure their authenticity.

It is recommended that all artworks in museums be photographed in different spectral ranges of light. At the moment, it is not possible to produce a fake that is identical to the original in all wavebands. If they are photographed with normal and oblique light and in UVF - ultraviolet fluorescence, IR - infrared reflectography, X-ray - radiogram and some other special photographic procedure techniques [10], art paintings can be protected from forgery in many ways. Thus, in the broadest sense, photographs of the original painting would be preserved in all these light areas. On this basis, it will be easy to identify and distinguish original paintings from forgeries in the future. However, it should be emphasized that the authenticity of the work can also be ensured by using an appropriate imaging method, such as in the near-infrared range by IR reflectography.

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Dijana Nazor was born in 1971 in Split. In 1995, she graduated from the Faculty of Natural, Mathematical Sciences and Education in Split (today the Academy of Arts) and earned the title of art professor-restorer. In the same year, she received the Faculty's Dean's Award for outstanding achievement. She is a doctoral student in the postgraduate study of painting at the Academy of Fine Arts of the University of Zagreb. From 1999 to 2004, she worked in primary schools as an art teacher and in XI. gymnasium as a teacher of fine arts. She participated in five European and world InSEA congresses (International Education through Art), where she published five texts in the field of art. Since 2004, he has been working at the Croatian Restoration Institute in the Easel Painting Department as a senior conservator-restorer. Since 1995, she has had 28 solo exhibitions in Croatia, Belgium and Australia. She participated in over 100 juried group exhibitions in the country and abroad. She is the winner of the Ivan Filipović State Annual Award (2012), the Order of Croatian Danica with the image of Antun Radić (2013) and the Grigor Vitez Commendation Award (2014). She holds the honorary title of AFIAP (Artiste FIAP) of the International Federation of Photographic Arts since 2013.