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UVOĐENJE NOVE TEHNOLOGIJE ZA REPRODUKCIJU UMJETNIČKIH DJELA U TISKARSTVU U VIZUALNOM I INFRACRVENOM SPEKTRU

INTRODUCTION OF A NEW TECHNOLOGY FOR THE REPRODUCTION OF ARTWORKS IN PRINT IN THE VISUAL AND INFRARED SPECTRUM

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SAŽETAK

Tijekom stoljeća brojni su umjetnici i krivotvoritelji preslikavali slike. Neki od najčešćih razloga bili su ekonomski, nezadovoljstvo naslikanom slikom, eksperimentiranje ili krivotvorenje djela. U Zagrebu je više od tisuću umjetničkih slika analizirano u vizualnom i u bliskom infracrvenom spektru (NIR). Tijekom navedenih analiza u oba su područja pregledane i snimljene slike iz sedam muzeja, triju zbirki, jedanaest izložbi u muzejskim i galerijskim izložbenim prostorima, pet privatnih zbirki i atelijeru. Zahvaljujući snimkama IR reflektografije na nekim slikama u slojevima koji su nevidljivi golim okom otkriveni su podcrteži, pentimenti/pomaci, preslikana slika i preslikani dijelovi slika, skriveni potpisi te podslici koji otkrivaju fazu gradnje slike. U likovnim monografijama, katalozima i raznim publikacijama slike se reproduciraju u crno-bijelom ili kolor tisku. Otkrićem i saznanjem InfraRedDesigna umjetničke reprodukcije otiskuju se istovremeno u oba spomenuta spektra. Takav tisak s IR svojstvima daje novi pristup u reprodukciji jer proširuje skrivena saznanja o slojevima u genezi originalne umjetničke slike. Uz korištenje IR kamere na reprodukciji slike prikazuje se infrared apsorpcija svjetla.

Ključne riječi: InfraRedDesign, IR kamera, infrared reprodukcija, preslikana slika, slojevi slike, tisak s IR svojstvima

ABSTRACT

Over the centuries, numerous artists and forgers had painted over paintings. Some of the most common reasons were economic, discontent with the painted image, experimenting, or art forgery. More than a thousand works of art in Zagreb were analysed in the visual and near-infrared (NIR) spectrum. During analyses in both areas, artworks in seven museums, three collections, eleven museum and gallery exhibitions, five private collections and one studio in Zagreb were analysed and photographed. Thanks to the IR reflectography, in some paintings, in the layers that are invisible to the naked eye, preparatory drawings, pentimenti/displacements, fully overpainted paintings or overpainted parts of painting, hidden signatures and underpaint were revealed thus unveiling the stages of the artist's work. In art monographs, catalogues and various publications, paintings have been reproduced in black and white or colour prints. With the discovery and understanding of the InfraRedDesign, art reproductions can be printed in both spectra simultaneously. Such print with IR properties offers a new approach to reproduction as it expands the so far hidden insights regarding layers in the creation process of the original artwork. With the use of an IR camera, infrared light absorption is shown in the image reproduction.

Keywords: InfraRedDesign, IR camera, infrared reproduction, painted over another painting, painting layers, print with IR properties

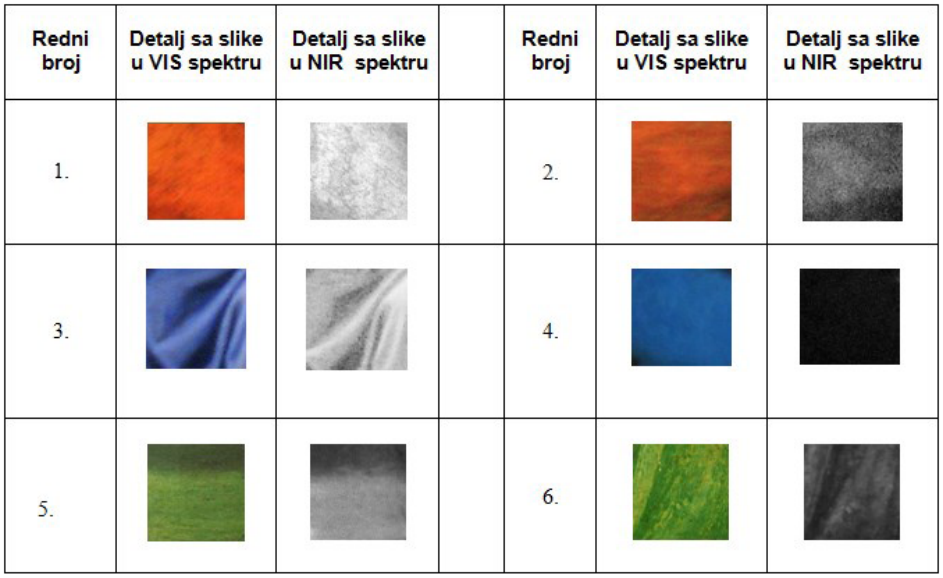
1. UVOD: PRESLIKAVANJE UMJETNIČKIH SLIKA

1. INTRODUCTION: PENTIMENTO IN ARTISTIC PAINTINGS

It is known from the history of art, scientific and conservation-restoration research that individual artists during different historical periods engaged in partial or complete pentimento of their own or other people's paintings. Such pentiments were discovered by recording with IR reflectography and X-rays on the art paintings of many famous painters such as Rembrandt, Sandro Botticelli, Vincent van Gogh, Pablo Picas, Paul Klee, Mariotto Albertinelli, Amadeo Modigliani and others. If we observe the paintings using the infrared reflectography technique, underdrawings or preparatory drawings are visible under the surface layers of the painting. For the history of art, the discovery of hidden underdrawings is a source of important data that helps in the attribution of works, the observation of changes in the composition or the working methods of individual workshops. In previous research, numerous underdrawings were discovered, especially in paintings from the Renaissance period, such as by famous painters such as Leonardo da Vinci, Jan van Eyck, Albrecht Dürer, Andrea del Sarto, [1] Joachim Beuckelaer, Raphael, Giorgione, Altdorfer and Bruegel. With Croatian painters, the most notable are the invisible information in the lower layers of paintings on canvas by three painters of the Munich circle - Josip Račić, Miroslav Kraljević and Vladimir Becić. These researches are documented and described in detail in the book "Secret Pictures of Miroslav Kraljević and Josip Račić" [2]. Thanks to many years of research by recording and analysing artistic paintings with an IR camera in the permanent exhibitions of Zagreb museums, interesting discoveries have been made. It was discovered and documented that on IR reflectography recordings, pentimenti (displacements) are present in paintings by Vladimir Becić and Milivoj Uzelac in the Modern Gallery in Zagreb and an unknown artist from the Museum of the City of Zagreb. Pentimented parts of the paintings were documented and confirmed by Guido Reni, Nives Kavurić Kurtović in the Museum of Arts and Crafts; Raffaello Santi from the Mimara Museum; Vlade Kristla from the Museum of Contemporary Art; Vjekoslav Karas from the Memorial Collection of Dr. Ivan Ribar and Cata Dujšin-Ribar; Mariotto Albertinelli, Oskar Herman from the Strossmayer Gallery of Old Masters, and the painting by an unknown author of the Our Lady of Remete, taken at the exhibition "On Restless Foundations - Archeology and 725 Years of the Sanctuary in Remete" in the Museum of the City of Zagreb. Double, connected RGB and ZRGB cameras were used during the work. Paintings were photographed simultaneously in both spectra (NIR and V). A modified digital camera for near-infrared recording Canon EOS 350D / Digital Rebel XT [1] was also used.

When viewing artistic images, one primarily enjoys the visual spectrum, their aesthetics, beauty, style of production, motif and/or skill. With an IR camera, we get extended information on the absorption of infrared light, which we see as an achromatic scale from white to black. Scientists, conservators-restorers and art historians use imaging in the infrared spectrum and X-rays to reveal painted works and other data hidden in the lower layers of the image for image analysis. In the near-infrared part of the spectrum, infrared reflectography has very good penetration through thinner image layers [3]. Photographing art paintings simultaneously in the visual and NIR spectrum helps in understanding their origins, and thus creates a database of the state of the paintings in two spectral areas, which is one of the methods that also serves to protect against forgeries [4].

In some cases, even under oblique light, layers of paint can be seen, which reveal a thicker stroke and a different surface of the image under the visible coating of paint. Most often, the artist himself applies subsequent layers of paint, but sometimes it is the intervention of another artist. Under the light of ultraviolet fluorescence, a layer of varnish, complete or partial overpaint and restoration-conservation interventions are revealed. For art lovers, collectors and the general public, the lower layers of the painting usually remain hidden because they are invisible to the naked eye. By introducing IR printing in the reproduction of works of art, it is possible to observe the secrets that paintings hide in



Slika 1 *V i Z-NIR Tonovi triju boja na šest umjetničkih slika iz Strossmayerove galerije starih majstora HAZU-a iz različitih razdoblja na kojima je vidljiva razlika u apsorpciji boja pod IR svjetlom (snimila: D. N. Čorda, 2014.)*

Figure 1 *V and Z-NIR Tones of three colours on six art paintings from the Strossmayer Gallery of Old Masters of HAZU from different periods, where the difference in colour absorption under IR light is visible (photographed by: D. N. Čorda, 2014)*

their layers throughout history. Printing colours (CMYK) have duality in the visual and IR spectrum [5]. An IR camera or detector is used to peer into the lower layers and at the reproduction of the artwork itself, and this possibility initiated the idea of a new reproduction in printing that includes the visual and IR state of the artistic image. In order to do this, it is necessary to master IR printing based on InfraReDesign [6]. Therefore, the reproduction of an artistic painting that is printed with modern infrared technology becomes connected to an IR camera and asks the observer to observe the hidden image through a device [7].

2. REZULTATI ISTRAŽIVANJA
2. RESEARCH RESULTS

For the purposes of research in Zagreb, about one and a half thousand artistic paintings were recorded in the visual and near-infrared spectrum in seven museums, three collections, eleven occasional exhibitions, five private collections and a studio. All paintings were simultaneously recorded in the visible spectrum (V) and near-infrared (NIR) range under the usual conditions of permanent setups, without an additional light source. Interesting overpaint and pentimenti were found on 33 paintings. In the research, it was discovered and confirmed that the art paintings included in this analysis hide in their layers pentimented paintings or parts of a painting, underdrawings, displacements/changes (pentiments) and subimages. IR images of individual paintings show erased signatures, clearer painter's handwriting (brush stroke), and some types of pigments can be determined and conservation-restoration interventions (retouch and fillings) can be detected [1]. It is difficult to make a copy or forgery of an image in two spectral regions, even if it is done by the author himself, because different colour properties are easily observed in an IR image. IR images enable an easier and more successful return to the original state in case of damage to the artwork. Research and recording of colour pigments in the visual and IR spectrum at 1000 nm in the permanent exhibition of the Strossmayer Gallery of Old Masters of HAZU confirmed the existence of very similar tones in the visual spectrum with completely different absorptions in the near IR range. 36 details of red, blue and green colours were recorded with 36 different artistic paintings from the 14th/15th century to the 19th century. The tones of the colour twins found were compared with those recordings, which are confirmed in the table by the greater difference in tone absorption, which is visible in the second column [1].

From the aforementioned research, we highlight interesting data that are found in four images in the lower layers of the IR images. Pentimento

(ital. pentimento, repentance) gives an insight into the artist's creative process and shows the stages of work through which the painting developed. In the painting "The Birth of Jesus and the Bowing of the Shepherds" by the Master of the Douai Carrying of the Cross, there are several preparatory drawings under the visible layer of the painting. The IR image shows pentimento, that is, a changed position of the Child's head. The most noticeable change is the angel above the cloak in the upper right part of the painting, whose wings have been changed, as well as the position and facial expression.

a) Visually

b)1000 nm

Slika 2 *V i Z-NIR Majstor Nošenja križa iz Douaija, moguće Majstor J. Kock, „Rođenje Isusovo i poklonstvo pastira“, 1. pol. 16. st.*

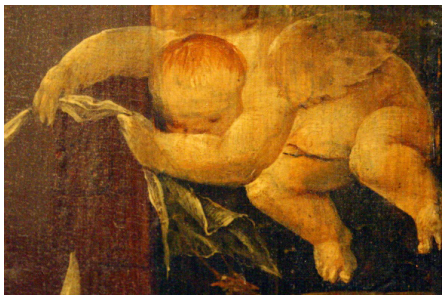
Figure 2 *V and Z-NIR The Master of the Douai Carrying of the Cross from possibly Master J. Kock, "The Birth of Jesus and the Adoration of the Shepherds", 1st half. 16th century*

a) Visually

b)1000 nm

Slika 3 *V i Z-NIR Detalj slike na kojem je pentimento glave Djeteta, a pripremni crteži prisutni su na njegovu tijelu, profilu ženskog lika u molitvi i na detaljima haljina anđela i pastira*

Figure 3 *V and Z-NIR Detail of the painting showing the pentimento of the Child's head, and the preparatory drawings are present on his body, the profile of the female figure in prayer and on the details of the dresses of the angels and shepherds*



a) Visually

b)1000 nm

Slika 4 *V i Z-NIR Detalj slike anđela na kojoj se vidi pentimento glave (snimila: D. N. Čorda, 2014.)*

Figure 4 *V and Z-NIR Detail of the image of an angel showing the pentimento of the head (by D. N. Čorda, 2014)*

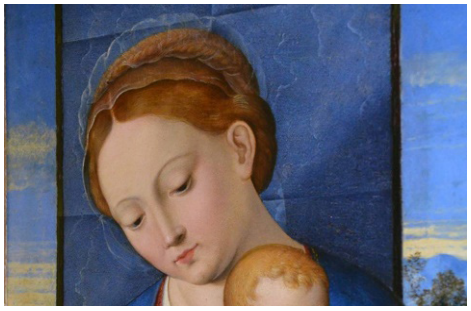
In the painting "The Virgin and Child" by Girolamo da Santa Croce, under the painted layer there is the original painting that has been moved a few centimetres to the left of the original one. The IR image shows that the painter decided to centre the painting differently. The original composition is visible on the details of the Virgin's head and the Child's feet.

a) Visually

b)1000 nm

Slika 5 *V i Z-NIR „Bogorodica s Djetetom“, Girolamo da Santa Croce, sredina 16. st. Na IR snimci otkriva se pomaknuti podcrtež*

Figure 5 *V and Z-NIR "Virgin and Child", Girolamo da Santa Croce, mid-16th century. The IR image reveals a shifted original composition*



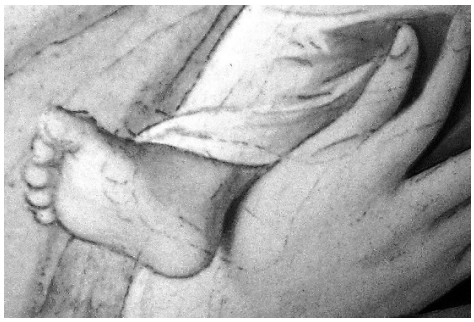
a) Visually

b)1000 nm

Slika 6 *V i Z-NIR Detalj lica u V i IR/Z spektru na kojem su tamne linije pomaknutoga pripremnog crteža*

Figure 6 *V and Z-NIR Detail of the face in the V and IR/Z spectrum, on which the dark lines of the shifted preparatory drawing*

a) Visually



b)1000 nm

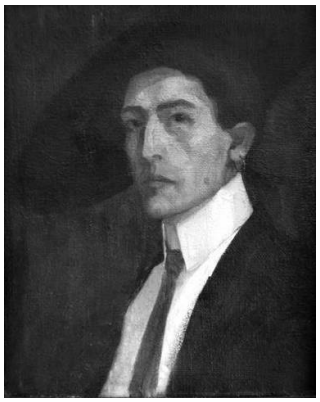
Slika 7 *V i Z-NIR Detalj noge u V i u IR/Z spektru na kojem su vidljive linije pomaknutoga pripremnog crteža (snimila: D. N. Čorda, 2014.)*

Figure 7 *V and Z-NIR Detail of the leg in the V and in the IR/Z spectrum, on which the lines of the shifted preparatory drawing are visible (photographed by: D. N. Čorda, 2014)*

Intriguing pentimento was also found in Nasta Rojc's painting "Symbolistic self-portrait". The IR reflectography shows that the self-portrait was

originally painted in profile, after which the artist changed her mind and painted it in half-profile. In the infrared range, the hat is less visible so that the female figure appears as if it were male. Photographs in the IR range reveal different colour compositions. The IR recording clearly shows the artist's change of mind during the work and subsequent changes.

a) Visually



b) CB

c)1000 nm

Slika 8 *V i Z-NIR Nasta Rojc, „Simbolistički autoportret“, 1914., usporedba vizualne i crno-bijele reprodukcije te snimka IR/Z koja otkriva u profilu pentimento nevidljiv golim okom*

Figure 8 *V and Z-NIR Nasta Rojc, "Symbolistic Self-Portrait", 1914, comparison of visual and black-and-white reproduction and IR/Z recording that reveals in profile a pentimento invisible to the naked eye*

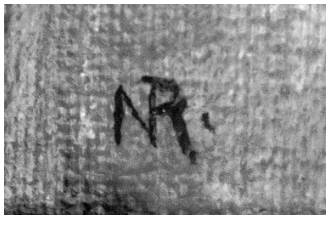
a) Visually

b)1000 nm

Slika 9 *V i Z-NIR Uvećani detalj slike na kojoj je otkriven pentimento u IR/Z području*

Figure 9 *V and Z-NIR Magnified detail of the image where the pentimento was detected in the IR/Z area*

a) Visually

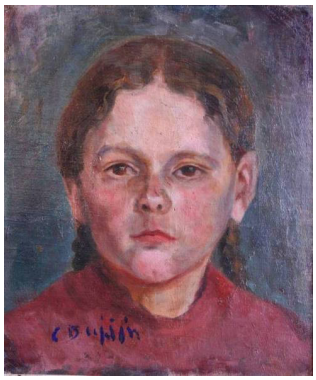


b)1000 nm

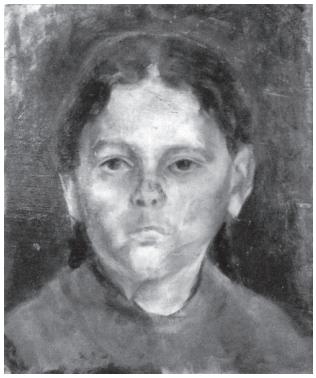
Slika 10 *V i Z-NIR Detalj potpisa koji se nejasno vidi u vizualnom području na tamnosmeđoj pozadini, dok se jasno očitava potpis u IR/Z spektru. Karbon crna boja apsorbira vizualno i blisko infracrveno svjetlo (snimila: D. N. Čorda, 2014.)*

Figure 10 *V and Z-NIR Detail of the signature that is vaguely seen in the visual field on a dark brown background, while the signature is clearly read in the IR/Z spectrum. Carbon black colour absorbs visual and near-infrared light (photo: D. N. Čorda, 2014)*

Of all the paintings that were taken for the purpose of research, only two had the artist's signature completely invisible in the IR/Z spectrum. One of these paintings, "Girl's Head" by Cata Dujšin Ribar, is signed with blue dye/paint that does not absorb IR light. In this picture, the NIR properties of blue and red are of the same origin, which is confirmed by the IR reflectography [1].



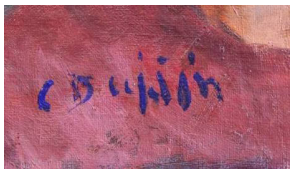
a) Visually



b)1000 nm

Slika 11 *V i Z (NIR) Cata Dujšin Ribar, „Glava djevojčice“, 1919., slika u V i Z/IR spektru*

Figure 11 *V and Z (NIR) Cata Dujšin Ribar, "Girl's Head", 1919, image in V and Z/IR spectrum*



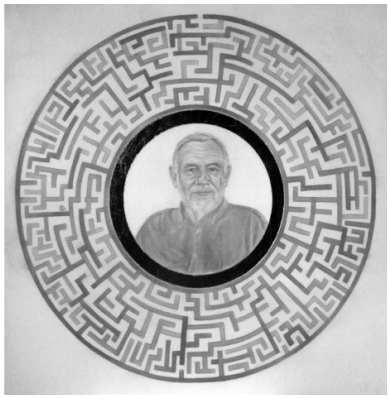
a) Visually

b)1000 nm

Slika 12 *V i Z (NIR) Izrazito upečatljiv potpis umjetnice u vizualnom i potpuno nevidljiv u IR/Z području (snimila: D. N. Čorda, 2014.)*

Figure 12 *V and Z (NIR) Extremely impressive signature of the artist in the visual and completely invisible in the IR/Z area (photographed by D. N. Čorda, 2014)*

In addition to the protection of various products and printing, InfraReDesign applied new knowledge in the near-infrared range and in the field of painting. Tonal twins of two or more dyes/colours in visual light are of the same or very similar colour tone, but they are of different chemical composition and these differences are detected on the same carrier with a ZRGB camera. They are purposefully mixed with the purpose of obtaining double images [8]. With the discovery and knowledge of InfraReDesign, double images are printed, i.e., reproductions in the visual and in the IR spectrum. Such dual printing gives a new approach in the reproduction of works of art. One of the examples is the IR printing of the catalogue of the exhibition "Black in infra (red)". The exhibition was presented in the Gallery of St. Ivan Zelina. On the left hand side is an image of a geometric abstraction, and on the right hand side is an image in the near IR spectrum where the IR camera reveals a portrait in the centre of the maze [9].



Slika 13 *V i IR/Z Detalj naslovnice kataloga „Crno u infra(crvenom) U polju infracrvene crne slike” s izložbe Dijane Nazor Čorda u Galeriji sv. Ivan Zelina, 2024. godine. Na istoj reprodukciji slike „Tajna ljubičastog kruga” otisnuta je i golom oku nevidljiva slika u IR spektru. (snimili: J. Škudar i D. N. Čorda 2024.)*

Figure 13 *V and IR/Z Detail of the cover of the catalogue "Black in infrared (red) In the field of infrared black images" from the exhibition Dijana Nazor Čorda in the Gallery of St. Ivan Zelina, 2024. An image invisible to the naked eye in the IR spectrum is printed on the same reproduction of the painting "The Secret of the Violet Circle". (recorded by: J. Škudar and D. N. Čorda in 2024)*

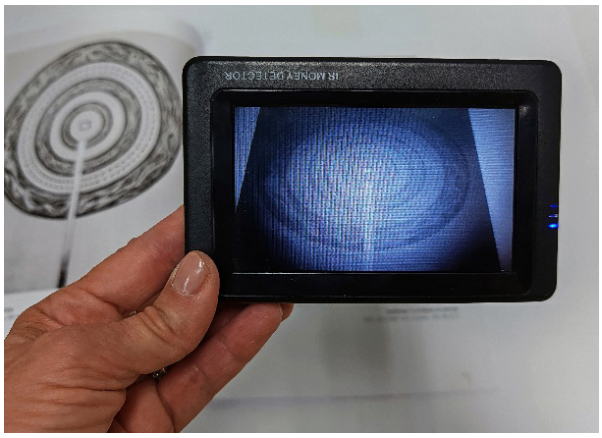
In the next image, there is a monochromatic image with a golden circle in the visual spectrum, and the right hand side image depicts the labyrinth with a wind rose, which is located in the IR spectrum within a smaller black circle. Infrared painting (InfraredArt) enables additional artistic freedom and the need to hide and paint motifs from the artist's intimacy that are purposefully placed in the spectrum invisible to the human eye. The method of painting double images creates a new, expanded visual representation, and the use of modern technology is only a tool, an additional possibility in the creation of a work of art [1].

Slika 14 *V i IR/Z Reprodukcija slike „Labirint sretnog susreta 1" 2023., akril na platnu i zlatni listići schlag metal, iz IR kataloga s izložbe „Crno u infra(crvenom)". (snimila: D. N. Čorda, 2024.)*

Figure 14 *V and IR/Z Reproduction of the painting "Labyrinth of Happy Encounter 1" 2023, acrylic on canvas and gold leaf schlag metal, from the IR catalogue from the exhibition "Black in Infra (Red)". (recorded by: D. N. Čorda, 2024)*

3. DISKUSIJA
3. DISCUSSION

In the IR reflectography recordings, the artist's creation process, the different stages of his work, are revealed in overpainted layers. What was invisible until then, hidden in the artist's mind, becomes visible in this way. Scientists discover hidden layers, argue about their meaning and try to discover the original layers, authors or artistic workshops through different analyses. Double infrared images hide another, completely different image, which creates additional artistic and aesthetic values in the near IR area [1]. With this method of printing, the invisible reproduction only complements the visible one with a new method of observation, and the print is enriched with the information that the original image possesses. For art historians and art lovers who are not able to directly study a particular original painting, IR printing allows the layers hidden in the NIR spectrum to be additional reading content. Printing with IR response makes it possible to observe the duality that exists in the original in the home environment. With such a way of observation, we primarily expand the study of the artistic image in order to reveal the layers that were created during its creation. Based on the findings of the InfraReDesign theory, the new IR technology provides an opportunity to fully experience a work of art through infrared reproduction that includes visual and IR conditions. The IR footprint remains the same in the visual spectrum hiding another achromatic reproduction in the near IR range.



Slike 15 i 16 *Otisnute infrared reprodukcije dviju slika „Labirint sretnog susreta 2" i „Skrivena Platonova Atlantida", 2023., akril i zlatni listići na platnu, promatrane kroz IR detektor (snimila: D. N. Čorda, 2024.)*

Figures 15 and 16 *Printed infrared reproductions of two paintings "Labyrinth of Happy Encounter 2" and "Hidden Plato's Atlantis", 2023, acrylic and gold leaves on canvas, viewed through an IR detector (photographed by D. N. Čorda, 2024)*

4. ZAKLJUČAK
4. CONCLUSION

In order to be able to analyse the layers of an artistic painting in detail, it is not enough to observe it in the visual spectrum only; recording the works with UV fluorescence, IR reflectography and X-ray technology is necessary.

The authors of the article perform their graphic preparation solutions with double-printed images that are viewed with two separate cameras after printing.

This property of the dual state of the image print is used as a new reproduction. Images in the NIR spectrum hide their secrets and stages of creation. By applying InfraReDesign's innovative printing, reproductions of works of art in publications can simultaneously have the lower layers of the image printed in the near IR region, as they are also present on the individual original. Such a double printing opens up a new possibility of reproduction, but also a broader approach to the analysis and understanding of the process of creation of works of art. While in infrared painting images are painted in several layers, in IR printing both reproductions in the visual and IR spectrum are printed simultaneously, in the same transition. The reproduction is viewed with two cameras, the IR image of which shows the state of the image in the lower layer.

For the preparation of dual printing, it is necessary to photograph artistic paintings in the IR range, in addition to the visible spectrum. In infrared painting, on one and the same medium, the artist paints two separate images that are visible in two spectra, visual and near-infrared. The IR print is observed with an IR camera because the reproduction contains the infrared state as well as the original artwork. With this, we have confirmed the possibility of a new method in print reproduction and in the field of fine art. It is suggested that printing in the IR spectrum be introduced for the printing of specialist books on art history, which would enable extended observation of artistic reproductions. In this way, it would be more accessible to analyse the stages of construction of individual paintings, overpaint and pentimenti, which provides the possibility of a more complete analysis of the work of art beyond the visual spectrum. In this article, all reproductions are printed with IR response.

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5. REFERENCES:

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• Dijana Nazor Čorda - was born in 1971 in Split. In 2017 she finished her PhD at the doctoral course Painting at the Academy of Fine Arts of the University of Zagreb, mentored by full professor Igor Rončević and associate professor Jana Žiljak Gršić. In 1995, Dijana graduated from the then Faculty of Science and Pedagogy in Split, today the Arts Academy, and acquired the title of art teacher and conservator-restorer. In 1990, she obtained a high school diploma from the School of Applied Arts and Design in Split.

Since 1995, Dijana has held 50 solo exhibitions in Croatia, Belgium and Australia. She has participated in more than 150 juried group exhibitions in the country and abroad since 1993. In 2006, she completed a 2-month resident training course in Paris, in the Cité Internationale des Arts atelier. She took part in 42 artists' colonies in Croatia, and Bosnia and Herzegovina. Dijana has won numerous awards, recognitions and commendations for her artistic work. For her contribution to the arts and pedagogical work, she was presented with two state awards: the Ivan Filipović Annual National Award in 2012, and she recieved the Order of Danica Hrvatska with the figure of Antun Radić for education in 2013. In 2013 she was awarded the title of Celebrity AFIAP by the International Federation of Photographic Art.

Dijana has published around thirty research and professional papers, and has participated in numerous national and international conferences.

She has been a member of the Croatian Association of Fine Artists (HDLU) Zagreb since 1998, of InSEA (International Society for Education through Art) since 2006, Photo Club Zagreb in the period 2003–2011 and of Croatian Heraldic and Vexillological Association since 2017). She lives and works in Zagreb.

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