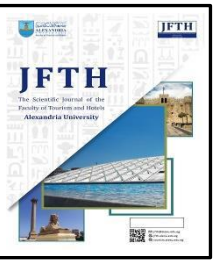
JFTH
Vol. 22, Issue 1 (2025)
ISSN: 2314-7024
E-ISSN: 2682-2180

The Scientific Journal of the Faculty of Tourism and Hotels, Alexandria University

Journal Homepage: https://thalexu.journals.ekb.eg



Using Multispectral Imaging for Studying Two Coptic Icons from St. Demiana Church, Boulaq, Cairo, Egypt

Randa Wagdi [(1)], **Souty Beskhyroun**[(2)] , **Makary ElMakari** [(3)], **Mary Magdy** [(4)]

[(1)] *Faculty of Tourism and Hotels, Fayoum University, Fayoum, Egypt*
[(2)] *Faculty of Archeology, Fayoum University, Fayoum, Egypt*
[(3)] *Monastery of Saint Macarius, Wadi El Natrun, Egypt*
[(4)] *Faculty of Tourism and Hotels, Alexandria University, Alexandria, Egypt*

ATRICLE INFO

Received 31 March 2025
Revised 09 April 2025
Accepted 25 May 2025

JOURNAL ARTICLE

https://doi.org/10.21608/thalexu.2025.372305.1141

Keywords:

Multispectral images 1, Icons 2, Boulaq 3, church 4.

ABSTRACT

Recently, modern non-invasive digital imaging techniques for documentation and studying the painted artifacts in general and Coptic icons, in particular, enabled professional experts to study new artistic schools with discrimination of the original painting materials, under drawings, artists' techniques, and successive conservation interventions to conduct scientific conservation interventions. Multispectral imaging (MSI) is increasingly used in museums, galleries, and churches to provide comprehensive multi-wavelength digital images with a range of useful information that is likely hidden to the naked eye such as condition assessment, mapping pigments and organic varnishes, uncovering hidden signatures, diagnosing underlying, sketches, and investigating successive retouches. In this research, multispectral images were acquired with different spectral bands of high-resolution visible light (VIS), raking light (RAK), reflected and fluorescence ultraviolet (UVR, UVF), infrared fluorescence and reflectography (IRF, IRR), and raking light images to study two of Coptic icons from St. Demiana church, Boulaq, Cairo. Multispectral photos confirmed that the two studied icons were heavily retouched. Modifications on the original artist's underdrawings were also detected in both studied icons. While the two studied Coptic icons were not signed by a specific artist, studying the artistic features of the icons and comparing them to the other published Coptic icons made attribution to Hafez Shamandi's artistic school.

1. Introduction

Recently, the use of multispectral imaging to study different substances of cultural heritage and archaeological paintings has become popular in the field of cultural heritage applications due to the capacities of such advanced techniques to obtain large amounts of information while overcoming the limitations of the sampling process **(San Miguel, 2011).** Being a non-invasive technique, multispectral images allow the archaeologists, conservators, and researchers to characterize and map the archaeological painted artifacts and enhance the readability of the hidden artist's modifications, signatures, underdrawings, previous conservation

CONTACT Dr. Randa Wagdy - rwn00@fayoum.edu.eg Faculty of Tourism and Hotels, , Fayoum University, Egypt
Supplemental data for this article can be accessed online at https://doi.org/10.21608/thalexu.2025.372305.1141

interventions, and structural elements, which are not visible to the naked eye and are essential to study the history and conduct scientific conservation of any historical and archaeological paintings. The fundamentals of the multispectral imaging technique are mainly based on how matter interacts with light. Light and other electromagnetic radiations are characterized in terms of the wavelengths **(Fig.1).** When the materials are illuminated by specific radiation, some radiation is reflected,

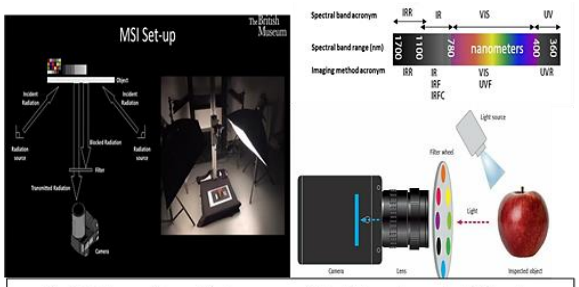


Fig 1. Set up of modified camera with different spectral filters to

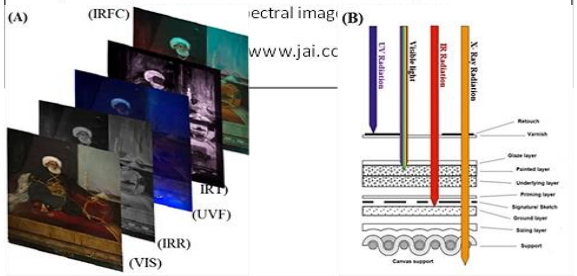


Fig 2. (A) Example of multispectral documentation & (B) the penetration of electromagnetic radiation through the layers of the paintings

(Beskhyroun, 2018; Beskhyroun, 2022)

and the rest passes into the material **(Fischer& Kakoulli, 2006; Gavrilov et al.., 2014).** Multispectral images are acquired in different ranges of spectral bands that include and extend beyond the human eye's capabilities including ultraviolet from 300-400 nm, visible light from 400-780 nm, and infrared from 780 to 1700 nm **(Fig.1).** The abbreviations of multispectral images are VIS (Visible), RAK (raking light), UVF (Ultraviolet Fluorescence) UVR (Ultraviolet Reflected), IRF (Infrared Fluorescence), and IRR (Infrared Reflectography), IRFC (infrared false color) **(Fig 2.A) (Cosentino & Stoul, 2014**). Every electromagnetic radiation can penetrate different depths into the painting layers **(Fig 2.B) (Cosentino, 2016)**

Digital-modified cameras, different lighting sources, and filters are used to acquire a selection of technically spectral images, each providing additional information regarding the object under examination **(Cosentino et al., 2014)**. Visible light imaging provides high-quality photographic diagnostics in the standard visible range of the electromagnetic spectrum. Visible light images provided high-resolution photographic diagnostics of the aesthetic features and changes that occurred on the artifacts upon natural aging **(Beskhyroun, 2022).** Raking light technical images represent the illumination of the examined painting with visible light at a sharp angle. In these conditions, the top of the painted surface produces different shadows and/or scattering to extract information, including shapes of brush strokes, bulges, scratches, wrinkles of canvas painting, craquelures, and texture of the ground layer **(Gavrilov et al., 2014).** Technical photography based on ultraviolet radiation gets a lot of interest in the examination of cultural heritage because of its simplicity and affordability. The ultraviolet fluorescence imaging method is based on the irradiation of the studied objects with UV light and the detection of their fluorescent response in visible light with completely dark surroundings **(Zaprzalska et al., 2024).**

The scientific basis of ultraviolet fluorescence mainly depends on the ability of different chemical compositions to absorb UV photons, bringing the molecule to a higher energy state, and when the molecule loses energy, it returns to its ground state and emits another photon of less energy. Because of that, different art and conservation materials exhibit various emissions **(Garini et al., 2006)**. The ultraviolet fluorescence technique is commonly used for characterization and mapping the painting materials such as varnishes, pigments, dyes, and organic

binders. Also, the ultraviolet-induced fluorescence technique can highlight the presence of previous conservation materials, such as retouches or synthetic coatings **(Shaheen, 2020)**. For example, dammar varnish gives off a greenish chroma, shellac appears an orange tonality, and synthetic coatings give a clear or lavender tone. The age of the painting materials also affects the color of fluorescence. The fresher the varnish and painted materials, the darker the tonality they are. This is why the detection of retouched areas is provided with UVF **(Gavrilov et al., 2014).** Ultraviolet-reflecting imaging is based on radiation with a short-pass filter mounted on the camera lens at 380 nm in a completely dark room to acquire the UV reflectance image from the painted surface **(Gargano et al., 2023).** Ultraviolet light only reacts with the topmost painted layer and does not influence the underneath paints **(Cosentino, 2014)**. Ultraviolet reflectance photography is applied for differentiation between white pigments. While zinc white and titanium white absorb UV radiation, appearing dark in UVR, lead white and lithopone are UV reflectors and show up brightly in UVR images **(Cosentino, 2015).** The advantage of mapping white pigments could be used to authenticate and detect forgeries or the addition of modern titanium white in some areas of the historical paintings **(Beskhyroun, 2018)**. Infrared reflectance radiation can penetrate the painted layer, and the underneath ground layer reflects it; this is why the infrared imaging method is used for showing carbon-based underdrawings that absorb IR radiation and appear dark **(Zaprzalska et al., 2024)**

Because of that, Infrared reflectance photography is commonly used to study the preparatory sketches underneath the painted layer of the original artists using charcoal and is a well-known tool to search for and detect the underdrawings, unraveling signatures, and writings. The infrared reflectance tool helps to authenticate the attribution of the studied paintings in some cases **(Fischer& Kakoulli, 2006; Liang, 2012; Pellicori, 2012)**. Infrared fluorescence is captured by illuminating visible light on the painting by using an IR filter to restrain some wavelength to detect some chemical minerals of pigments with Infrared fluorescence response. This technique allows the mapping of some specific pigment materials, such as Egyptian blue and cadmium-based pigments **(Shaheen, 2020)**. Infrared False color imaging technique is based on superimposing two photographs; one taken in the infrared region while the other is in visible light. The infrared photograph is translated into grayscale while that in visible light is composed of the three primary components of RGB_ red, green, and blue resulting in three different images for each color channel. At this point, an infrared false-color photograph is carried on the red RGB channel, and the decomposition of the red channel derived from the visible photograph is carried on the green channel; alike, the green decomposition in the blue channel and the blue decomposition is disregarded **(Paolini, 2022)**

IRFC image is useful for mapping pigment materials and detecting forgeries of art as it is useful to identify and examine a single painted layer by detecting the multilayers of the painted surface **(Shaheen, 2020; Paolini, 2022)**. This research aims to study the aesthetic school of unsigned two Coptic icons from St. Demiana church in the Boulaq district in Cairo, which is considered to be the first church built and consecrated in the name of Saint Demiana in Cairo. The foundation stone of the church was laid by the 112th Patriarch Pope Cyril V, in 1882 AD. The church area is a square without columns, with buildings supported only by the side walls. It has two floors and a ceiling made of wooden beams. There are two large domes: the first is in the

middle of the church courtyard, and the second is above the main church altar. The church has three doors, and the upper floor was designated for women, according to ancient customs. The church passed by the conservation interventions three times. The first conservation interventions were conducted during the 1950s under the leadership of the 115th Patriarch Pope Yousab II. The church was restored and renovated comprehensively in the buildings without any change in its landmarks. The second conservation occurred in the church by the 116th Patriarch Pope Kyrillos VI in which the church buildings were renovated and painted with the removal of the main altar. The establishment of a new one inaugurated the new altar in 1961. The third conservation interventions were carried out from 1987 to 1989 during the reign of the 117th Patriarch Pope Shenouda III, in which the old wooden icon holder was removed and replaced with a new one, preserving the old icons. The main old structure's altar was removed, and a marble altar replaced it. The wooden altar, named after the Virgin Mary, was renewed in Saint Demiana's chamber **(Church of Saint Demiana, Boulaq, 2024)**. Because of the multiple conservation interventions in the church, including the old Coptic icons, multispectral imaging was conducted in this study to verify the hidden signatures or underneath sketches of the icon's artist and if there were intentional modifications carried on the original icons. Multispectral images were provided for the two studied icons. The first icon represents the resurrection of Jesus Christ, and the second is a double-sided icon of the burial and resurrection of Jesus Christ.

1.1.Methodology

This research employed both a descriptive and an experimental methodology:

The descriptive method was used to analyze the artistic and stylistic features of the icons under study.

The experimental method used scientific tools and imaging technologies to examine the materials, techniques, and interventions.

The research samples (icons) were selected based on the following criteria:

1- The presence of some chromatic retouches on the icons under study, distinct from the stylistic features characteristic of the artist Hafez Shamendi, indicates the addition of non-original pigments, which differ from the original color scheme.

2- The studied icons were also selected after multispectral imaging and examination of many Icons, which confirmed the presence of modifications, additions, and underlayers in the selected icons.

3- Certain artistic modifications made by the iconographer himself, during the work phases, were identified through multispectral imaging techniques, rendering these icons a valuable source for in-depth art-historical and technical analysis.

4- The selected icons were not previously examined through formal artistic analysis, and Hafez Shamendi's artistic school was academically unexplored, despite the wide presence of his works in numerous churches.

1.2. Research Objectives

1. To introduce the concept and principles of multispectral imaging technology.
2. To highlight the artistic school of the painter Hafez Shomanda through the application of this study to two of his most renowned icons.
3. To examine and provide an artistic analysis of two icons that have not previously been studied.
4. To demonstrate the effectiveness of multispectral imaging in detecting chromatic retouches, identifying artistic modifications made during the painting process, and

revealing the type of varnish used on the icons under study.

5. To emphasize the significance of modern imaging techniques in the preservation and protection of tangible heritage, particularly in preventing theft, forgery, and undocumented alterations.

2. Materials and methods

2.1. The Studied Coptic Icons

Two icons from St. Demiana church in the Boulaq district, Cairo, were studied to track the aesthetic features of the icons, make attribution to the specific artistic school, and characterize if modifications were conducted during the conservation interventions. The first icon represents the resurrection of Jesus Christ applied on wooden panels **(Fig 3.A)** with dimensions of **80 cm** length and **95.2cm** width. The second is a double-sided icon of the burial and resurrection of Jesus Christ. The icon is applied on a wooden panel with **53cm** width and **74 cm** in height. This icon is well known to be used during the Holy Week liturgies of crucifixion and resurrection in the Orthodox churches **(Fig 3.B&C).**

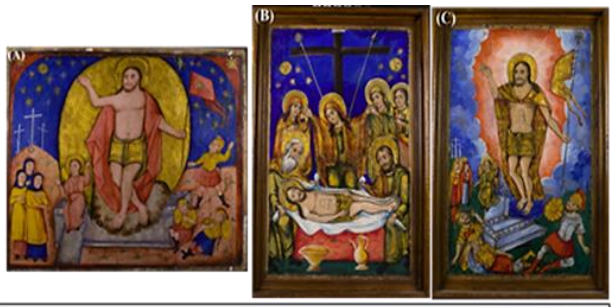


Fig.3. The studied icons from St. Demiana church (A) resurrection of Jesus Christ icon & (B, C) double-sided icon of the burial and resurrection of Jesus Christ

(by the researcher)

2.2. Technical Features of Icons

2.2.1 The first icon **(Fig.a)** represents the Resurrection of Jesus Christ **(Matthew 28:1-8).** In the center of the icon, Christ is depicted larger than the other figures, emphasizing His importance as the main subject of the event. He is portrayed in a frontal stance, with brown hair and a beard, a golden halo surrounding His head. He wears a golden loincloth, and a red sash drapes over one of His shoulders. His right hand is raised towards the sky, while His left hand holds a red victory banner, symbolizing His triumph over death. He stands on a cloud, surrounded by a large golden halo resembling a *mandorla*.

In the lower part of the icon:

To Christ's right, an angel is seated on the edge of the tomb in a frontal position, wearing a pink robe with a golden halo around his head. He gestures with his right hand towards the women and with his left hand towards Christ, signifying his message to them about the Resurrection. The three women stand in a three-quarter view, wearing blue and pink robes connected to head coverings of the same colors, with yellow cloaks over them. Their hands are placed on their chests, expressing astonishment and joy. Behind them, Golgotha is depicted with the three white crosses where Christ was crucified.

To Christ's left, three Roman soldiers, who had participated in His crucifixion are shown in varied postures. One is standing with his head raised, gazing at Christ; another is asleep, and the third looks at Christ with an expression of fear and shock. They are dressed in Roman military attire.

The background is divided into two sections:

- The upper part is blue, adorned with golden stars, symbolizing the heavens.

- The lower part is pink, featuring green plants, symbolizing the earth.

2.2.2 The second icon is double-sided. The first side (Fig 3.B) depicts the burial of Jesus Christ. He is shown lying on a white linen shroud in a three-quarter position, with a

golden halo around His head and wearing a golden loincloth.

On the right side of the shroud, Joseph of Arimathea, who requested Pilate's permission to take Jesus' body for burial, is depicted in a three-quarter view with brown hair and a beard and a golden halo around his head. He wears a yellow robe with a red cloak over it and holds the end of the shroud at Christ's feet with both hands.

On the left side, Nicodemus, who brought a mixture of myrrh and aloes for the burial **(John 19:28-40),** is also shown in a three-quarter view with white hair, a beard, and a golden halo. He wears a green robe and a yellow cloak and holds the other end of the shroud at Christ's head with both hands.

In the center, behind Christ's shroud, the Virgin Mary stands in a frontal position, expressing deep sorrow and grief. She raises both hands in mourning and lamentation. She wears a green robe with a brown cloak and head covering, with a golden halo around her head, gazing at Christ's body with sadness.

On either side of the Virgin Mary, the women are depicted in a three-quarter view with golden halos, looking at Christ's body with expressions of sorrow and grief.

In the background, a black cross appears with the spear and the sponge soaked in vinegar, which were used during Christ's suffering. The background is blue with golden stars, along with the moon and sun, representing the darkening of the sky from the sixth to the ninth hour of Christ's death on the cross **(Luke 23:44-46).**

The second side of the icon represents the Resurrection of Christ. Artistically, this depiction does not significantly differ from the Resurrection scene in the first icon, except for variations in the colors of Christ's robe and victory banner, which are golden in this version. Additionally, differences can be observed in the colors of the mandorla, the garments of the women, and the Roman soldiers. However, overall, this icon follows the same artistic characteristics as the first.

Through an artistic study of the icons by Hafez Shamandi under examination, the following observations can be made:

1. The artist disregards anatomical proportions in body representation.

2. He extensively uses the colors blue, gold, and yellow.

3. The icons lack inscriptions or signatures.

4. Certain liturgical inaccuracies appear in Shamandi's depictions, such as the tomb depicted beneath Christ in the Resurrection icon. In reality, Christ was buried in a rock-hewn tomb **(Mark 15:46).**

5. The artist represents the mandorla around Christ's body. The *mandorla* is Italian for "almond" and is used in art to denote the halo or almond-shaped aura surrounding Christ in icons. The mandorla symbolizes the Kingdom and eternity, as well as the Divine Presence. It consists of three levels of almond-shaped circles in shades of blue, transitioning from lighter to darker, symbolizing the three heavens preceding the Heaven of Heavens, where God's throne is located **(Athanasius, 2011).**

2.3.Hafez Shamendi

The tracking of the aesthetic features of the studied icons with the twentieth-century aesthetic features of icons that are spread across several churches such as the Church of St. Demiana in Boulaq, the Archangel Gabriel in Harat al-Saqayeen, the Church of the Virgin Mary in Babylon El-Darag, the Church of St. Barbara, the Monastery of Anba Ibram in El-Azab, and the Church of Abu Sefin in ancient

Egypt, as well as the Virgin Al-Damshiriyah (Fig 4.), referred to the attribution of the studied icon to Hafez Shamandi_ an artist who probably lived in Egypt at the end of the 19th century and in the earlier period of the 20th century. However, there is occasional confusion between the artistic work of Hafez Shamandi and that of Anstasi El-Romi. The artworks of Hafez Shamandi have a distinguishable artist style. Hafez Shamandi always neglected the anatomical body proportions. He also depicted heads with relatively large sizes. His compositions always appear rigid, especially when portraying small-sized figures. His pictorial palette is often bright and vivid as he used to use blue, green, golden, and red paints. Unlike the style of Anastasi El-Romi's artistic school, which paid attention to showing the folds and pleats in robes, especially in the garments of Jesus Christ and the Virgin Mary, Hafez Shamandi did not care about depicting clothing details. Hafez Shamandi's icons included some liturgical errors, especially in the crucifixion and resurrection, depicted events such as the placement of nails in Jesus Christ's hand palm and portraying Jesus Christ's tomb as a stone or wooden coffin. Interestingly, there are no artist signatures on the widespread icons, possibly because Hafez Shamendi's production of these icons was not driven by profit, unlike icons by Ibrahim Al-Nasikh, Yuhanna Al-Armani, and Anastasi El-Romi.

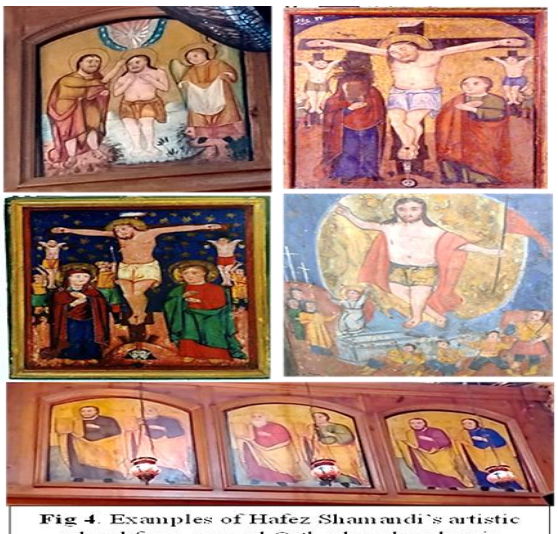


Fig 4. Examples of Hafez Shamandi's artistic school from several Orthodox churches in Egypt (Researchers)

The Multispectral imaging

To characterize any modifications that occurred on the studied Coptic icon either from the original artists or from the following conservation interventions **(El-Rifai et al., 2016; Beskhyroun et al., 2022**), a multi-spectral imaging system has been set up using a modified Nikon D5200 camera. The multispectral images were collected and processed in the following modes: Visible (VIS), raking light (RAK), Infrared Reflected (IRR), Infrared Fluorescence (IRF), Ultraviolet Fluorescence (UVF), and Ultraviolet Reflected (UVR). The system employs a Hoya B-52RM72-GB filter, B+W 830/093 IR Black red filter (52mm), Kolari Vision Infrared lens filter (52mm,930nm), and B+W 52mm UVA Black 403 Filter (320 - 385nm) in addition to 365nm UV, 720 nm IR and VIS lights.

Studied Coptic icons were investigated with multispectral imaging to verify the modifications conducted on the icons during the previous conservation interventions and to determine if there were underdrawings from the original artist. The icons were examined under visible light, raking light, fluorescence, reflectance infrared, fluorescence, and reflectance ultraviolet. The visible light image of the resurrection icon gave a high-resolution image that was professionally taken using the color checker, so the VIS image provided the exact color of the painted surface as it is in reality **(Fig 5.A).** There is no doubt that a VIS image can not provide any information about the underlying layers, and it is also not easy to verify the retouched areas with it. Infrared-reflectance image of the resurrection icon detected modifications conducted by the original artist in his sketches referring to changes in the artist's mind during the drawing stages. The use of the infrared reflectance technique for studying the resurrection icon

showed the alternations made by the original artist, especially at the folds and pleats of Jesus's robes and the modification of the angel placed on the left side. Also, the position of the soldier's legs on the right side is changed by the artist **(Fig 5.B).** From the IRR technique, the random brush strokes of the artist become visible in the blue paint around the mandorla. In addition to that, the difference between the reflection of the original and non-original paints is quite visible. For example, the retouched stars from the previous conservation interventions appear darker than the original paint. Infrared fluorescence image (IRF) did not showe any fluorescence in the icon, which refer to the unuse of cadmium pagments in the painting **(Fig 5.C).** Cadmium yellow pigment started to be used during the first half of the nineteenth century. Ultraviolet fluorescence imaging showed that the icon was heavily overpainted during the previous conservation interventions as the UVF image **(Fig 5.D)** revealed a distinct difference between the original paints and the retouches in the icon. The retouches appeared as darker purples in Christ's clothes, the mandorla, Christ's chest, left foot, some stars, and the face of one of the soldiers, as well as in some of their clothing. It also seems there are residues of the natural varnish on the original paints as varnish reflections are particularly visible in yellow at Christ's attire, the surrounding mandorla, and the soldiers' clothes. Ultraviolet reflected (UVR) imaging **(Fig 5.E)** revealed different paint reflections. The retouched paints appeared darker than the original paints. Additionally, variations in light contrast for one color within the icon indicate that they do not have the same composition and properties. Notably, the uniform reflection of blue color throughout the icon, such as in the soldiers' clothing and the Virgin Mary, is contrasted with the irregular blue background, which appears to be from different materials. The raking light imaging technique **(Fig 5.F)** showed that the common deterioration phenomenon of the icons is spreading the separates during the stratigraphic structure of the icon from the wooden panels to the painted layer.

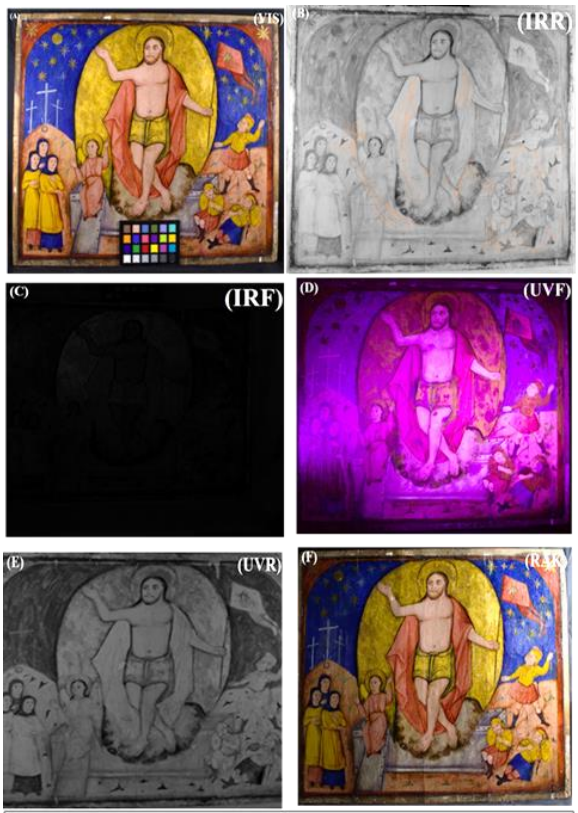


Fig 5. Multispectral images of resurrection icon (A) VIS, (B) IRR, (C) IRF, (D) UVF, (E) UVR & (F) RAK images (Researchers)

The visible light image of the double-sided icon of the burial and resurrection of Jesus Christ gave high-resolution images that were professionally taken using the color checker, so the VIS images provided the exact color of the double-sided painted surfaces as they are in reality **(Fig 6. A &7. A).** There is no doubt that VIS images can not provide any information about the underlying layers, and it is also not easy to verify the retouched areas on both sides with them. An infrared-reflected image of Jesus Christ's burial side detected modifications conducted by the original artist in his sketches, referring to changes in the artist's mind during the drawing stages. The use of the infrared reflectance technique for studying the burial side from the icon showed

the alternations made by the original artist, especially at the locations of the ropes used to lower Jesus from the cross **(Fig 6.B).** The second side of the resurrection did not show any modifications made by the original artist. **(Fig 7.B).** Infrared fluorescence images (IRF) of both sides completely appeared dark, which is referred to the absence of cadmium-based paints on both sides of the icon **(Fig 6. C& 7.C).** Ultraviolet fluorescence imaging of both sides showed that the icon was heavily overpainted during the previous conservation interventions, as the UVF images revealed a distinct difference between the original paints and the retouches on both sides of the icon. The retouches appeared as darker purples in the burial side in the lower part with heavily retouched areas to include the saints' halos, Arimathea Jossef's beard, and the place where Jesus Christ lies. Also, the blue background behind St. Mary showed retouches. The sun, moon, and stars are also retouched from the

Fig 6. Multi-spectral images of the burial side of the double-sided icon (Researchers)

previous conservation interventions **(Fig 6.D).** UVF image of the resurrection side also showed retouched areas from the previous conservation interventions. The retouches included some parts from the background and mandorla. The background behind the right soldier and his attire are retouched. Also, the background behind the Maryams and their attires showed retouches **(Fig 7.D).** It also seems there are residues of the natural varnish on the original paints on both icon's sides as varnish reflections are particularly visible in yellow. Ultraviolet reflected (UVR) images of both sides of the icon revealed different paint reflections. The retouched paints appeared darker than the original paints **(Fig 6. E & 7.E).** The raking light imaging technique did not show deterioration phenomena of the icons on both sides of the icon are in good condition **(Fig 6. F & 7.F).**

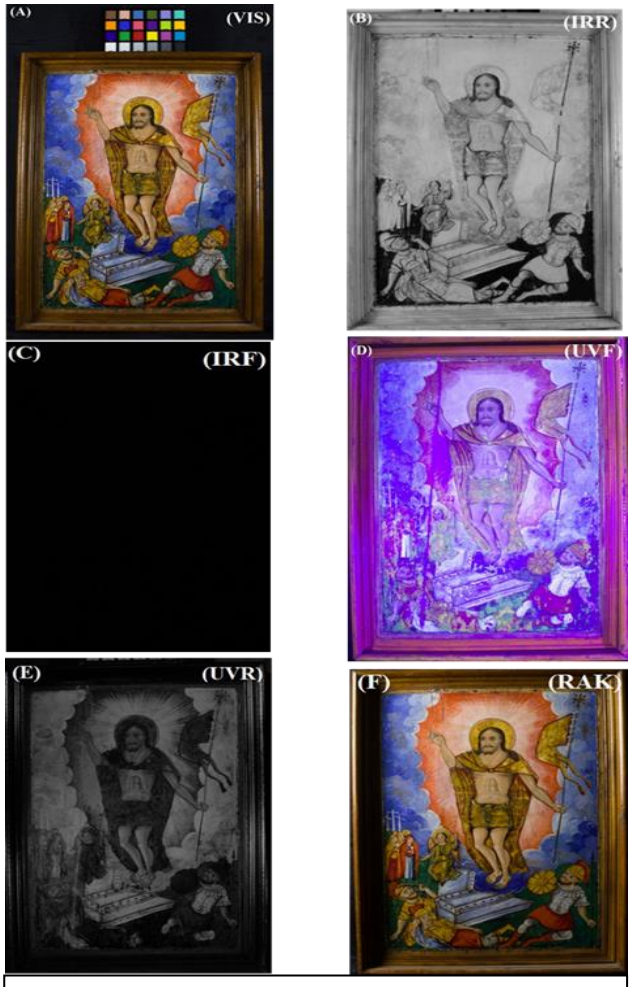


Fig 7. Multi-spectral images of the resurrection side of the double-sided icon (Researchers)

An analytical commentary on the applied study

Multispectral imaging has emerged as a pivotal non-invasive tool in the examination and conservation of painted artifacts. Its application provides deep insights into the material composition, condition, and history of artworks without inflicting any physical damage or alteration.

This technique plays a crucial role in:

Detecting artistic modifications made throughout the stages of an icon's creation, including changes in the artist's conceptual approach, stylistic development, and compositional adjustments.

Identifying some pigments and their chemical components, which not only aids in technical documentation but also enriches the historical and contextual understanding of the artwork.

Revealing hidden pictorial elements beneath surface layers, which is especially valuable in cases of superimposed scenes or overpainting, thus contributing to a more accurate interpretation of the underlying visual narratives.

Providing precise scientific data regarding the materials used such as pigments, varnishes, and stratigraphy as well as evidence of past restorations. This information supports conservators in developing tailored preservation strategies that respect the original integrity of the artifact and suit the surrounding environmental conditions.

Uncovering erased or concealed signatures, which enhances the process of attribution and documentation, particularly for works of religious and historical significance.

Authenticating artworks and detecting forgeries, thereby ensuring the credibility and provenance of icons and murals.

Examining the stylistic and technical features of under-researched artists, such as Hafez Shamendi, an early 20th-century iconographer, whose two icons were identified and published here for the first time as part of this study.

To examine the icons and determine the modifications that have been made either by the original iconographer or during subsequent conservation interventions, a multispectral imaging system was employed using a modified Nikon D5200 camera. The imaging modalities included:

Visible (VIS), Raking Light (RAK), Infrared Reflectance (IRR), Infrared Fluorescence (IRF), Ultraviolet Fluorescence (UVF), and Ultraviolet Reflectance (UVR) A range of filters and light sources were used to capture detailed images across different spectral bands.

Two unsigned Coptic icons were examined using these techniques, including the Resurrection icon and a double-sided icon depicting the Burial and Resurrection of Christ

Visible imaging (VIS) provided high-resolution documentation of the painted surfaces using color checkers, but was insufficient for detecting underlying layers or retouched areas.

Infrared Reflectance (IRR) revealed artistic modifications by the original painter, particularly in compositional elements such as Jesus's robes, angel positioning, soldiers' limbs, and sketch lines indicating changes in the artist's creative process.

IR fluorescence imaging (IRF) reveals some pigments' properties, especially the cadmium-based colors. It showed the absence of cadmium pigments in the palette of the iconographer Hafez Shamandy.

UV Fluorescence (UVF) identified extensive overpainting and retouching from previous

restorations. Retouches appeared as darker tones, especially in Christ's attire, mandorla, halos, and celestial motifs. Natural varnish residues were visible through yellow fluorescence.

Ultraviolet Reflectance (UVR)differentiated between original and retouched paints based on reflectance intensity. Consistency in color reflectance indicated homogeneity, whereas uneven reflection suggested use of non-original materials.

Raking Light imaging (RAK) detected stratigraphic separation and surface deterioration in the Resurrection icon, while the double-sided icon appeared structurally stable.

Multispectral imaging proved instrumental in identifying both artistic interventions and conservation history. It allowed for a more accurate attribution of the icons, detailed visual analysis of brushwork, and material distinctions. This approach also provided essential insights for conservation planning, highlighting the value of advanced imaging in heritage science.

Conclusion

The two unsigned icons of the study, originating from St. Demiana Church in the Boulaq district of Cairo, have been attributed to the artistic school of Hafez Shamendi, an Egyptian iconographer believed to have been active during the late 19th or early 20th century. His works are characterized by their widespread presence in various Orthodox churches across Egypt.

Hafez Shamendi's artistic style is notable for disregard for anatomical proportions. He often portrays figures with disproportionately large heads and minimal attention to the detailed depiction of garments. His color palette tends to favor bright and vivid hues, especially in using red, green, blue and golden colors, contributing to the unique visual identity of his icons.

The application of multispectral imaging to the Resurrection icon and the double-sided icon revealed valuable information regarding the original artistic interventions, including irregular brushwork patterns indicative of the artist's expressive technique. Additionally, ultraviolet fluorescence imaging confirmed that both icons had some retouched areas during prior conservation efforts.

In this context, multispectral imaging not only contributed to the authentication of the icons but also provided critical insights into their aesthetic characteristics and their history, particularly concerning the use of pigments and modifications. These findings affirm the role of advanced imaging technologies in enhancing the analytical and interpretative study of colored artworks.

Recommendations

- Emphasize the importance of using modern technology in documenting and studying archaeological artifacts.

- Increase awareness about multispectral imaging technology through participation in local and international forums and conferences.

- Educate stakeholders about the significance of multispectral imaging for documentation, historical research, and artifact preservation.

- Specifically, focus on its role in detecting forgeries

- Conduct educational workshops for museums, universities, and specialized centers involved in archaeological work.

-

These workshops should cover how to effectively use multispectral imaging in various archaeological contexts.

- Utilize scientific research published in recent years regarding the applications of multispectral imaging in the field of archaeology and documentation.

References

- -Beskhyroun, S. (2018). Condition assessment of oil based painted stone surface; a case study for treatment and conservation of a 19th century painted dome in Cairo, Master thesis, Conservation Department, Faculty of Archaeology, Fayoum University, P 48-50.
- -Beskhyroun, S. (2022). Evaluation of using the biobased green solvents for the cleaning of oil-painted works applied on a selected model, Ph.D. dissertation, Conservation Department, Faculty of Archaeology, Fayoum University, PP. 93-98.
- -Beskhyroun, S., Mahgoub, G. Elserogy, A., Darwish, S., and El-Rifai, I. (2022). Physiochemical diagnostic study of the conservation state of Mohamed Ali Pasha painted portrait (National Military Museum, Cairo), Scientific Culture, Vol 8(3), PP191-204. DOI: 10.5281/zenodo.6631440
- -Cosentino, A. (2014). Identification of pigments by multispectral imaging; a flowchart method, Heritage Science, Vol 2(8), PP1-14, DOI; 10.1186/2050-7445-2-8.
- -Cosentino, A. (2016). Terahertz and cultural heritage science; examination of art and archaeology, Technologies, Vol 4(1), PP 1-13. DOI; https://doi.org/10.3390/technologies4010006
- -Cosentino, A. and Stoul, S.(2014). Photoshop and multispectral imaging for art documentation, e-preservation science, Vol 11, PP 91-98.
- -Cosentino, A., (2015). Practical notes on ultraviolet technical photography for art examination. Conservar Patrimonio 21, pp. 54.
- -Cosentino, A., Caggiani, M.C., Ruggiero, G., and Salvemini, F. (2014). Panoramic multispectral imaging; training and case studies, Bulletin, PP 7-11.
    - Church of Saint Demiana, Boulaq, (2024). Church of Saint Demiana, Boulaq: Centenary Celebration
- -El-Rifai, I, H. Mahgoub, and Ide-Ektessabi, A. (2016). Multi-spectral Imaging System (IWN) for the Digitization and Investigation of Cultural Heritage, Digital Heritage Progress in Cultural Heritage: Documentation, Preservation, and Protection, Proceedings of the 6th International Conference, EuroMed2016, Nicosia, Cyprus, Springer International Publishing, LNCS 10058, pp. 232-240, DOI: 10.1007/978-3-319- 48496-9_19.
- -Fischer, Ch. and Kakoulli, I. (2006). Multispectral and hyperspectral imaging technologies in conservation; current research and applications, Reviews in conservation, Vol 7, PP1-14.
- -Gargano, M., Interlenghi, M., Cavaleri, T., Salvatore, Ch., Ludwig, N. and Castiglioni, I. (2023). Giovanna Garzoni Miniaturist at the Savoy Court: Imaging and Materials Investigations to Discover the Painting Technique, Applied Sciences, Vol 13(5), PP 1-14, DOI;10.3390/app13052790
- -Garini, Y., Young, I.T., and McNamara, G. (2006). Spectral imaging; principles and applications, International Society for Analytical Cytology, PP. 735–747, DOI: 10.1002/cyto.a.20311.
- -Gavrilov, D., Maev, R.Gr., and Almond, D.P.(2014). A review of imaging methods in analysis of works of art; Thermographic imaging method in art analysis, Canadian Journal of Physics, Vol (92), PP341-364, DOI https://doi.org/10.1139/cjp-2013-0128.
- -Liang, H. (2012), Advances in multispectral and hyperspectral imaging for archaeology and art conservation, Applied Physics A, Vol 106, PP 303-323. DOI: 10.1007/s00339-011-6689-1.
- -Paolini, C. (2022), The diagnostic technique of False Colour and the application of Artificial Intelligence for its interpretation, FinAis collection, Vol 2, PP 15-17.
- -Pellicori, V. (2012). Image spectroscopy for diagnostic and conservation of contemporary art materials, Ph.D. dissertation, Ferrara University, Faculty of Mathematical, Physical and Natural Sciences, Physics Department, Italy.

- -San Miguel, E.P.R. (2011). Applications of imaging spectroscopy to the chemistry of cultural heritage field, Ph.D. dissertation, University of Padua, Department of Chemical Sciences.
- -Shaheen, I. (2020). Study of the Most Effective Analysis Procedures Using Multispectral Imaging Techniques on Ancient Egyptian Painted Objects, Master's thesis in archaeological materials science, Sapienza University, Rome.
- -Zaprzalska, D., Georgiou, R., Gasanova, S. and Bakirtzis, N. (2024). Revealing the unseen; advanced digital imaging and spectroscopy for the documentation and non-invasive analysis of a 16th century Cypriot composite icon, Heritage Science, Vol 12(1), PP 1-32. DOI: 10.1186/s40494-024-01282-6.