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DOCUMENTING COLORS BY SPECTRAL FINGERPRINT IN OIL PAINTINGS USING ARTIFICIAL INTELLIGENCE

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Abstract:
Technical documentation helps date the painting and determine the restoration method. Artistic documentation includes the knowledge of the materials used in drawing and the artistic style. The artistic style was analyzed using the spectral fingerprint of color and texture based on the data of the spectral reflectance of each shade on the surface of the painting, especially a distinct area in which the texture of the brush appeared. This was done using Python and artificial intelligence-related computer programs. The result showed that the number of colors was nine with wavelengths of (613.48, 611.37, 594.01, 587.1, 599.42, 497.42, 603.03, 481.94, and 566.33) nm. The texture of the brush was hard and with parallel lines. Similarly, analyses and examinations were conducted on the painting to determine its components. They helped in the identify the artist and the period. Additionally, in the event of a change in color during the preservation intervention was made, and the environment provided was suitable. The study was conducted on a private oil painting representing impressionism in Europe. It was found that the painting suffered from many aspects of deterioration. XRD-FTIR-Raman (SEM-EDX) analysis showed the use of iron oxide in skin color, zinc oxide additives to obtain color gradations, and chromium green mixed with a small percentage of ground green to obtain gradations in the hilly area of the painting. FTIR and Raman analysis showed that the medium used was linseed oil. Furthermore, the microscopy and stereomicroscope examination of the cross-section showed the cross-sectional structure, the number of imaging layers, and several aspects of damage. Thus, an archival record was produced for future monitoring to prioritize treatment aspects, develop a current pre-treatment record, determine the treatment needed, and provide information on the treatment materials and methods used.

1. Introduction

Paintings tend to lose their aesthetic characteristics with time. Therefore, it is essential to document and preserve them because they are part of our cultural heritage. Documenting the artistic method of painting includes measuring colors, knowing the characteristics of color, and describing texture, e.g., knowing the rough or smooth surfaces, following up on the preservation of artworks, and monitoring their behavior during display to investigate the value of color measurement, and its texture over time [1]. Artists usually describe paintings by space, texture, shape, color, tone, and line. In addition, the movement and texture of the brush, through which the painting can be dated, and the artist can be known [2]. The method was analyzed manually in the past, which took more time and effort. Technological development, artificial intelligence, and modern devices have been employed to save time and effort and obtain detailed and accurate documentation. For instance, artificial intelligence helps artists analyze artworks and extract common patterns and standards between paintings [3]. It can play an important role in the field of colors, including analysis or discussion [4]. It can analyze and recognize the colors used in a painting, know the most common colors, and extract distinctive color patterns and color combinations in oil paintings [5]. Digital archiving of art, especially oil paintings, is the process of archiving artistic data using a specific system by studying its surface characteristics. Archiving and digitizing art is important due to its benefits, especially as a strength in literacy for researchers in the history of oil paintings and other art-related areas. In addition, this step helps efforts to preserve cultural arts so that artworks survive [6]. Digital image analysis is the extraction of information from an image, such as descriptive statistics [7], color/ brightness, and distribution of color on a surface, using edge detection and line [8] identification techniques, extracting texture, color, and edges. Documentation is carried out through the color imprint of the brush area whose drawn contour lines between every color edge are determined using Python and artificial intelligence-related computer programs [9] to study several visual features, such as brush strokes [10], texture, and color [11]. Digital technologies have been used in the problem of art preservation. For instance, geographic information systems (GIS) and 3D modeling [12] have successfully documented painted artworks to fully determine the changes in the artwork before, after, and during restoration. The change detection was applied by identifying surface transformations in the heritage of Byzantine icons over time [13]. Digital images are divided based on colors into three types, namely binary images, grayscale images, and color images, where the sum of the intensity of those colors determines the color of each point of light. A digital image is represented by a two-dimensional array (x, y) of the digital data, each representing a value. In the case of storing color images (RGB) with 24 bits, the contents of each of these three colors are (8 bits), and approx. 16 million possibilities are produced [14]. Colorimetry is the science that describes colors in numbers and is applied in the field of restoration and conservation [15] to evaluate the differences between colors in artworks before and after restoration, monitor the phenomenon of fading [16] resulting from exposure to colors in an unsuitable environment [17], and to study color change. Spectral information is valuable in color discrimination as an aid to color recognition alongside other techniques, where optical reflectance spectra are used to identify colors [18] and create specific databases of color spectral curves [19]. Recently, an archaeological research team from the Helsinki University undertook a campaign to apply colorimetry on the frescoes of Pompeii to study the colors from the surface of the walls spectroscopically. Spectral characterization was performed on various artworks, including Paleolithic cave paintings, medieval polychrome sculpture, and modern oil paintings [20]. Colorimetric measurements of the color content of colors ($L^*a^*b^*$), wavelength, color value, and saturation were determined. HVS is important in determining and measuring color properties. At the same time, colored materials and the ground were analyzed by EDX-SEM and X-ray diffraction (XRD) to determine the chemical composition of the color and Fourier transform infrared spectroscopy/total reflectance (FTIR) and Raman spectroscopy to determine the medium in oil painting. Documentation was carried out by examinations by optical microscopy and PLM polarizer light microscopy, which was used in wall paintings in the National Archaeological Museum in Napoli [21]. A new approach was used to analyze drawing using computational tools based on the assumption that an artist's brush could be distinguished by texture, movements, and directions of the artist's brush [22]. Furthermore, measurements could be used as additional evidence in stylistic tasks [23]. The artistic method of paintings was documented in several ways, such as drawing contour lines between each color, extracting color tones and the percentage of their spread on the surface, features in faces, decorations, drawings, or signature letters, and their angles [24]. Moreover, the artistic method was documented through the known wavelengths called the spectral fingerprint and extracted brush strokes to classify the types of painters [25]. Brush strokes and color could help identify the artist [26,27]. Paintings are documented by selecting a part that shows color, surface roughness, and brush strokes [28] and documenting them based on their length, thickness, and inclination angle of the brush stroke [29], in addition to studying the analytical examination of the materials involved in making the painting [30]. Accordingly, the date of the painting is suggested, and the artists can be identified. Based on the extraction of distinctive features identified through brushstroke analysis and colorimetry, this study is believed to help understand the production techniques of works through the colorimetric record, which helps monitor preservation conditions, such as color change [31]. Artificial intelligence was used using Python to recognize the painters' signature like any handwritten signature, classify the contents of an image from the shapes and elements in the image, and clarify their location on the surface [32]. The Python C^{++} programming language is widely used in image processing and computer vision. It is possible to read the oil painting and perform many operations, such as analyzing colors and shapes and obtaining graphs. Moreover, the help of the Python language Open CV was used in comparing paper and counterfeit currencies by discovering dimensions, recognizing colors, and extracting edge detection [33,34].

2. Materials and Methods

2.1. *Materials*

The study was carried out on an oil painting belonging to the late nineteenth century, titled *War Battle*, from a private collection dated 1893, fig. (1). It was a landscape carried out on a linen canvas covered with a white ground layer. The scale was (80 cm wide× 63 cm long) without a frame. The painting depicted a war battle. It is not signed but dated and depicts a group of soldiers in war. The background of the houses and the sky are in a realistic style.

Figure (1) Shows the archaeological painting (*Battle of the War*), and the zoom part of the date of the painting

2.2. *Methods*

Documentation of the artistic style by extracting (color fingerprint, brush texture, and identifying edges) using artificial intelligence. Documentation of the materials by examining and analyzing samples of both red and green colors falling from the edges and removing soot from the samples before analyzing them.

2.2.1. Documenting of the artistic style with artificial intelligence

The oil painting was converted into a digital image by a 100-megapixel camera, a 50 mm lens, and a D50 flash located at the same distance and angle on both sides of the oil painting, fig. (2). It was converted by a computer into a grid of pixels, and the stored values were then used for the digital image to give each pixel its color and brightness. The quality of a digital image depends on the number of pixels; the more pixels, the higher the quality. The old painting was scanned with a million pixels to show the damaged aspects and extract the color and texture.

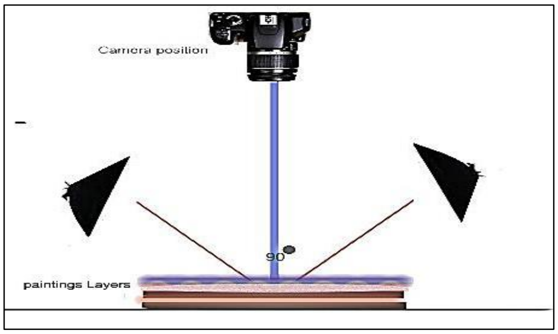


Figure (2) Shows placing the camera vertically on the surface of the painting

2.2.1.1. *Documentation of brush texture and fingerprint color by AI*

The extraction was done by separating each color on a surface that could have a very different texture than other adjacent strokes [35], which were caused by various factors, such as the concentration of the paint and the direction of the brush [36].

2.2.1.2. *Extracting and detecting edges by artificial intelligence:*

Documenting artistic oil paintings with artificial intelligence, using Python to extract the grayscale, helped obtain strong revealing edges to identify the boundaries of the drawn shapes, the boundaries separating each color, and color characteristics, such as the color hue or value (light and dark gradation), saturation (gradation from intense to dull), and the name of the color. Color in painting HSV (Hue-Saturation-Value) is more related to how humans perceive the colors used and determine which colors the painter used in paintings. This is done by entering the code in Python to obtain the information about the panel as follows:

- *import numpy as np*
- *import cv2 as cv*
- *from matplotlib import pyplot as plt*
- *img = cv.imread('aaaa1.jpeg', cv.IMREAD_GRAYSCALE)*
- *assert img is not None, "file could not be read, check with os.path.exists()"*
- *edges = cv.Canny(img,100,200)*
- *plt.subplot(121),plt.imshow(img,cmap = 'gray')*
- *plt.title('Original Image'), plt.xticks([]), plt.yticks([])*
- *plt.subplot(122),plt.imshow(edges,cmap = 'gray')*
- *plt.title('Edge Image'), plt.xticks([]), plt.yticks([])*

2.2.2. Microscopic Examination

Examination and documentation were carried out using a optical microscope (OM) and scanning electron microscope (SEM), to study the layered structure of the painting after preparing samples as cross-sections.

2.2.3. Identifying the type of fiber canvas

A sample of textile fibers was treated with a warm solution of cyanine blue at a concentration of 1% for a few minutes. Then, it was washed with water, and the fibers were treated with dilute sulfuric acid. The fibers were examined by a scanning electron microscope.

2.2.4. Raman analysis

The medium was analyzed using Raman; type: BRUKER-SENTERRA II. Raman's spectra were recorded using a laser with a power of 0.25 micrometers, a wavelength of 785 nm, and exposure duration of 10,000 milliseconds in backscattering arrangements 180 degrees. The resolution was 4 cm^{-1}.

2.2.5. X-ray analysis

Energy-dispersive X-ray spectroscopy (EDX) and X-ray diffraction (XRD) analyses were used to find out both elemental and mineralogical composition of the painting is made. In this context, SEM Model Quanta 250 FEG (Field Emission Gun) attached with EDX Unit and Philips X-Ray diffraction equipment model type pw/1840 with CU-k radiation and Ni-filter at 40 K V, 30 MA, and 0.02/sec scanning speed were used for realizing these targets.

2.2.6. Fourier transform infrared spectroscopy (FTIR) analysis

The FTIR model Cary 630 FTIR spectrometer was used in the spectral range from 400 cm^{-1} to 4000 cm^{-1}. It is a useful technique for identifying chemical compounds, provides information about the chemical or molecular bonding of the material structure [37], and determines the medium [38].

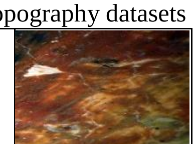
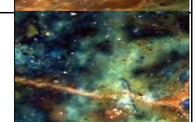
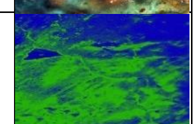
3. Results

3.1. *Documenting of the artistic style by artificial intelligence*

3.1.1. Documentation of fingerprint color by AI

Each color point applied to the surface of a painting is a specific point within a three-dimensional space represented by a linear combination of surface details. The painting understudy was digitized. Then, a filter was used to give strong edge enhancement to the shapes, get three-dimensional space represented by a linear combination of surface details, and get three-dimensional models of the painting for documenting damage to the painting's surface, such as cracks, peeling, and loss of color. An elevation map was obtained, showing the thickness of the falling paint layer (2 mm), tab. (1). The painting was done with a digital camera under certain operating conditions of lighting that scanned the surface and entered the image on programs [Photoshop; Painter 11; Tiny Eye]. All the colors on the surface were documented through the wavelength of each color and the percentages of the spread of each color tone on the surface, fig. (3). The result was that the painting had nine tones. The color code 461718# spread on the surface at 29.1%, a hue was 359°, and its wavelength was 613.48 nm. The color code #f4efef spread on the surface at 21.1%, a hue was 0°, and its wavelength was 611.37 nm. The color code #b76547 # spread on the surface at 13.6%, a hue was 16°, and its wavelength was 594.01nm. The color code #d4ad99 spread on the surface at 12.1%, a hue was 20°, and its wavelength was 587.1 nm. The color code #852b1b spread on the surface at 9.2%, a hue was 9°, and its wavelength was 603.03 nm. The color code #5c7a8e spread on the surface at 8.5%, a hue was 204°, and its wavelength was 481.94 nm. The color code #753426 spread at 4.8%, a hue was 11°, and its wavelength was 599.42 nm. The color code #999596 spread at 0.9 %, a hue was 345°, and its wavelength was 497.42. The color code #504d57 spread on the surface at 0.7% spread, a hue was 258°, and its wavelength was 566.33 nm.

Table (1) Documentation surface topography datasets

Surface details flacking-cracks	
Surface details	
Height map	
Map of surface roughness	

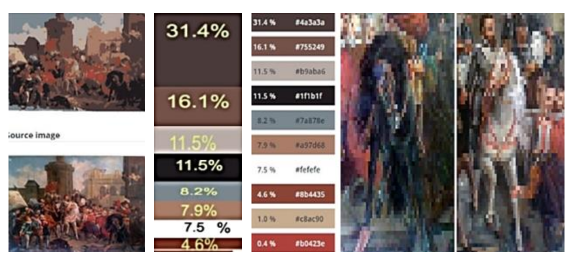


Figure (3) Shows the extraction of each color's properties and the percentage of each color on the surfaces

3.1.2. Extraction of the edge detection by (Python for data analysis) with AI

Edge detection is an essential tool in extracting features for some of the thicker areas of dense color planes, the appearance of brush stroke textures, and creating brush texture *edges on the surface using Python based* on artificial intelligence. The brushstroke is represented by lines, and low and high strokes are defined according to color intensity, which clarifies the finer details, fig. (4). The edge angle can be calculated, and the edges of the shapes drawn in the painting can be determined and documented through colors.

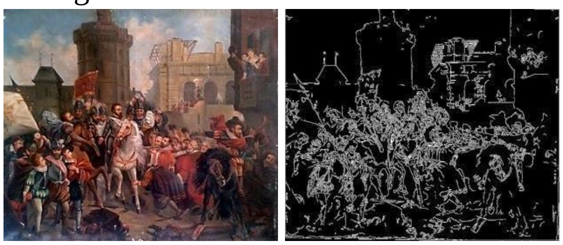


Figure (4) Shows the extraction of edge detection by (Python for data analysis) with AI

3.1.3. Extraction of object detection by AI

It is a computer vision technique used to locate objects in images. It can be used to count the number of objects in the painting, resulting in two horses in the middle of the painting from the bottom, fig. (5).

Figure (5) Shows the extraction of object detection (the horses).

3.1.4. Documentation of the movement of the brush strokes and type of brush

The texture of the brush with a rough style was extracted in some areas [39]. The texture of the brush consists of parallel lines of hard hair and has a rough appearance and texture. The artist loads the dry brush with color before applying it to the canvas. The movement of the end of the brush [40] was circular and curved in some areas and parallel in other areas, fig. (6-a), and the texture of each artist with his brush is a fingerprint [41,42]. Brushes can be measured in length and width according to the angle at which the brush head is projected onto the surface of the painting. We assume that the coordinate system of the painting is x, y. The coordinates and color distribution are according to the movement of the brush fig_s. (6-b & c). The result of the measurement is that the angle of the end of the descent of the brush bristles on the surface of the painting [43] is 45° degrees, fig. (6-d).

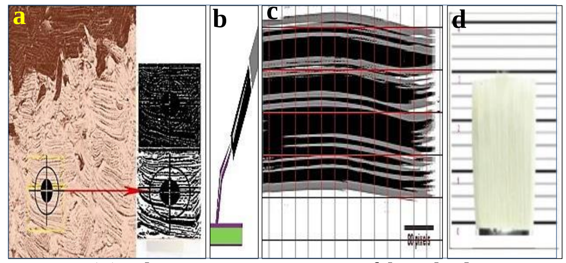


Figure (6) Shows **a.** extraction of brush detection, **b.** position bush on the surface, **c.** painting's coordinate system is x & y, **d.** measured brushstroke

The brush type is Flat Hake. Size flat is 4 cm, bristle width is 3.5 cm, and bristle length is 2.9 cm. The artist used several types of brushes. Analyzing the brush strokes through the direction of movement, the angles of the lines, and the length of the brush stroke from beginning to end revealed that the artist used types of different flat brushes and types of different round brushes [44], as shown in fig. (7).

Figure (7) Shows the movement of the brushes and the types of different types of brushes in many areas.

3.2. ***Analysis and examinations of the archaeological painting***

3.2.1. Examination by microscope

3.2.1.1. *Identifying the type of canvas*

The stain examination showed that the fibers were colored blue. Comparative studies were carried out to identify the apparent shape of the fibers, which were proven to be linen fibers, as a result of the presence of pectin substances in them. The SEM examination showed that the fibers are cylindrical cells with transverse septa between them. This confirms that the fibers are linen. The aspects of fiber damage included fragility, breakage, and weakness, which resulted in poor storage. It can be noticed that canvas deterioration was a reason for oxidation, heat, mechanical stress, and moisture, as fig. (8)

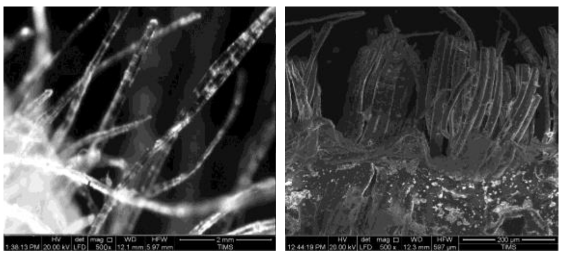
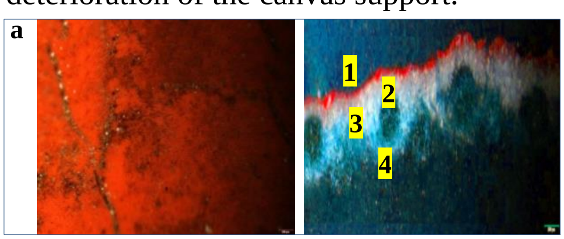


Figure (8) Shows SEM image of linen textile sample 500 X) that showed the linen fibers and weakness.

3.2.1.2. *Cross section*

The red color sample taken from the mantle consists of three layers: The linen support layer, the ground layer, and the color layer. The microscopic examination showed that the artist applied a red color layer in two layers: A lower part is thin, and its color is rose, while the upper layer is thicker and has a reddish hue. It became clear from the color distribution of the granules that the mixing took place on the painting and not on the pallet, as shown in fig. (9-a). The second sample taken from the green color of the background in the dunes consists of two layers: The bottom layer is thick white, while the top layer is thin green with some yellow granules, as fig. (9-b), which shows that the color layer is falling, as well as cracks in color, ground, darkening color, and deterioration of the canvas support.



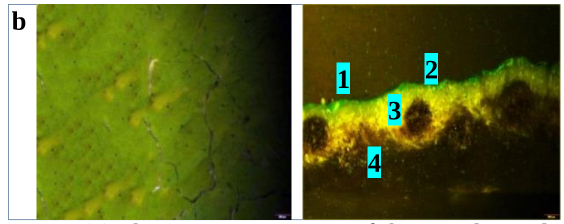


Figure (9) Shows a cross section of the **a.** red sample from a soldier's scarf, **b.** green sample of the dune area.

3.2.2. Raman analysis

Raman analysis, as shown fig. (10), indicated the presence of the linseed oil which observed; vibrations at 1783 cm^{-1}, 1609.20 cm^{-1}, 1587.69 cm^{-1}, 1524.70 cm^{-1}, 1330.74 cm^{-1},1175.59cm^{-1},1 136.11 cm^{-1}, 971 cm^{-1}, 985.43 cm^{-1}, 950.78 cm^{-1}, 866. 44 cm^{-1}, 723.16 cm^{-1}, 619.76 cm^{-1}, 598.83 cm^{-1}. Calcite was also observed for the presence of the spectrum at 280.56 cm^{-1}, 723.16 $cm^{-1,}$ and 886.44 $cm^{-1,}$ and the most intense one at 1330.87 cm^{-1} [45]. The analysis indicated the presence of rabbit skin glue. It was also observed for present use in the ground layer by Raman bands at 619.76 cm^{-1}, 799.72 cm^{-1}, 1034 cm^{-1}, 1136.11 cm^{-1}, 1448.02 cm^{-1} and 1609.20 cm^{-1}[46].

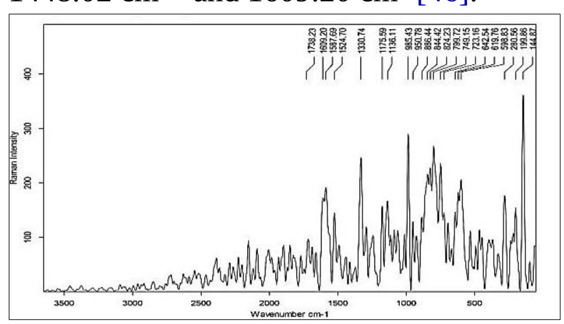
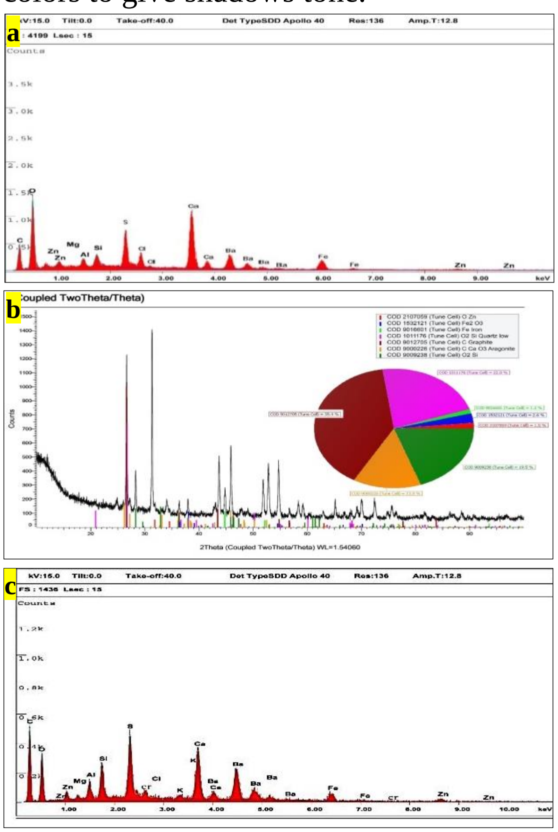


Figure (10) Shows Raman spectra are recorded with the 785nm laser

3.2.3. Analyses by (SEM-EDX) & XRD

The result of the EDX analysis showed, as shown fig. (11-a), that the elements in the colored materials used by the artist in this painting were oxygen at 28.95%, carbon at 7.54%, zinc oxide at 10.43%, magnesium oxide at 89%, aluminum oxide at 0.14%, and carbon dioxide, silicon oxide at 1.20 %, calcium oxide at 22.41%, chlorine oxide at 2.98%, and iron oxide at 8.98%. The result of the XRD analysis confirmed the EDX results about hematite, fig. (11-b), which showed the presence of silica dioxide at 19.5 %, zinc oxide at 1.5%, iron at 2.6%, carbon at 39.4%, calcium carbonate at 13.8%, and quartz at 22%. The presence of iron oxide associated with quartz confirmed the red color of hematite. Furthermore, EDX analysis of a sample of green from the dunes, fig. (11-c) showed carbon at 52.76%, oxygen at 12.61%, magnesium at 0.07%, aluminum at 1.30%, silicon dioxide at 1.65%, chromium at 2.86%, barium at 10.39%, zinc at 2.44%, calcium at 3.49%, iron at 1.37%, potassium at 0.20%, and sulfur at 10.82%. XRD analysis confirmed the result of the EDX analysis about the use of earth green mixed with chrome green, as fig. (11-d) that the green color was composed of calcium carbonate at 45.7%, zinc oxide at 20.1%, and chromium oxide at 25.3%. This result confirmed the use of two types of green colors to give shadows tone.



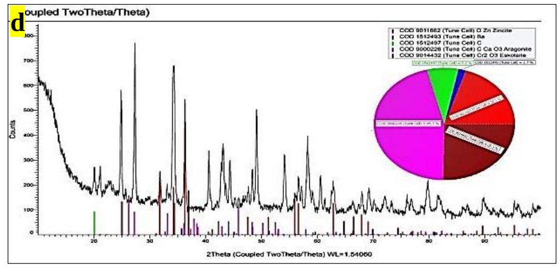


Figure (13) Shows **a.** & **b.** EDX and XRD patterns of a red color a soldier's scarf, **c.** & **d.** EDX and XRD patterns of a green sample from the dune area

SEM examination of the red-colored area of the soldier's uniform, fig. (14-a) showed that the irregularity in the surface, cracking, ground losing adhesive strength, separation of both the paint layer and the ground from the support, and the occurrence of partial or total separation between these layers as a result of the mechanical reaction that arises between two layers of flexible paint on a solid paint. The sample of the green area in the dunes, fig. (14-b), showed crakes and the separation of both the paint layer and the ground from the support.

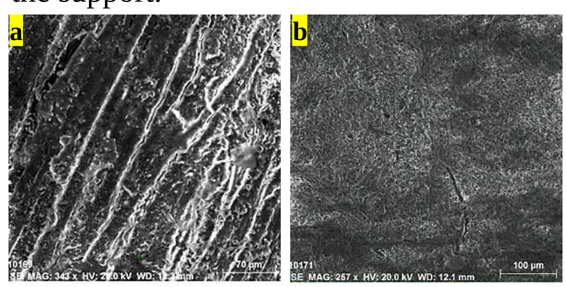


Figure (14) Shows SEM photomicrographs of **a.** red color sample from the soldier's uniform, **b.** green color sample from the dune area

3.2.4. FTIR analysis

The resulted data of the red color sample by ART-FTIR, fig. (15-a), revealed the appearance of O-H stretching group at wavenumber 3254 cm^{-1}, νASCH3 absorption group stretching at wavenumber 22936 cm^{-1}, νASCH2 absorption group stretching at wavelength 2936 cm^{-1}, C=O (ester) stretching group at wavenumber 1738 cm^{-1}, and the CH_3 asymmetric bending absorption group at wavenumber 1443 cm^{-1}, which indicated the use of linseed oil as an intermediate with colored materials. The analysis indicated the presence of red ocher, which is the natural earth oxide that contains silica and clay due to the presence of the absorption group (Si-O-Si) (silicates) at the wavenumber 1075 cm^{-1}, 1040 cm^{-1} and the presence of the kaolin/ hematite O-Si-O/Fe -O group at a wavenumber of 445 cm^{-1}. The sample green color analysis by ART- FTIR, fig. (15-b), showed the presence of an absorption group that indicated chromium oxide Cr_2O_3 at wave number at 743 cm^{-1}, 537 cm^{-1}, 514 cm^{-1}, 482 cm^{-1}, 461 cm^{-1} and 442 cm^{-1} [47] and the presence of a carbon-ate group represented in calcium carbonate in the ground at wavenumber 1438 cm^{-1} [48]. In addition, it showed the functional groups of glue with a stretching band N-H at wavenumber at 3278cm^{-1}, stretching band C=O at 1629 cm^{-1}, bending bands C-N-H at 1514 cm^{-1}, and bending bands C-H at 1438 cm^{-1} [49].

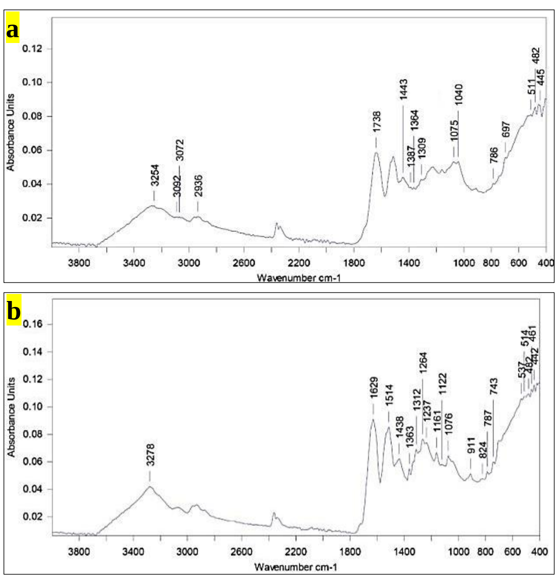


Figure (15) Shows ART-FTIR spectrum of **a.** red color sample from the soldier's uniform, **b.** green color sample from the dune area

4. Discussion

Paintings are considered a cultural heritage, and documenting them is important in the field of archaeology. Documenting the artistic style of drawing is analyzing the artist's drawing style with numbers in terms of measuring color shades with numbers and determining the wavelength of each color (hue), which was determined by placing a number between 0 and 360. At the number 0, the red color begins with its degrees; at number 120, the green color begins with its degrees; at number 240, the blue color begins with degrees, and determining a place where brush strokes appear, extracting and defining them on the surface, and determining the shapes and their locations in the painting through the values of the "X" and "Y" axes, and based on that, documentation is done. The painting, as well as its history and which school of art it belongs to, can be deduced through its artistic style and its comparison with paintings from the same century and the style of the era [50]. The color fingerprint is measured in numbers using artificial intelligence under certain operating conditions of lighting and position. Measuring the proportion of each color and determining the wavelength of each color spread on the surface [51]. The color measurement by numbers using fingerprints using artificial intelligence was conducted by converting oil painting into digital images, where it is divided into elements, a point is determined, the color content in it is measured, and its location on the surface of the painting is geometrically [52] represented using Python programming using artificial intelligence and entering the program code, which is considered a code and creates lines defining the edge of the brush texture of an area. Determine each color shade and apply a filter to sharpen the details to highlight the edges [53]. Frame representation of color is used to find edges and observe colors at the edges of shapes. During periodic maintenance, each point has a numerical value and a specific location on the x, and y axes [54], and the numbers are used to transfer information about the color in the brush texture area [55] from the locations specified in the original painting [56], extracting statistical features, angles between edges, direction of movement, and determining length and width [57]. It is stored in the form of documentation [58], which produces an algorithmic approach to analyzing the boundaries in the artists' line drawings, the shape of the brush stroke and its characteristics [59], and measuring the wavelength of each color. The result showed brush shape was parallel lines, the direction of the brush, which was shown to be inclined at an angle lines, the direction of the brush, which was shown to be inclined at an angle of 45, and the type of brush, which was found to be flat, which are considered signs. A distinctive artist's document that prevents the counterfeiting of oil paintings. An indicator is also given during periodic preservation through monitoring the colors and measuring the percentage of color spread over time. If the measurement value changes over time, the painting is vulnerable to damage, which requires providing the appropriate environmental conditions for preservation. In parallel with the documentation carried out through artificial intelligence and computers, the materials used in oil paintings are documented through analysis and examinations. Examination with an OM through a cross-section taken from the red scarf - the artist's artistic method - showed that the painting consists of several layers, that the surface shows the texture of the brush with lines inclined at an angle of 45 degrees and that the artist applied the color in several layers. The second sample was taken from the green color. It contains some white grains, which confirms that the artist used the mixing method to give the shadows. The SEM-EDX and XRD results proved that the ground layer consists of calcite as the main compound. The red-colored substance was made from ground oxides of iron oxide and is accompanied by quartz and zinc oxide. The explanation for the presence of silica with red iron oxide is that the artist used silica (ground glass) in the colors because the transparency of the glass allows light to penetrate the color and illuminate the translucent pigments mixed with it, as well as the glass. It works as a desiccant and the presence of zinc oxide with the red coloring matter that the artist can add to give a light tone of red color. The artist used a green color composed of chromium oxide mixed with earth green to give the shadows, and the presence of zinc oxide with the green coloring material gave the light tone. The FTIR and Raman spectroscopy analysis proved that the medium used was linseed oil, the adhesive used on the ground was animal glue, and the floor was calcium carbonate. The medium and ground were confirmed by using Raman analysis.

5. Conclusion

Artificial intelligence is one of the modern methods for extraction the "color fingerprint" by measuring the color, the wavelength, and each artist's method of drawing by detecting the edges of the shapes drawn on the oil painting, how to apply colors to the surface of the oil painting, and extracting the texture of the brush، using pattern recognition techniques to characterize the visual characteristics of brush strokes that correspond to a specific artist and visual measurement data of color and artist style through surface morphology to assign works to oil paintings based on that information that indicates the artists' style using machine learning. These techniques are considered complementary to the examinations and analyses of oil paintings for preservation, documentation, and forgery detection. The study of digital oil painting using digital image processing technology using Python programming is considered to achieve the desired goals of documentation (Color space processing - Histtogram Calculation - Structural Analysis and Shape Descriptors- Feature Detection)

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