

The Implementation of VR Technology in the Recoloring of the Historical Pharoanic Sites (Case Study On Khuwy's Tomb)

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Abstract

Egypt has a rich pharoanic heritage. Most of them are tombs or temples as the Egyptians believed in eternity in afterlife. The ancient Egyptian artist decorated tombs and temples with colored hieroglyphic texts and illustrations that serve their eternity believes. By developing his own color identity a remarkable color scheme was distinguishing most of the pharoanic arts. The ancient Egyptian artist used pigments made from inorganic substances for coloring, which explains the extraordinary good preservation of most of the colors on tomb walls. But these inorganic pigments are affected by degradation factors through the years so the colors that appears now to the viewer are different than the original colors, in addition to the deterioration of some parts of the historical illustrations in most tombs and temples. Therefore studies of the chemical compositions of pigments used in each Egyptian dynasty and their effect on the degradation of colors is important to analyze the original colors used and understand the color scheme chosen by the Egyptian artist in his illustrations. This research will examine the impact of using the modern technology of VR - virtual reality - that replaces the real word with a virtual one, in representing the ancient pharoanic sites in a complete assumption of their original colors before degradation. Based on the recent researches regarding chemical degradation of Egyptian colors. The study will provide an interesting experience for the visitors leading to attraction of large numbers of tourists to Egypt. A historic pharoanic site is used as a case study for the research (Khuwy's tomb in Saqqara- discovered in April 2019).

Keywords: Virtual Reality, Khuwy's Tomb, Pharoanic Heritage, Color Degradation

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Introduction

During the COVID-19 lockdown, Egyptian authorities launched virtual trips of some of the historic Egyptian sites. The project was applied through 3D modeling by Harvard University offering free virtual entry to historical places. This project had a great impact in promoting the Egyptian historical areas, and encouraging tourists to visit Egypt after the lockdown ends. The Egyptian virtual trips included some of the most important tombs in ancient Egypt as the 5000 years old tomb of Queen Meresankh III. (Stewart, J. 15-4-2020)

This research will study a new approach of the Egyptian virtual trips using the existing theoretical researches on AR and VR technology in providing recolored historical arts to the viewer, providing two images of the tombs, a virtual 3d image of the tomb in its meanwhile condition, and an interactive option where the user can experience the same tomb in its full colors and a perfect restored condition resembling how it looked like thousands of years ago. Which is expected to increase the touristic potentialities, leading to more economical recovery demanded after the Egyptian economical crisis that followed the country's revolution in 2011.

Introducing VR and AR in Saqqara

VR and AR technologies have a strong impact in the 21st century, as the viewer feels it's a real environment. The VR is capable of representing a complete 3d image of the historical place, while the AR integrates this image with information about it in different ways to the visitor. "The interaction with special devices creates an isolation field to the user, allowing him to enter an immaterial digital space, and to experience it through a spherical projection around him through these devices" (Gauzzaroni, G. Pillai, A.S. 2020. p.89). The spherical projection is the recreation of original colors, images and illustrations in the tombs of Saqqara, allowing the user to experience a new prehistorical visit to the tomb.

Khuwy's tomb in Saqqara as a case study

Khuwy's tomb - the case study for the research - chosen by the American archeology magazine as one of the 2019's top 10 discoveries, and was announced by authorities on the 13th of April 2019 in a press conference. The tomb was created for a man named Khuwy, a dignitary from the Fifth Egyptian Dynasty that dates from 2494 B.C to 2345 B.C, it represents the Dynasties III, IV and VI under the title of the Old Kingdom (Hawass, Z. 2002), as announced by authorities; the discovery of this tomb was during the documentation of the collection of pyramids that belong to King Djedkarea, who was the eighth ruler of the Fifth Egyptian Dynasty that ruled Egypt for 32 years (Essam, A. 13-4-2019). The artistic scenes on the walls of the tomb is covered with remains of most of the colors, providing a perfect case study for color restoration and degradation factors to provide a 3d virtual recolored interactive visit to the user.



Figure 1: Khuwy's tomb in Saqqara- discovered in April 2019, case study for the research. The tomb consists of three decorated walls, the front wall contains a clear illustration of the tomb's owner sitting in front of horizontal registers containing offerings. Photo adapted from Megahed, M & Vymazalová, H. 2019. Republished with permission.

Art in the fifth dynasty followed the same rules in the fourth dynasty in a more developed concept. According to Pflüger, K., & Ethel W. Burney (1937) "Art In the fifth Dynasty took a remarkable and completely unexpected course, as it became elegant, imaginative, and bright, instead of remaining stiff due to the changed political situation within Egypt" (p. 7)



Figure 2: Two scenes from the right and left walls of the tomb. The right wall of the tomb is divided into vertical columns, while the left wall is divided into horizontal registers containing illustrations. The three walls of the tomb show clear color remains that support the study. Photo adapted from (Megahed, M & Vymazalová, H. 2019). Republished with permission.

The study of color degradation in Khuwy's tomb

According to Giménez, J. (2015), "Most pigments used by the Ancient Egyptians were obtained from minerals relatively ubiquitous in the Egyptian landscape; the colors obtained are usually called "earth colors" and are generally characterized by a high stability against weathering and, consequently, the color remains unaltered for centuries or millennia " (p.1).

This explains the preservation of most of the colors on the walls of Khuwy's tomb. But these minerals are exposed to degradation factors as chemical reactions occur between the pigments and different weather conditions resulting in new visible colors (Robins, G. 2008). This study will examine the results of the original colors assumption based on Egyptology researches regarding the Egyptian art in the old kingdom, and the chemistry of the degradation process through chemical engineering, in order to produce a digital virtual recreation of the original colors.

Egyptian blue was a very unique color in ancient Egypt. Ancient Egyptians synthesized a blue pigment that is considered the earliest artificial pigment. The Blue pigment was obtained from azurite (copper carbonate), the blue color is due to the presence of crystals of the mineral Cuprorivaite ($\text{CaCuSi}_4\text{O}_{10}$), when interacts with different minerals causes copper chloride disease which results in the transformation of the blue color to a greenish color -a different form of copper carbonate - (Giménez, J. 2015).

White pigment in the fifth dynasty was usually obtained from calcium carbonate, remains of the white color still appears in different illustrations in the tomb, but it loses its pure intensity through the years and turns to tints of light grey mixed with slight remains of the clear white calcium carbonate. Black pigment was obtained from charcoal, which also loses its saturation and intensity through time. The different hues of Yellow pigment were obtained from iron oxide, while the bright yellow was obtained from orpiment. The yellow color was a remarkable color in ancient Egypt representing gold particularly in royal tombs, but orpiment fades overtime and turns to dull shades of yellow (Robins, G. 2008). Red pigment was obtained from Realgar. Red realgar is transformed to different shades of yellow or orange depending on the interaction with oxygen where Pararealgar is created. Green pigment was a result of chemical synthesis composed of crystals of Wollastonite (CaSiO_3), which turns to dark shades of dull green (Giménez, J. 2015).

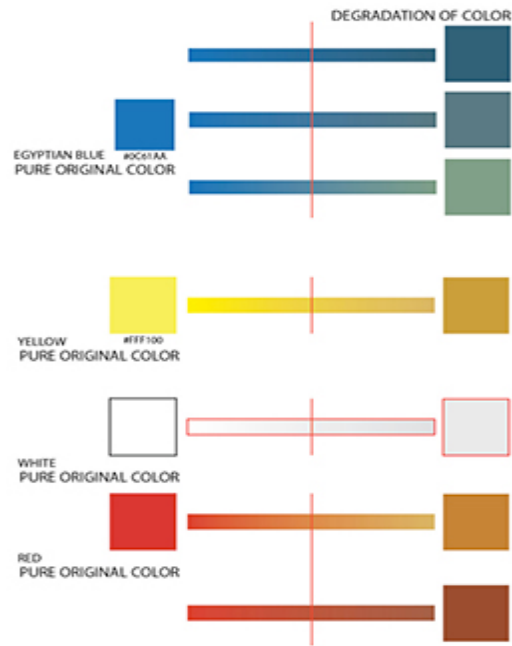


Figure 3: The degradation of colors in Khuwy's tomb; Blue (azurite) changes to malachite (green in color). Yellow (orpiment) changes to dull shades of yellow. Red (realgar) changes to yellow or orange (pararealgar). White (calcium carbonate) changes to a light tint of grey.

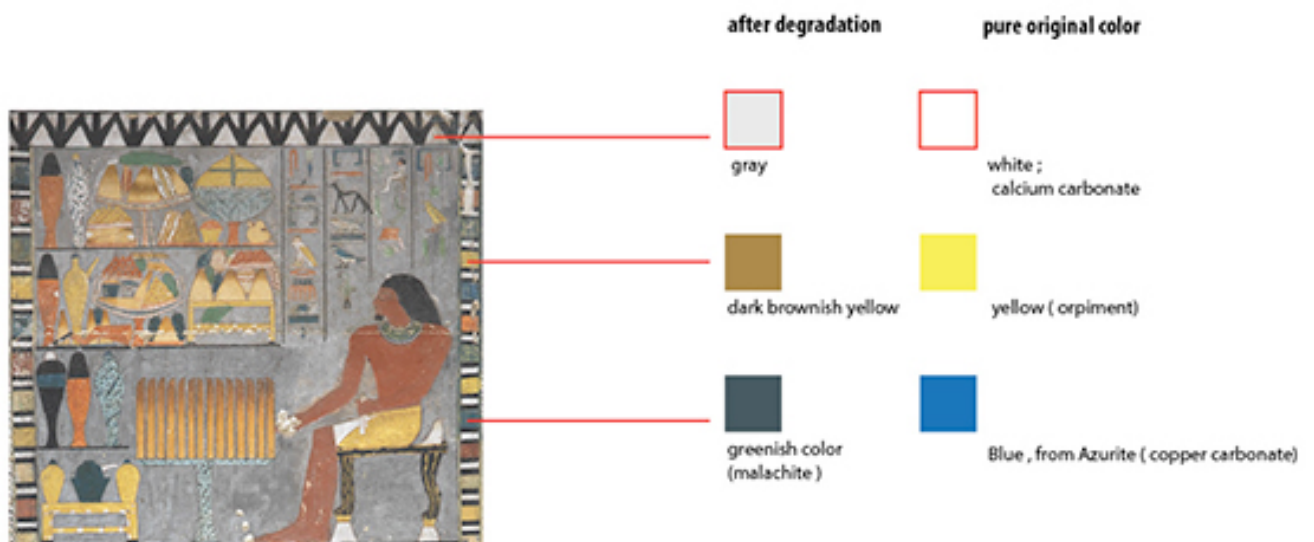


Figure 4: The front wall of Khuwy's tomb in its meanwhile condition, showing an example of the extracted colors versus their original assumption. Photo adapted from (Megahed, M. Vymazalová, H. 2019). Republished with permission.

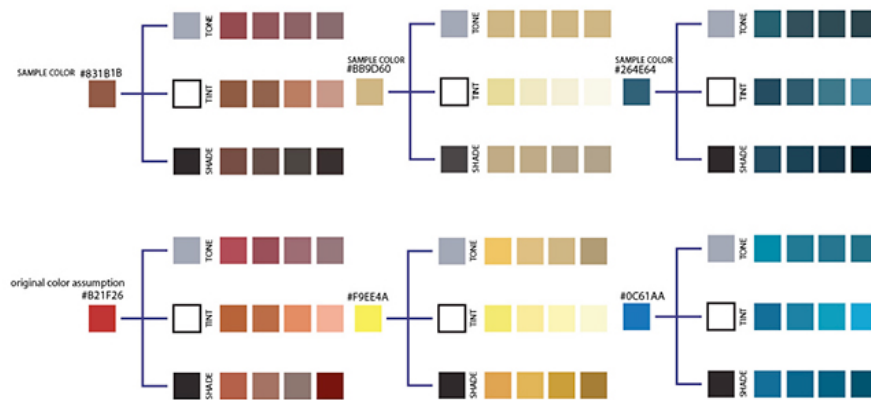


Figure 5: The Tones, tints and shades of the extracted colors in Khuwy's tomb after degradation are studied and analyzed. Also Tones, tints and shades from the original assumption of colors based on the study of color degradation in this research is generated in order to be used in the virtual recolored images of Khuwy's tomb.

Digital restoration of Khuwy's tomb.

Digital restoration of historical sites has attracted more and more attention, it is considered a very important and economical method in the historical sites preservation, as low-cost hardware can be easily functioning to produce the virtual restored structure of the historical site. Image-based restoration is very easy to apply with only few images from the original site to reproduce the 3d virtual structure (Hou, D. Shen, X. Li, X. Liu, Y. & Wang, Y. 2006).

The digital restoration of Khuwy's tomb starts with the image collection, where multiple consequence clear images of the walls are collected, followed by the optimization processing to build the 3d virtual image of the tomb in it's meanwhile condition. The second stage of the project is to recreate any damaged areas in the tomb's illustrations. The process includes the integration with digital reassembly using adobe Photoshop software where damaged areas has been accurately recreated as in figure 6. The third stage is the recoloring assumption of the tomb's illustrations, where the tomb is recolored digitally to recreate the original image of the tomb before degradation. The recoloring process has been applied using both Adobe Photoshop software and Adobe Illustrator. The recoloring process follows the research's study of color degradation. All the green shades in the tomb's illustrations are recolored blue, where Blue (Azurite) has changed to Malachite (green in color). All the dull shades of yellow are recolored to pure vibrant yellow, as Yellow (orpiment) has changed to dull shades of yellow. The orange shades are recolored pure vibrant Red, as red (Realgar) has changed to yellow or orange (Pararealgar). Any remains of white indicates the presence of calcium carbonate that was used to produce the white color, so they are recolored to clear pure white, also light tints of grey is recolored to white. The black remains that lost its intensity is recolored to pure saturated black color (Gimeñez, J 2015).

The Egyptian artist used burning devices to light up tombs during his painting process, Egyptology researches assumes that the ancient Egyptian artist used animal fats as fuels for burning. The light emitted from animal burning fat is a warm light, causing the pigments to look visibly warmer to the artist, therefore the recoloring

simulation of the tomb recommends the colors to be red shifted to reflect the original visible condition (Strong, M. 2018).

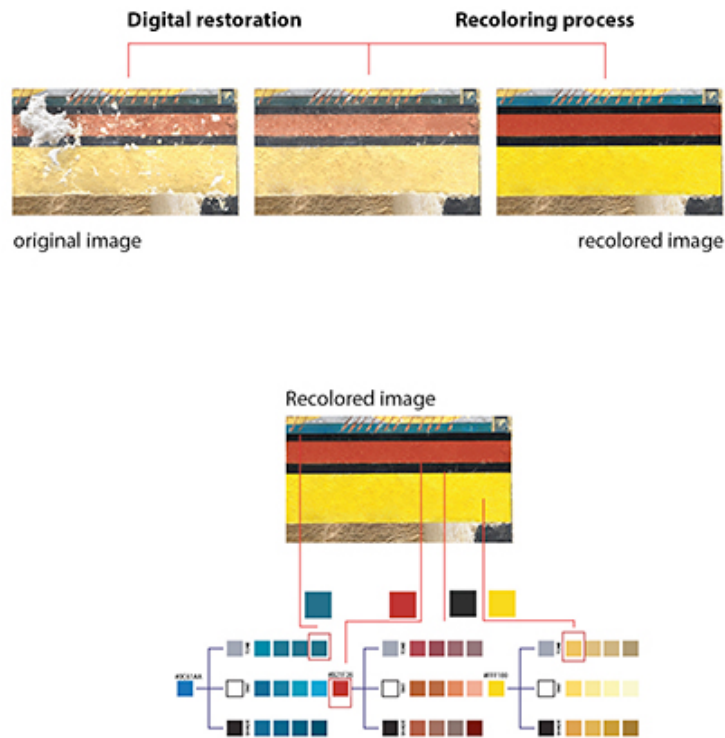


Figure 6: An enlarged portion of the illustration is chosen to explain the process. The damaged area in the original image is the recreated using adobe Photoshop software followed by the digital recoloring .



Figure 7: An example of the recoloring process of the original illustration on the front wall of Khuwy's tomb using the color degradation study in this research to retrieve an original image of the front wall.

Processing of the virtual recolored tomb

The virtual content of both the recolored and the real image of the tomb are presented to the user through special devices with high-resolution image quality available at the touristic site and can be accessed online. The user enters a virtual 360° circular view of the tomb when he wears his headset (Gauzzaroni, G. Pillai, A.S. 2020). The user

interface design is processed to support the user's virtual experience and make it more valuable to the viewer by providing multiple Interactive information options. First the user can hear general information regarding the tomb's historic value, the tomb's owner and the history of the fifth dynasty. The viewer can explore specific information regarding each color, color identity, color symbolism and color inspiration for the ancient Egyptian artist in the fifth dynasty. He can then explore explanatory information provided regarding the virtual recoloring process, the color sources, the degradation pattern of Khuwy's tomb, and how the 3d recolored virtual assumption has been produced. He can compare the steps of color transformation through an infographic analysis provided in the integrated virtual visit.

The virtual experience of recoloring the tomb offers interactive scrollbars, designed horizontally to be easily functioning during the viewer's virtual trip. These horizontal scrollbars offer the viewer interactive options to change each color manually to see how it transformed in thousands of years, giving him an enriched experience of viewing the tomb.

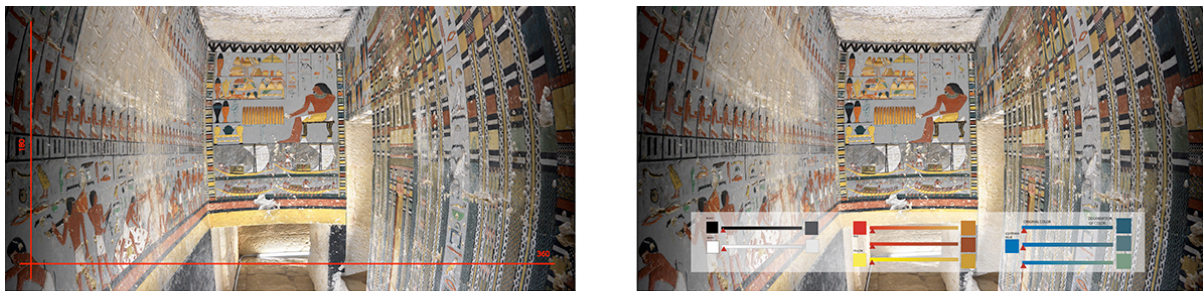


Figure 8: The user enters a virtual 360° circular view of the tomb when he wears his headset.

He can also navigate this virtual view, and explore the original colors through interactive scrollbars, where he can experience changing each color manually between its original pigment and the visible color after degradation. The interaction with the VR and AR information depends on personal skills and experience of the user on how to interact with the user interface.

The interactive scrollbars are divided into five colors positioned on the left side of the bars; these colors are black, white, red, yellow and blue, representing the original colors of the tomb before degradation. Each color can be changed manually to its visible color in the real tomb after degradation - placed on the right side of the scrollbar- and vice versa. The high-saturated black color scrollbar offers changing the color to a dark shade of grey. The white color can be changed to a light tint of grey. The red color can be changed through the scrollbar to two different dull shades of

orange-yellow extracted from the tomb. The saturated yellow color can be changed through the scrollbar to a dull shade of yellow, and the blue color can be changed through the scrollbar to three different shades of green color extracted from the tomb (Figure 9).

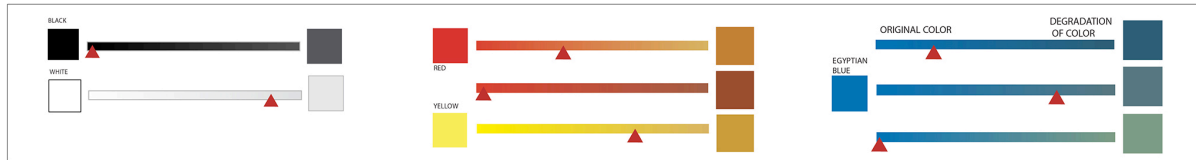


Figure 9: The interactive scrollbars are designed to be easily functioning during the viewer’s virtual trip, giving him an enriched experience, where he can change each color manually to see how it transformed in thousands of years.

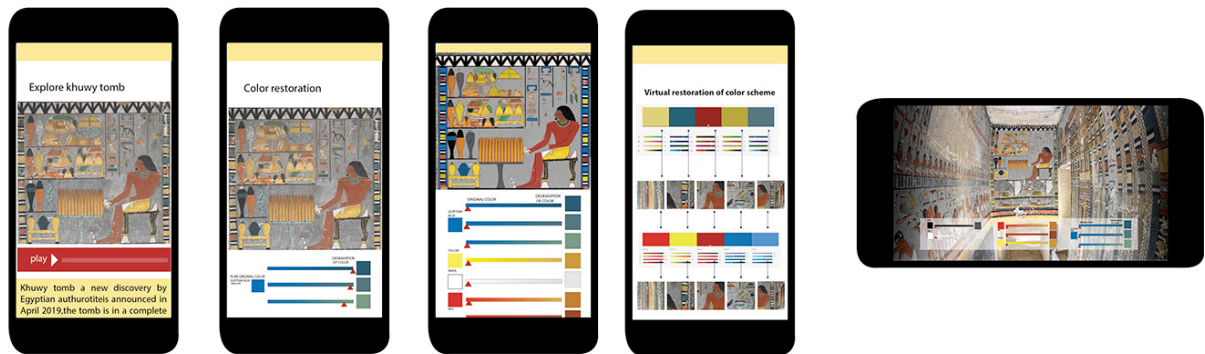


Figure 10: Designing an integrated UID that supports the user’s virtual experience of the tomb with organized screen flows (Kim, U. Wang, Y & Yuan, W. 2020), that allows the user to navigate interactive information, videos, and infographs that provides information regarding each color, the color identity, color symbolism and color inspiration for the ancient Egyptian artist.

Conclusion

This paper studied the impact of the integration of VR and AR technologies in restoring and recoloring Khuwy’s tomb. It offered a new touristic virtual visit to the user, allowing him to view the tomb in it’s original restored colored condition, with interactive UI design to change each color manually between it’s original pigment and the visible color after degradation resulting in an enriched experience to the visitor. The study is expected to increase the Egyptian touristic potentialities leading to more economical recovery in Egypt by promoting the historical places in Egypt in a new virtual restored condition. The interactive experience is also applicable to Egyptian tombs that are not open the public due to preservation issues.

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